ITS Architecture for the Denver Regional Area

November 2007
Regional ITS Architecture for the Denver Regional Area

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Regional Intelligent Transportation Systems Architecture for the Denver Regional Area

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<thead>
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<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AD</td>
<td>Archived Data Management</td>
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<td>APTS</td>
<td>Advanced Public Transportation Systems</td>
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<td>ATIS</td>
<td>Advanced Traveler Information Systems</td>
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<td>ATMS</td>
<td>Advanced Traffic Management Systems</td>
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<td>ATR</td>
<td>Automatic Traffic Recorder</td>
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<td>Automated Vehicle Location</td>
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<td>AVSS</td>
<td>Advanced Vehicle Safety Systems</td>
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<td>BNSF</td>
<td>Burlington Northern and Santa Fe</td>
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<td>CCTV</td>
<td>Closed Circuit Television</td>
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<td>CDOT</td>
<td>Colorado Department of Transportation</td>
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<td>CSP</td>
<td>Colorado State Patrol</td>
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<td>CTMC</td>
<td>Colorado Transportation Management Center</td>
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<td>CVO</td>
<td>Commercial Vehicles Operations</td>
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<td>DMS</td>
<td>Dynamic Message Sign</td>
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<td>DTN</td>
<td>Data Transmission Network</td>
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<td>DRCOG</td>
<td>Denver Regional Council of Governments</td>
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<td>EM</td>
<td>Emergency Management</td>
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<td>ES</td>
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<td>FHWA</td>
<td>Federal Highway Administration</td>
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<td>GIS</td>
<td>Geographical Information System</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>Highway Advisory Radio</td>
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<td>Highway Rail Interface</td>
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<td>Intelligent Transportation Systems</td>
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<td>MCM</td>
<td>Maintenance and Construction Management</td>
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<td>MDSS</td>
<td>Maintenance Decision Support System</td>
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<td>Market Package</td>
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<td>MPO</td>
<td>Metropolitan Planning Organization</td>
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<td>O&amp;M</td>
<td>Operations and Maintenance</td>
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<td>PDA</td>
<td>Personal Digital Assistant</td>
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<td>POE</td>
<td>Port of Entry</td>
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<td>RMDI</td>
<td>Revised Model Deployment Initiative</td>
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<td>RTD</td>
<td>Regional Transportation District</td>
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<td>RWIS</td>
<td>Road and Weather Information Systems</td>
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<td>TMC</td>
<td>Traffic/Transportation Management Center</td>
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<td>Transit Operations Center</td>
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<td>TPR</td>
<td>Transportation Planning Region</td>
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<td>UP</td>
<td>Union Pacific</td>
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<td>Weigh-In-Motion</td>
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Executive Summary

This architecture for intelligent transportation systems (ITS) in the Denver Regional Area describes the ITS elements, their relationship to each other, the roles and responsibilities of the stakeholders and a systematic approach for implementation of intelligent transportation systems in the Area, including the Colorado Department of Transportation (CDOT) Regions 1, 4 and 6, over the next 20 years. Intelligent transportation systems consist of the application of computers, electronics, communications, and data management used for the purpose of effectively and efficiently managing the transportation system to improve transportation mobility and safety and to provide information to travelers. This document is a technical companion document to the Denver Regional Intelligent Transportation Systems Strategic Plan.

The ITS vision established by the ITS Working Group (regional stakeholders) for the Denver Regional Area is:

*The ITS Working Group will deploy efficient management processes and systems to promote and facilitate cooperative, regional transportation and multimodal operations.*

A. Denver Regional Area

The Denver Regional Area includes nine counties of the Denver Regional Council of Government’s (DRCOG) Regional Area, all of CDOT Region 6, and that portion of Regions 1 and 4 that are in the DRCOG Region (see Figures ES-1 and ES-2). The nine counties in the Denver Regional Area are as follows: Adams, Arapahoe, Boulder, Clear Creek, Broomfield, Denver, Douglas, Gilpin, and Jefferson The area also includes over 50 towns and cities within the counties.
The Denver Regional Area has the following major highways:

- **I-70** - is the dominant east-west regional and interstate corridor in the north of the Metro Area. The I-70 corridor through the Denver Regional Area is a major travel corridor for access to the mountains for recreational use and tourism as well as intrastate and interstate travel.
- **I-76** – is an interstate highway that provides important connectivity within the Denver Regional Area from I-70 northeast to US 85. I-76 continues into Northeast Colorado and terminates at I-80 in Nebraska.
- **I-25** - is the dominant north-south regional and interstate corridor. The I-25 corridor through the central Denver Regional Area is a major travel corridor for inter-urban and inter-state travel along the entire Front Range (eastern slope) of the Rocky Mountain region.
- **I-225** - is a bypass route for the interstate system between I-25 and I-70 on the east side of Denver with access to Aurora.
- **I-270** – is an “intra-regional” highway connecting I-70 with I-25 and US 36 to the Northwest.
- **C-470** - is a public highway on the western and southern perimeter of the Regional area and is used as a bypass route west of Denver between I-25 and I-70. It also provides access to southern and western suburbs in Arapahoe, Douglas and Jefferson Counties.
- **E-470 and the Northwest Parkway toll roads** complete the perimeter ring of the Regional area from the south and east to the northwest. These toll highways provide a bypass route to the east and north and provide access to Parker, Aurora, DIA and northern suburbs in Adams, Boulder and Jefferson Counties.
- **US 6** - is a regional east-west state highway through the central part of the Denver Regional Area.
- **US 285** - is a State Highway in the south-central part of the Regional area which is part of a larger state route system.
- **US 36** – is a State Highway in the north-west part of the Regional area connecting the Denver Area to the Boulder Area.

The Denver Regional Area also has the following characteristics:

- Long-haul trucking represents a large percentage of travel on highways;
- Recurring congestion exists on all major urban highways and arterials in the Denver Regional Area.
- The T-REX expansion of I-25 was recently completed including construction of the southeast light-rail line.
- Future FasTracks projects will expand the regional rapid transit system.
- Several major traffic generators exist in the region such as: Central Downtown Denver, the Denver Technological Center (DTC), Boulder, University of Colorado in Boulder, Auraria Higher Education Center (AHEC), Fitzsimons campus, and the Denver Federal Center.
- The western part of the region is located in the foothills of the Rocky Mountains and is at higher altitude. Weather conditions in this part of the region are often more severe.
Tourism and recreation provide significant economic benefits to this, and other parts of the state. These recreational activities generate significant travel demands on regional highways.

There are many significant special event traffic generators in the area – Coors Field, Invesco Field at Mile High Stadium, The Pepsi Center, Elitch Gardens, the Denver Convention Center, Folsom Stadium at University of Colorado in Boulder, Red Rocks Amphitheater.

Denver International Airport is the state's busiest airport and the fourth busiest airport in the country.
Figure ES – 2 Denver Regional Area Relationship to CDOT Regions 1, 4, and 6
B. Issues and Needs

Transportation issues and needs that could potentially be addressed through ITS were identified through a series of stakeholder workshops and review of Incident Management Plans, the 2030 Metro Vision Regional Transportation and other transportation plans. These include:

Several critical issues related to ITS were identified both from stakeholder input, as well as review of existing planning documents. These include:

1. The inadequacy of funding and inability of infrastructure improvements to keep up with transportation demand is placing more stress on existing facilities. Aging infrastructure must be monitored and repairs scheduled within the confines of funding availability.

2. A data mart or data warehouse is needed to collect and dispense transportation related performance metric data for use in transportation planning. Data may be decentralized and held locally by multiple jurisdictions or collected and controlled by a single entity. In either case, with agreements to share information, standards for maintaining data could be defined and used to better control and process data.

3. CDOT CTMC is moving towards regional operational control, with local jurisdictions that desire such control, during off-hours and special events. Currently however, limited regional operational control exists and further connectivity in the region is a challenge. Backbone communications networks are near capacity and limited funding exists for ITS improvements and expansion. Also, regional agreements need to be made to establish interagency coordination, management strategies, roles and responsibilities, and cost sharing between jurisdictions.

4. Traffic congestion in Denver and along the Front Range is continually growing and must be managed. The region should expand usage of methodologies such as ramp-metering, employ traffic signal systems, transit signal priority, video monitoring, and courtesy patrol dispatch.

5. Non-recurring congestion from incidents and special events can be a major problem. Motorists don’t always know ahead of time to take an alternate route or which routes to use. More information sharing with event centers and incident management planners should occur. Information about travel advisories and closures, as well as traveler information in general, needs to be made easily accessible. Information needs to be centralized, real time and accurate.

6. Ongoing construction operations are disruptive to traffic in the metro area. Construction and maintenance information needs to be shared between jurisdictions so scheduling and coordination of activities, and cooperative purchasing synergies can be utilized to reduce impacts and costs.

7. There needs to be greater coordination between jurisdictions and service providers in maintenance and construction for weather data collection and distribution. Weather information sharing between CDOT, DIA and local jurisdictions which collect and monitor weather data can be used to improve maintenance operations, construction scheduling and traveler information.

8. Weather and crash related incidents on major freeway corridors cause major disruption to travel locally and region-wide. Independent incident management plans (IMP) have been developed for I-25, I-70, US 36, US 6, the I-25 Express Lanes, and the Northwest Parkway. There is a need for a unified plan for incident detection and response; utilizing existing IMPs, building on existing infrastructure in conjunction with processes prescribed by the Department of Homeland Security.
9. Homeland security issues have become a new concern for all ITS transportation systems. ITS infrastructure and systems must be protected from intrusion and made available to security officials.

10. Emergency Management planning efforts need to be coordinated with centralized planning. Communication infrastructure and protocols need to be standardized between jurisdictions.

11. It is very important to track commercial vehicle operations, safety, and transport security. Improved connectivity between CDOT CTMC, DOR Permitting, PrePass systems, Colorado State Patrol, Safety Inspectors and Ports-of-Entry is needed.

12. With planned expansion of the transit system in coming years, ITS planning for integration of the system with other travel modes will need to be done. Transit operations and information will need to be interconnected with traffic operations centers and information providers to enhance transit convenience and efficiency and maintain appeal to travelers.

13. Transit operations can be improved with the deployment of additional new ITS technology. Advanced Vehicle Location technology, Automatic Passenger Counting, passenger fare “smart cards”, parking management, security and surveillance technologies are currently available and needed to be implemented. Parking management will be used to implement automatic pricing, billing, and fee collection, with parking and reservations information provided to consumers via internet phone and wireless technologies.

C. ITS Transportation Service Areas

Based on analysis of the major needs in the Region, discussions with stakeholders, and review of other transportation and ITS plans, as mentioned earlier, nine ITS Transportation Service Areas have been identified to address regional issues and needs.

1. Regional Traveler Information – Regional traveler information involves a variety of systems that collect and process transportation data then distribute the information to the public. It includes such information as: traffic conditions, travel times, incident locations, construction closures, weather condition, transit operations, and alternative travel options (e.g. DRCOG’s RideArrangers). The regional vision is to consolidate access to all traveler information sources through CDOT’s traveler information system consisting of the 511 phone system and the CoTrip.org website. This information will also be available for redistribution through other means such as traveler information kiosks, personalized e-mail or text messaging, mobile access, third party traveler information, etc.

2. Regional Transportation Operations & Management – Regional transportation management provides coordinated transportation monitoring, response, and control functions. Regional partners will collect local data and control their local transportation systems while sharing the data through a display system that offers a regional view of traffic operations (e.g. website). This view will give transportation managers the opportunity to cooperate and respond quickly with management strategies that benefit regional travelers.

3. Regional Traffic Incident Management – Traffic incident management requires coordination between transportation managers as well as the cooperation of the public safety community. Currently, they have cooperated in the development and use of corridor-level incident management plans (IMPs), but one regional-level incident management plan is envisioned for the future. This plan will have the transportation managers using ITS devices to detect and verify incidents and will disseminate traveler information regarding the incident. Public safety personnel will be responsible for incident site management and incident clearance while coordinating with transportation managers.
4. **Transit Operations & Management** – Specific coordination between transit operations and other transportation managers is key to the regional traveler information and the regional transportation operations service areas above. ITS investment in transit operations is intended to improve the operational efficiency and public attractiveness of transit.

5. **Maintenance and Construction** – ITS activities will include: coordination in planning and notification for maintenance and construction activity; roadway maintenance systems that are supported by weather data collection; and, the capability to monitor ITS devices from remote locations, thus allowing quick and managed dispatch for repair.

6. **Regional Parking Management** – ITS parking management strategies include pricing mechanisms and the distribution of real-time information regarding the availability of parking. Parking facilities will be equipped to automatically track the parking availability. This information may also be tied to electronic parking fee collection systems, possibly integrated with systems used on regional toll highways.

7. **Regional Data Management** – ITS inherently collects a lot of data that may be useful to operators, traffic engineers, planners, and researchers. A regional network of data collection sites will be the source of transportation data to be archived in a central web-based data warehouse hosted by DRCOG.

8. **Regional Emergency Management** – Regional Emergency management includes security and evacuation to support Department of Homeland Security initiatives including the *National Response Framework* and the *National Infrastructure Protection Plan*. The public safety community leads these initiatives in this region; the transportation community offers support through traveler information and transportation operations.

9. **Commercial Vehicle Operations** – Activities may involve the implementation of additional ITS devices and systems to improve traveler information, operational safety, commercial vehicle monitoring and inspections and administration of commercial vehicle operations.

**D. Requirement to Develop Regional ITS Architecture**

The provisions of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) requires that ITS projects carried out using funds made available by the Highway Trust Fund be in conformance with the National ITS Architecture and Standards. CDOT, under federal guidelines, is one of the agencies with a responsibility to ensure this conformance for ITS projects within the State of Colorado. The Regional ITS Architecture resulting from this project will address the elements noted in the Federal Highway Administration published rule 23 CFR Part 940, (http://www.fhwa.dot.gov/legsregs/directives/fapg/cfr0940.htm) and the Federal Transit Administration’s parallel Policy.

The federal regulations require that a regional ITS architecture includes, at a minimum, the following eight elements:

1. A description of the region;
2. Identification of participating agencies and other stakeholders;
3. An operational concept that identifies the roles and responsibilities of participating agencies and stakeholders in the operation and implementation of the systems included in the regional ITS architecture;
The federal regulations also require that the Regional ITS Architecture also include procedures and responsibilities for maintaining the Regional ITS Architecture as needs evolve within the region.

The **ITS Architecture for the Denver Regional Area** [“the Architecture”] provides a framework for ensuring institutional agreement and technical integration for the implementation of the ITS projects as identified in the DRCOG Regional ITS Strategic Plan. The Regional ITS Architecture for the Denver Regional Area will be considered in the update of the Statewide ITS Architecture.

An Architecture database has been created with Turbo Architecture version 4.0. Turbo Architecture is a software tool that allows users to catalogue and organize project and/or regional architectures in a database format. The software also provides users with enhanced functionality in working with architecture stakeholders, elements, market packages, operational concepts, functional requirements, interfaces, standards and agreements. The software defines the architecture, relationships and interconnects between stakeholders and elements and gives the user the ability to access physical and logical diagrams at multiple levels. Use of the software will facilitate consistency, version control, maintenance and subsequent updating of the Regional Architecture. This document reflects the information contained in the Turbo Architecture database.

**E. Roles and Responsibilities**

The principle stakeholders in the Denver Regional Area and their primary responsibilities are described below:

**DRCOG** is the Metropolitan Planning Organization for the Denver Regional Area and is responsible for the preparation and maintenance of both the regional transportation plan and the regional ITS architecture. Also, DRCOG’s RideArrangers lead travel demand management programs with the goal of promoting and facilitating mobility options that reduce single-occupant vehicle travel. Specifically, RideArrangers promote and facilitate ridesharing, vanpooling, transit, bicycling, walking, alternative work schedules and telecommuting.

**CDOT ITS** Branch operates the Colorado Transportation Management Center (CTMC), which monitors urban area freeway traffic, performs incident detection, dispatches courtesy patrols on regional freeways and manages the statewide traveler information system. The CTMC also coordinates control and operations with local jurisdictions and acts as a surrogate information service provider by disseminating information provided to CDOT by the local jurisdictions.
the latter role, public information officers at CTMC provide coordination with the Media. CTMC staff also updates the CoTrip website, disseminate broadcast fax and email, update the 511 statewide traveler information telephone advisory system, and place messages on DMS and HAR as needed. Regionally, there is increasing video sharing between jurisdictions including the CTMC and other CDOT Regions and interconnectivity between the CTMC and some local jurisdiction TMCs. Since the CTMC is a 24-hour facility, the CTMC may also take on local control to monitor and control local TMC functions during off-hours, on weekends, or to assist local traffic control during special events or incidents.

The City and County of Denver (CCD), Lakewood, Douglas County and other stakeholders with TMC facilities: These local cities and counties operate traffic management centers in the Denver Regional Area which manage devices primarily on major arterials and surface streets in their respective jurisdictions. CCD TMC, the largest local TMC, gathers local road conditions from sensors and video and uses it for local traffic management. It also shares information with the CTMC. Most of the smaller TMC facilities manage some traffic signals, signal timing and video at signalized intersections.

The Regional Transportation District (RTD) operates the Transit Operations Center (RTD TOC), which manages the transit system in the service area. RTD provides transit traveler information via DMS at transit facilities, website and telephone systems. RTD’s vision also includes expanded security and transit traveler information at Park-n-Rides and transfer centers. Systems would also be expanded on vehicles which would be monitored and controlled by the Transit Operations Center and RTD Security.

CDOT Regions 1, 4 and 6 Traffic Operations are responsible for control of ramp meters and traffic signals on the state highway system within the region. In the event of an incident, traffic operations staff would make any needed adjustments to signal timing or meter operation. Region 6 also operates the HOV/HOT system on I-25/US36.

CDOT Regions 1, 4 and 6 Maintenance provides resources such as signs, cones and barricades, and heavy equipment as may be needed to clear incident or control traffic during an incident. This may also include signing and control for detours and alternate routes. CDOT Maintenance also provides, weather station monitoring and information feeds, and MDSS to schedule maintenance activities. In this effort, they may call upon county and local maintenance forces for additional resources. CDOT Maintenance is also responsible for clearing debris and restoring the roadway to operating conditions after the incident has been cleared.

Colorado State Patrol (CSP) and local law enforcement are responsible for traffic enforcement and accident investigation. They are also usually the first responders on site and therefore usually provide incident command for short duration events. They provide an initial assessment of the incident, take control of the scene, and initiate the appropriate incident management plans. They work closely with CDOT and local traffic operations to determine any necessary lanes closures and when to reopen lanes to traffic. This includes determining the need to establish detours and alternate routes.

Other Regional Stakeholders include local jurisdictions with smaller, or no TMC facilities, and other private entities in the Denver Regional Area with a variety of roles and responsibilities. Local cities and counties may own and operate a variety of traffic monitoring and safety equipment. Local government agencies also may have maintenance operations, transit systems, regulate trucking, public health and safety, emergency response, toll roads, parking and other
services. Private interest stakeholders operate trucking companies, railroads and special event centers.

F. **Strategic Project Application Implementation**

The ITS working group identified nine ITS Transportation Service Areas in which ITS can directly address the regional transportation problems. These Service Areas are listed in Figure ES-3 along with the proposed priority for project application implementation. Service Areas are listed as either Short-Term (0-5 years), Medium-Term (5-10 years) or Long-Term (greater than ten years).
### Regional Traveler Information

- Consolidate access to regional traveler information (include freeways, arterials, transit and transportation alternatives)
- Expand probe surveillance on freeways
- Implement pilot probe surveillance on arterials

### Regional Transportation Operations & Management

- Develop regional transportation operations display mechanism
- Context TMCs and public safety operations
- Develop regional operational strategies
- Coordinate signal operations on emphasis arterials
- Pilot Transit Signal Priority (TSP) projects
- Implement ramp meters as warranted
- Deploy speed monitoring as needed

### Regional Traffic Incident Management

- Develop a unified, regional incident management plan
- Expand incident detection and response on freeways
- Cities and counties explore incident detection for arterials
- Initiate improvements in communications and protocols with public safety community

### Transit Operations & Management

- Replace and/or upgrade automatic vehicle location (AVL) system
- Expand traveler information dissemination on buses and at bus stops
- Expand automated passenger counting deployment
- Expand transit security on buses and at transit facilities
- Expand advanced transit operations functions
- Pilot TSP projects

### Maintenance and Construction

- CDOT and Denver to expand use of MDSS
- CDOT and Denver to explore methods to coordinate separate systems
- Plan and deploy regional environmental sensor stations (weather stations, de-icing stations and other weather detection related equipment)
- Implement dynamic ride sharing website
- Expand participation in consolidated traveler information
- Expand network surveillance coverage on freeways
- Expand network surveillance on emphasis arterials
- Expand probe surveillance on arterials
- Deploy additional DMS of freeways and emphasis arterials

### Regional Parking Management

- Define data warehouse network and protocols
- Establish data mart at TMCs consistent with data warehouse network and protocols
- Coordinate with public safety community to identify critical infrastructure
- Support public safety community planning efforts for disaster operations, evacuation and recovery
- Implement parking information systems for RPD (as part of fee collection system)
- Implement parking information systems for Denver CBD event centers

### Regional Data Management

- Fulfill regional network for data collection
- Establish data warehouse
- Continue to support public safety community planning efforts for disaster operations, evacuation and recovery
- Link to transportation operations display to public safety dispatch
- Continue to support public safety community planning efforts for disaster operations, evacuation and recovery
- ITS deployment to support critical infrastructure protection functions

### Regional Emergency Management

- CDOT to coordinate with CDOT to improve traveler information functions at port-of-entry
- CDOR to coordinate with CDOT to improve traveler information functions at port-of-entry
- Work with PrePass to improve functionality of PrePass system
- Link PrePass system to CDOT Permitting
- Link CDOT Permitting to PrePass
- Improve driver credentialing and tracking

### Commercial Vehicle Operations

- Coordinate with public safety community to identify critical infrastructure
- Support public safety community planning efforts for disaster operations, evacuation and recovery
- Implement parking information systems for RPD (as part of fee collection system)
- Implement parking information systems for Denver CBD event centers
- Fulfill regional network for data collection
- Establish data warehouse
- Continue to support public safety community planning efforts for disaster operations, evacuation and recovery
- ITS deployment to support critical infrastructure protection functions
- CDOT to deploy roadside commercial vehicle safety detection systems

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**Figure ES – 3 ITS Transportation Service Area Project Application Summary**
I. Introduction

Intelligent Transportation Systems (ITS) consist of the application of computers, electronic sensors, communications, and data management for the purpose of effectively and efficiently managing the transportation system to improve transportation mobility, safety, and to provide timely and accurate information to travelers. An architecture is a formalized description of all the elements of a fully functioning intelligent transportation system, including which entities are responsible for the individual elements and how those entities and elements interface with each other.

In order to promote efficient investment across the nation in intelligent transportation systems, federal regulations were established that require that regions provide focused planning for the deployment of ITS in order to be eligible to receive federal funding:

A regional ITS architecture shall be developed to guide the development of ITS projects and programs and be consistent with ITS strategies and projects contained in applicable transportation plans. 23 CFR 940.9 (a)

The USDOT has prepared the National ITS Architecture (most current version is 6.0) as a guide for the development of regional architectures. The National ITS Architecture describes a high-level framework for developing regionally integrated transportation systems. The National ITS Architecture includes the systems to be deployed, the stakeholders involved, the roles and responsibilities of the stakeholders, and the relationships and information exchange requirements between the stakeholders in order to support integrated operations.

This regional architecture for the deployment of Intelligent Transportation Systems in the Denver Regional Area is based on the National ITS Architecture and describes the relationships between the ITS elements and the roles and responsibilities of local stakeholders. Turbo Architecture, version 4.0 is an interactive software program designed to facilitate the development of a project architecture or regional architecture and is based on the National ITS Architecture. The software was used to develop this update of the Denver Regional ITS Architecture.

The Denver Regional Intelligent Transportation Systems Architecture (DRCOG 2001) was initially developed by Denver’s metropolitan planning organization (MPO), the Denver Regional Council of Governments (DRCOG), in 2001 and is being updated by this document. The Regional Intelligent Transportation Systems Strategic Plan (DRCOG 2002) was updated concurrently with this document. It is updated on about a five-year basis to support DRCOG’s Metro Vision Regional Transportation Plan updates. DRCOG will maintain the Regional ITS Architecture more frequently through annual administrative updates to reflect regional ITS deployment and technical changes in the deployment of ITS elements.

The Denver Regional Intelligent Transportation Systems Strategic Plan was developed with extensive interaction with the Colorado Department of Transportation (CDOT), the Regional Transportation District (RTD), the Denver Regional Council of Governments, local governments, and other regional stakeholders. The Strategic Plan presents a regional vision and provides guidance for ITS deployment over the coming years. The ITS Architecture for the Denver Regional Area builds upon these efforts to define the technical and institutional relationships among transportation related agencies and to move towards integrating individual systems for a coordinated ITS deployment within the Denver Regional Area.
CDOT, in cooperation with DRCOG have done considerable work planning, implementing and operating ITS in Colorado. Within the Denver Regional Area, many local, regional and state agencies have been deploying Intelligent Transportation System (ITS) applications. Typically, in the past, these ITS deployments addressed the individual agency’s needs or problems and involved little or no interaction with other agencies.

The Revised Model Deployment Initiative (RMDI) initiated by the Colorado Department of Transportation in 1998, was the first effort within the region to start the integration of existing traveler information, communication networks, and traffic management systems. RMDI began the development of partnerships among multiple transportation system operating agencies in the region. DRCOG initiated efforts to develop a regional ITS plan in advance of the Transportation Expansion (T-REX) Project. Preparation of the ITS concept plan and project specifications for T-REX has helped integrate deployment of ITS applications among multiple state, regional and local agencies in the region. The deployment of ITS for T-REX included linking and integrating transportation management and information systems along the project corridor.

Since the Denver Regional Intelligent Transportation Systems Architecture (DRCOG 2001) and the Regional Intelligent Transportation Systems Strategic Plan (DRCOG 2002), regional stakeholders have continued to deploy ITS infrastructure statewide consisting of a fiber optic communications backbone, ITS devices and computer and network equipment necessary to operate the system. Some of the accomplishments include:

- **Colorado Transportation Management Center (CTMC) Relocation** – In late 2006, the CTMC, located within the Denver Regional Area, was relocated to Golden from its interim facility in Lakewood. The facility was expanded to include additional operator consoles, state-of-the-art network and computer center, and a media broadcasting room. The CTMC now has a state-of-art video wall that enables the operators to monitor the ITS infrastructure and quickly display camera images and other operational materials and maps to meet specific operational situations. All of the ITS Branch staff work at the CTMC. The facility remains a 24/7 operation. It is physically connected via fiber optics to TMC facilities state-wide and regionally.

- **Communication Infrastructure and C2C Connectivity** - Fiber optic communications were deployed on I-70 from Denver, west to Frisco. This provided connectivity to ITS field devices, lateral connections to local law enforcement in the corridor and center-to-center (C2C) connectivity between CTMC and the Eisenhower Johnson Tunnel TMC. Fiber optic communications were also deployed on I-25 from Denver south to Pueblo. This provided connectivity to ITS field devices and C2C connectivity between CTMC and the Colorado Springs TMC. C2C connectivity also exists between the CTMC, the Regions, and several local centers and the Office of Emergency Management’s Multi-Agency Coordination Center (MACC). The MACC offers the ability for state, federal, and local agencies to come together in a central location to coordinate the response to emergencies and disasters throughout the state.

CDOT has estimated that if the total amount of closures (related to truck traffic) incidents could be reduced by as little as 10 percent on I-70, closure time would decrease by as much as twelve hours per year, which results in a savings of approximately $ 9.6 million dollars.

There are more than 500,000 vehicles in the Front Range that have toll tag transponders.
- **Travel Time Application** - Real-time travel time information is now provided to travelers on the I-70 corridor from Golden to Vail. This has been received very favorably by the traveling public and with requests to expand the application to other corridors. CDOT plans on expanding the real-time travel time application on strategic freeway corridors in the Denver metropolitan area. In conjunction with this real-time travel time application, CDOT will be able to maximize on and use the existing infrastructure to enhance other services such as: improved incident and traffic management strategies. Related to this at the travel time system level, CDOT is developing an “alarm” feature that will notify operators regarding potential problems on the corridor so that they can evaluate the situation (using CCTV and other devices) and initiate appropriate measures more rapidly.

- **511 Statewide Implementation** - For more than 15 years CDOT has provided statewide traveler information via an automated phone system, which required callers to dial a ten-digit phone number from their specific calling area. However, in November 2006 CDOT ITS completed a statewide 511 implementation, as part of a national effort to consolidate multiple calling area numbers into the abbreviated one-point of contact number of 511. CDOT ITS worked with landline and wireless carriers to activate 511 statewide throughout their coverage areas. In addition, CDOT ITS implemented a call transfer feature to allow callers to access neighboring states' traveler information systems. In the near future, CDOT ITS intends to incorporate real-time travel times into the 511 statewide traveler information system. Longer term, access to other regional transportation related providers (RTD, other transit and municipal agencies, tourism, etc.) information will be available through 511 and voice recognition features will be incorporated into the 511 statewide traveler information system.

- **Traveler Information Website** – For more than 7 years CDOT has provided statewide traveler information via a website at [www.cotrip.org](http://www.cotrip.org). The website contains the latest information on road and weather conditions. In addition, it has real-time information as it relates to traffic cameras, electronic signs and weather stations. The website is getting increasingly popular each year. Similarly to the 511 system, more regional information is expected to be provided by, or linked to the website in the future.

- **Development of ITS Strategic Plans and Architectures** - CDOT ITS has worked with CDOT Regions 1, 2, 3, 4 and 5 to develop Regional ITS Strategic Plans and Architectures. The Plans/Architectures can be accessed at [www.cotrip.org/its/arch.html](http://www.cotrip.org/its/arch.html).

- **Statewide ITS Inventory and Maintenance Management System**, CDOT ITS Branch working with stakeholders developed the ITS Maintenance Management System (ITS MMS)
framework and a detailed system of functional requirements. As part of this, an inventory of ITS infrastructure and ITS device as-built plans are being compiled and are nearly complete. This complete ITS inventory will be available for CDOT ITS, the CDOT Regions and CDOT Division of Transportation Development (DTD) maintenance staff to perform maintenance activities using a work order based system. This will allow CDOT to track expenditures for labor, materials, equipment, warranties, device-life cycles, preventative maintenance protocols and cycles, device and system condition, state-wide and within the Region.

- **Statewide ITS Capital Replacement Program** – Over the years, the funding for maintenance and operations remained the same even as the ITS infrastructure increased substantially. CDOT ITS Branch working with stakeholders was successful in continually demonstrating a clear need for additional maintenance resources. Through such efforts, the Transportation Commission approved the continuance of the ITS Capital Replacement Program at about $4.0 million per year, which is currently programmed through FY09. About 24% of these funds have been allocated to the Denver Region between FY2004 and FY 2008.

- **Standards, Specification and Guidelines** – CDOT ITS has worked with numerous stakeholders to develop ITS device specific standards and specifications. Also, CDOT ITS developed Statewide ITS Implementation Guidelines to assist the Regions and local municipalities with ITS deployments.

- **TMC Operations Manuals** - CDOT ITS has been working with the four major TMCs statewide to develop Operations Manuals. The City and County of Denver is also preparing an operator’s manual. The purpose of the manuals is to document TMC procedures, protocols and practices, define step-by-step processes that the TMC employs in carrying out its daily functions, identify roles and responsibilities regarding TMC interoperability and remote operations of a TMC by another TMC and recommend training and cross-training activities. The Manuals will be completed by early 2008.

- **DRCOG Regional Intelligent Transportation Systems Pool Projects** – DRCOG has established this pool in the Transportation Improvement Program (TIP) to fund ITS projects which will implement the Denver Regional Intelligent Transportation Systems Strategic Plan. CDOT ITS will implement real-time travel time applications on: I-25, US 36, US 6, C-470, and on I-70. Infrastructure to support center-to-center connectivity is also being installed to connect Northglenn and Thornton to the CTMC. Denver, Broomfield and Westminster are installing CCTV within their jurisdictions. Finally, RTD is installing DMS at select park-n-Ride locations.

- **T-REX** - The T-REX project deployed over $20 million (over 200 permanent ITS devices and an additional 250 devices were deployed both on freeways and local agency arterials during the project to manage traffic during construction) of ITS infrastructure to support traffic management and incident management functions on I-25 and I-225 in the Denver Regional Area. Also, the project provided center-to-center connectivity between the CTMC and seven local (city and county) traffic operations centers. The project also installed CCTV cameras and supporting equipment in Aurora, Englewood, Littleton, Greenwood Village, Douglas County, and Arapahoe County.

- **I-25 Express Lanes** – The Colorado Tolling Enterprise completed the conversion of the HOV lanes to include high-occupancy toll lanes. The reversible lanes run from 20th Avenue in the south to just past US 36 in the north and up to Sheridan Boulevard along US 36. Electronic toll collection and changes in the operation of the facility were implemented. CDOT Region 6 is
ITS Architecture for Denver Regional Area

responsible for maintenance and operation of the facility and E-470 is responsible for toll collection and remittance of those tolls to CDOT.

- **Regional Traffic Agencies** – Several of the regional traffic agencies invested fund in ITS deployment. Denver installed several CCTV cameras and DMS while expanding the number of signals that are connected to the traffic signal system. Douglas County expanded their communications infrastructure, installed several CCTV cameras and upgraded their TMC facility.

- **Partnerships** – Through partnership agreements with both public and private entities, CDOT has deployed communication infrastructure along several key corridors. Public entities include Colorado Springs (Traffic & Municipal Water), Douglas County, Eastern School District, School of Mines, etc. CDOT is also considering working with private entities such as Xcel and other Utilities, etc.

### I.A. Purpose of the Regional ITS Architecture

A regional ITS architecture is a powerful tool for planning regional integration and coordination of ITS elements between jurisdictions and across different modes of transportation. The process of creating a regional ITS architecture often enhances regional planning by bringing together a wide array of agencies and stakeholders to discuss future transportation needs and how these needs might be met by ITS.

In January 2001, FHWA and FTA jointly published a rule/policy to implement section 5206(e) of the Transportation Equity Act for the 21st Century (TEA-21)\(^1\) (succeeded by SAFETEA-LU in 2005). It required that all ITS projects using federal funding must “conform” to the National ITS Architecture and ITS technical standards. The implementation of this requirement is found in Federal Highway Administration (FHWA) Rule\(^2\) and Federal Transit Administration (FTA) Policy\(^3\), which took effect on April 8, 2001. This requirement calls for the development of a Regional ITS Architecture to guide the development of ITS projects and programs and be consistent with ITS strategies and projects contained in applicable transportation plans. Regional ITS Architecture is defined as a regional framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects\(^4\).

Intelligent Transportation Systems (ITS) are interrelated systems of electronics, computers and communications that must work together to provide transportation services. Integration of these systems requires a framework to define how each subsystem relates to the other subsystems and to gain consensus from the stakeholders on the approaches to be taken regarding their particular systems. An ITS architecture defines the systems and the interconnections and information exchanges between these systems. A regional ITS architecture is a framework, specific to the region under consideration, for

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\(^1\) Transportation Equity Act for the 21st Century, Public Law 105-178, 112 Stat. 457, Section 5206(e)


ensuring institutional agreement and technical integration for the implementation of ITS projects in a that region.

Typically, a region contains multiple transportation agencies and jurisdictions. These may have both adjoining and overlapping geographies, but all of the agencies have a need to provide ITS solutions to transportation problems such as traffic congestion and safety hazards. These solutions should be provided using public funds in a responsible manner. The purpose of developing a regional ITS architecture is to foster regional integration so that planning and deployment can proceed in a coordinated and organized manner.

Regional integration allows for the coordination of activities and sharing of information among different transportation systems to efficiently and effectively operate. Regional integration also has a synergistic effect in that information from one system may be used by another system for another purpose, reducing the need for redundant systems. An example of this would be toll tags being used by a freeway management center as probe data to obtain speed information on freeway segments. A regional ITS architecture illustrates this integration and provides the basis for planning the evolution of existing systems and the definition of future systems that facilitate the integration over time.

This regional integration can only take place with the participation and cooperation of the organizations within a region. These stakeholders must work together to establish a regional ITS architecture that reflects a consensus view of the parties involved.

A regional ITS architecture’s most important goal is institutional integration; providing a framework within which regional stakeholders can address transportation issues together. As indicated earlier, a strategic plan is a road map for implementing a system of strategies over a period of time. It provides a starting point for bringing ITS projects and systems together into an integrated plan, and identifying transportation related needs that can be addressed by ITS applications within the context of a systematic approach. The DRCOG Regional ITS Strategic Plan, which has been a collaborative effort involving key transportation agencies, along with other stakeholders to develop a framework for deploying ITS. This framework addresses the institutional and operational elements required for effective, integral statewide and regional transportation systems.

**High-level Statewide ITS Goals**

The goals of ITS are primarily to maximize transportation system management thereby enhancing mobility and safety for transportation users. The *CDOT Statewide ITS Strategic Plan* identifies the following major goals for ITS which are also applicable to the Denver Regional Area.

**Improving mobility through maximizing the productivity of the transportation system** by using ITS to increase the throughput of passengers and vehicles on the transportation system. This will effectively increase the capacity of the existing transportation system. Regional stakeholders would use ITS to continuously manage and fine tune the operation of the transportation system in response to travel demand and in the event of incidents that interrupt their normal operations.

**Improving mobility through providing travel choices and increasing travel efficiency** through access to comprehensive, reliable, accurate, and timely traveler information. Travelers will be able to make informed decisions concerning their travel prior to and during travel. ITS will enable travelers and businesses to choose travel time, mode, and route more efficiently based on real time information regarding travel conditions. This will help spread the volume of travelers
among modes and over time, reduce the costs of doing business, and enhance the quality of life in the Region.

**Increasing safety for the traveling public** by enabling faster response to incidents and reducing incidents through active traffic and incident management. In addition, a secondary mobility benefit will be realized where Incident Management Plans have identified alternative routing that is used during incidents. Regional Stakeholders will use a combination of ITS technologies to enhance the safety of the traveling public, by monitoring system operations, planning and managing transportation affected by special events, and providing travel related weather advisory information.

**Enhancing intermodal connectivity and inter-jurisdictional coordination** by promoting and supporting seamless connectivity between multiple modes of transportation and regional ITS systems. It is envisioned that information will be managed as a resource that will enhance intermodal connectivity between services provided by public and private transportation providers.

Table 1 below highlights the principal benefits and corresponding performance measure metrics associated with the identified goal areas.

<table>
<thead>
<tr>
<th>Principal Benefits</th>
<th>Performance Measure Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximizing productivity of current</td>
<td>• Increase in vehicle and passenger throughput.</td>
</tr>
<tr>
<td>transportation system</td>
<td>• Reduction in total lost productivity due to incidents and</td>
</tr>
<tr>
<td></td>
<td>congestion.</td>
</tr>
<tr>
<td>Increasing travel efficiency</td>
<td>• Use of travel information to select travel mode and</td>
</tr>
<tr>
<td></td>
<td>reduce travel time and costs (through use of pre-trip and</td>
</tr>
<tr>
<td></td>
<td>en-route travel information).</td>
</tr>
<tr>
<td>Increasing safety</td>
<td>• Shorten incident response times.</td>
</tr>
<tr>
<td></td>
<td>• Reduction of secondary accidents due to incidents.</td>
</tr>
<tr>
<td>Enhancing inter-modal connectivity</td>
<td>• Promoting and supporting seamless connectivity</td>
</tr>
<tr>
<td></td>
<td>between multiple modes</td>
</tr>
</tbody>
</table>

**I.B. Plan Update Process**

The previous DRCOG ITS Architecture was completed in December 2001. It was developed within the context of the National ITS Architecture (Version 3.0) as a framework. Since that Architecture was developed, there has been significant deployment of ITS infrastructure in the region and the National ITS Architecture has been advanced to Version 6.0. The advanced version of the National ITS Architecture includes a number of new ITS tools and services that had not previously been considered as elements to address regional transportation issues. As discussed previously, local, state, and regional agencies have been implementing and operating ITS applications for nearly two decades. The Architecture provides a framework through which these numerous stakeholders can achieve cooperative, coordinated, interoperable systems deployed region-wide to provide maximum public benefit for dollars spent.
Stakeholder Participation Process

As part of the update process, a series of stakeholder workshops was conducted in Denver by the DRCOG from May 2007 to September 2007 at the DRCOG offices at 4500 Cherry Creek Drive in Denver. The ITS Working Group consisted of regional stakeholders (see appendix for list of stakeholders), which was assembled for the initial development of the Denver Regional Intelligent Transportation Systems Architecture (DRCOG 2001), reconvened as a technical resource to assist in the update of the new Architecture. Membership of the working group included representatives from the Colorado Department of Transportation’s (CDOT) ITS Branch and from all three CDOT regions serving the DRCOG area, from the Regional Transportation District (RTD)—the region’s public transit agency, and several local governments that have deployed and are operating ITS equipment. Local government membership was self-selecting; invitations to technical staff were issued at several opportunities, and ALL interested persons were placed on the working group notification list. Federal Highway Administration (FHWA) staff also participated as a member of the working group. Members of the working group provided updated ITS inventory information, and assisted in all steps of the update process.

At the first Regional ITS Strategic Plan and Architecture Update Stakeholder Workshop meeting on May 9, 2007, regional strategic vision and goals were discussed along with market packages and operational concepts. The workshop addressed four major topics:

- A review of the existing ITS inventory;
- A review of existing problems on the transportation network that may benefit by implementing ITS;
- A review of ITS applications that may be applied to problems on the network; and,
- A definition of an ITS deployment vision and strategies.

Following the initial workshop, a series of eight workshops were conducted to focus on the development of operational concepts for specific transportation service areas that related to specific transportation network problems. Roles and responsibilities were defined for implementation, operation, maintenance and management functions on each topic, for each stakeholder. One break-out session was conducted for each transportation service area topic. Only stakeholders with a particular interest in the meeting topic were requested to attend the breakout meetings. The meetings covered the following transportation service areas:

- Regional Traveler Information
- Regional Transportation Operations & Management
- Regional Traffic Incident Management System
- Transit Operations and Management
- Maintenance and Construction
- Regional Data and Parking Management
- Regional Emergency Management
- Commercial Vehicle Operations

The Regional Data and Parking Management service areas were discussed at the same meeting session as they are related topics and require the same stakeholder participants (they are discussed in the remainder of this document as separate Service Areas however). The Architecture update process is illustrated in Figure 1.
Figure 1 - Regional ITS Architecture Update Flow Chart
I.C.  Related Planning Efforts

As indicated earlier, a number of previous related planning efforts have been undertaken which have looked into transportation issues in the Regional area and state-wide. These reports were reviewed as part of the update process to determine previously identified transportation problems and to identify ITS initiatives that have been recommended during other planning efforts.

The following related planning documents were referenced as a resource for this report:

- *Denver Regional Intelligent Transportation Systems Architecture, DRCOG 2001* – This document was used as the basis for the update to the Regional ITS Architecture.
- *Regional Intelligent Transportation Systems Strategic Plan, DRCOG 2002* – This document is the companion document to the Regional ITS Architecture; both documents were updated concurrently.
- *2030 Metro Vision Regional Transportation Plan, DRCOG 2005* - A regional transportation plan which outlines needed transportation system improvements and denotes improvements that can be reasonably expected in the region over the next 25 years.
- *2030 Statewide Transportation Plan, Moving Colorado – Vision for the Future, CDOT 2004* - This plan combines Colorado Transportation Commission policy and direction drawn from the state’s 15 Transportation Planning Regions (TPRs).
- *Statewide Intelligent Transportation Systems Strategic Plan, CDOT 2002* - A statewide strategic plan to provide guidance and direction for current and future ITS investment.
- *2035 Statewide Transportation Plan, Intelligent Transportation System (ITS) Technical Report, CDOT 2007* - This document provides a technical supplement regarding the role of ITS in the statewide transportation plan.

I.D.  Conformance with the National ITS Architecture

In 1997, the Federal Highway Administration (FHWA) began preparing a National ITS Architecture and Standards in an effort to guide standardized development and deployment of ITS across America. The architecture established a framework to facilitate the regional deployment of ITS projects, while the standards help ensure the compatibility and maintainability of the deployed technologies.

On April 8, 2001, the FHWA established a Final Rule (the Rule) on the National ITS Architecture. The purpose of this rule was to foster integration between existing regional ITS and to ensure that subsequent deployments will be integrated into the existing systems. The Rule established that jurisdictions intending to deploy ITS projects and who wish to seek funding from the Highway Trust Fund must conform to the National ITS Architecture and appropriate standards.

The Rule requires that regions, which are already deploying ITS projects, must prepare a Regional ITS Architecture – a specific framework for ITS deployment tailored to the region from the National ITS Architecture. The Rule has also established April 8, 2005, as the deadline for such regions to have their Regional ITS Architecture prepared.

The purpose of this project was to develop a Regional ITS Architecture and an ITS Strategic Plan to guide the deployment of ITS applications in the Project Area over the next twenty years. These documents were developed in conformance with the National ITS Architecture Version 6.0.
I.E. Requirement to Develop Regional ITS Architecture

The provisions of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) requires that ITS projects carried out using funds made available by the Highway Trust Fund be in conformance with the National ITS Architecture and Standards. CDOT, under federal guidelines, is one of the agencies with a responsibility to ensure this conformance for ITS projects within the State of Colorado. This Regional ITS Architecture addresses the elements noted in the Federal Highway Administration published rule 23 CFR Part 940, and the Federal Transit Administration’s parallel Policy.

The federal regulations require that a regional ITS architecture includes, at a minimum, the following eight elements:

1. A description of the region;
2. Identification of participating agencies and other stakeholders;
3. An operational concept that identifies the roles and responsibilities of participating agencies and stakeholders in the operation and implementation of the systems included in the regional ITS architecture;
4. Any agreements (existing or new) required for operations, including at a minimum those affecting ITS project interoperability, utilization of ITS related standards, and the operation of the projects identified in the regional ITS architecture;
5. System functional requirements;
6. Interface requirements and information exchanges with planned and existing systems and subsystems (for example, subsystems and architecture flows as defined in the National ITS Architecture);
7. Identification of ITS standards supporting regional and national interoperability; and
8. The sequence of projects required for implementation.

The published rule also requires that the Regional ITS Architecture also include procedures and responsibilities for maintaining the Regional ITS Architecture as needs evolve within the region.

The Regional ITS Architecture for the Denver Regional Area provides a framework for ensuring institutional agreement and technical integration for the implementation of the ITS projects as identified in the DRCOG Regional ITS Strategic Plan. The Regional ITS Architecture will be considered in the update of the Statewide ITS Architecture.

An Architecture database has been created with Turbo Architecture version 4.0. Turbo Architecture is a software tool that allows users to catalogue and organize project and/or regional architectures in a database format. The software also provides users with enhanced functionality in working with architecture stakeholders, elements, market packages, operational concepts, functional requirements, interfaces, standards and agreements. The software defines the architecture, relationships and interconnects between stakeholders and elements and gives the user the ability to access physical and logical diagrams at multiple levels. Use of the software will facilitate consistency, version control, maintenance and subsequent updating of the Regional Architecture.
I.F. Overview of Physical Architecture

The Physical Architecture is a framework of physical elements of ITS systems; these elements include cars, people, computers, buses, trucks, etc. Figure 2 shows the National ITS Architecture Subsystems and 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).

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.

![Figure 2 - National ITS Architecture Subsystem Diagram](image-url)
I.G. The Systems Engineering Approach

The DRCOG ITS Strategic Plan provides a guide for ITS deployment in the Denver Regional Area over the next 20 years. Although there is currently no regulatory planning requirement to develop an ITS Strategic Plan, federal ITS rules and regulations call for the incorporation of ITS Architecture development and ITS project programming into the existing planning process in the region.

In order to meet the requirements to receive federal funding, an ITS project must demonstrate that a systems engineering analysis was performed during the design of the project. The systems engineering analysis process includes the following seven elements that must to be addressed to ensure a project conforms to the federal ITS requirements:

1. Description of how project fits into the Regional ITS Architecture
2. Roles and responsibilities of participating agencies
3. Requirements definition
4. Analysis of alternative system configurations and technology options
5. Procurement options
6. Applicable ITS standards and testing procedures
7. Procedures and resources necessary for operations and management of the system

CDOT and DRCOG are developing Systems Engineering Analysis (SEA) Guidelines that will describe the method of demonstrating compliance with the federal ITS requirements. The requirement for SEA only applies to those ITS projects that have federal funding, however CDOT and DRCOG believe that there is value in requiring all ITS projects to use the SEA in order to ensure architectural consistency and integrity. In lieu of the SEA Guidelines, and until they are finalized, a common approach to ensuring SEA compliance is to have the project sponsor “self-certify” that they will comply with the ITS requirements. In this way, the project sponsor is taking responsibility for meeting the federal ITS requirements for their project. An official that could commit the organization to compliance (i.e., Public Works Director, Transportation Director) would be required to authorize the certification. The self-certification would take place at two points in the project development cycle:

Planning: At the planning level, the project sponsor would provide a short description of how their ITS project would fit into the Regional ITS Architecture and agree to conduct a systems engineering analysis for the project during the design phase. If the project were not currently addressed in the Regional ITS Architecture, it would be addressed as an incremental change as described in the Architecture Maintenance Process.

Design (Prior to Construction): Many of the details about the ITS elements of a project are developed in greater detail during the design phase. Providing in-depth details about the project’s compliance with the new federal ITS requirements is most appropriate during the design phase, prior to construction. The project sponsor would, again, “self-certify” that the systems engineering analysis was completed and provide information on the final project ITS Architecture and its relationship with the Regional ITS Architecture for the purpose of maintaining the Regional ITS Architecture. FHWA or FTA may independently request additional documentation on the systems engineering analysis before funds are released for construction.
I.H. Organization of this Report

Following this introduction, Section I, this report consists of nine sections as follows:

Section II – Description of the Denver Regional Area: This section provides a description of the geography and demographics of the Denver Regional Area along with a description of the transportation system, the current state of ITS services, infrastructure and transportation issues and needs. Transportation issues and needs as related to ITS were identified through planning studies, particularly the regional transportation plans, and through stakeholder input.

Section III – Market Package Plan: Presents the rationale as to which of the user services and market packages in the National ITS Architecture appropriately address the issues and needs of the region.

Section IV – Operational Concept: This section provides a scenario-based approach to identifying the roles and responsibilities of major stakeholders as well as key interconnections and information flows.

Section V – Agreements: This section discusses existing agreements between stakeholders and which agreements still need to be done to further ITS services and coordination and cooperation in the Region.

Section VI – Functional Requirements: Functional requirements identify the tasks or activities that are, or will be, performed by each system or subsystem in the region.

Section VII – Interface Requirements: Information exchanges and architecture flows with planned and existing systems and subsystems.

Section VIII – ITS Standards: A discussion of Region specific ITS standards to regulate and govern ITS technology implementation to support project areas.

Section IX – Strategic Project Application Implementation: This section identifies the projects and time horizons proposed for ITS technologies to be deployed to implement the ITS goals.

Section X – Architecture Maintenance Process: This section describes the process and responsibilities for maintenance of the architecture database and report.
II. Description of the Denver Regional Area

This Regional ITS Architecture update is for the Greater Denver Transportation Planning Region (TPR), which includes the following nine counties: Adams, Arapahoe, Boulder, Clear Creek, Broomfield (county), Denver (county), Douglas, Gilpin, and Jefferson (see Figure 3). The Denver Regional Area also includes over 50 towns and cities within these nine counties. The Denver Regional Area also contains all of CDOT Region 6 and portions of CDOT Regions 1 and 4.

Figure 3 – Greater Denver Regional Transportation Planning Area

ITS Working Group

An ITS Working Group was established in 2001 that consists of the regional ITS stakeholders. Participants on the working group included representatives from the Colorado Department of Transportation’s (CDOT) ITS Branch and from the three CDOT regions serving the DRCOG area, from the Regional Transportation District (RTD)—the region’s public transit agency, and several local governments that have deployed and are operating ITS equipment. All interested persons were placed on the working group notification list. Federal Highway Administration (FHWA) staff also participated as a member of the working group. See Appendix A for a list of the regional stakeholders; or members of the working group.
II.A. Geography of the Region

The region is highly urbanized along the I-25 corridor through the Denver Metropolitan Area, which includes the surrounding suburbs. There are smaller communities and rural areas outside the metro area between Denver and Fort Collins to the north, and Colorado Springs the south. The Region extends west into the foothills of the mountains in Jefferson, Clear Creek and Gilpin Counties and East into the flat agricultural areas of the plains in Adams and Arapahoe Counties (see Figure 4). The Region is the largest urbanized area in Colorado with approximately 2.75 million people. The largest cities within the Region are Denver, Aurora, Lakewood, Thornton and Westminster with Denver being the largest; having about one-half million people (see Table 2). Figure 5 illustrates the regional roadway systems.

Table 2 – Approximate Population of the Ten Largest Cities in the Denver Regional Area

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denver City and County</td>
<td>570,000</td>
</tr>
<tr>
<td>Aurora</td>
<td>300,000</td>
</tr>
<tr>
<td>Lakewood</td>
<td>145,000</td>
</tr>
<tr>
<td>Thornton</td>
<td>105,000</td>
</tr>
<tr>
<td>Westminster</td>
<td>105,000</td>
</tr>
<tr>
<td>Arvada</td>
<td>105,000</td>
</tr>
<tr>
<td>Centennial</td>
<td>100,000</td>
</tr>
<tr>
<td>Boulder</td>
<td>95,000</td>
</tr>
<tr>
<td>Longmont</td>
<td>80,000</td>
</tr>
<tr>
<td>Broomfield</td>
<td>45,000</td>
</tr>
</tbody>
</table>

Source: Dept of Local Affairs, Demography Office - 2005
Figure 4 – Municipalities in the Greater Denver Geographic Region
II.B. Transportation

Highways
Principal highways in this Project Area include Interstate Highways: I-25, I-76 and I-70, with regional bypass and connector highways: I-270, I-225, C-470 and toll roads E-470 and the Northwest Parkway. US Highway 36 between Denver and Boulder, US Highway 6 west of Denver and US Highway 85 are major Regional US Highways. The area also includes major interstate routes including US 287 from Wyoming to Oklahoma, which has been designated as the Ports-to-Plains corridor, providing a major connection to I-27 in West Texas, and US 285 which heads west and south from Denver through Alamosa to New Mexico. For more specifics on highway locations see the following Figure 5.
Figure 5 – Denver Regional Area Roadway Systems
Approximate Average Daily Traffic (ADT) which is the average number of vehicles per day, from recent traffic counts on major highways across the Denver Regional Area are listed in Table 3 and Table 4 below:

**Table 3 – Denver Regional Area Average Daily Traffic: East - West Highways (2006)**

<table>
<thead>
<tr>
<th>E-W Corridors</th>
<th>Average Vehicles-Per-Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-70</td>
<td>60,000 – 170,000</td>
</tr>
<tr>
<td>US 6</td>
<td>60,000 – 125,000</td>
</tr>
<tr>
<td>US 40</td>
<td>10,000 - 50,000</td>
</tr>
<tr>
<td>US 285</td>
<td>22,000 – 75,000</td>
</tr>
<tr>
<td>C-470 (SH 121 to I-25)</td>
<td>105,000</td>
</tr>
<tr>
<td>NW Pkwy (toll)</td>
<td>15,000</td>
</tr>
<tr>
<td>Arapahoe Road (SH88)</td>
<td>38,000</td>
</tr>
<tr>
<td>Arapahoe Ave.(CR7)</td>
<td>40,000</td>
</tr>
</tbody>
</table>

Source: CDOT DTD

**Table 4 – Denver Regional Area Average Daily Traffic: North-South Highways (2006)**

<table>
<thead>
<tr>
<th>N-S Corridors</th>
<th>Average Vehicles-Per-Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-25</td>
<td>90,000 -245,000</td>
</tr>
<tr>
<td>US 287</td>
<td>30,000 – 45,000</td>
</tr>
<tr>
<td>US 36</td>
<td>70,000 – 120,000</td>
</tr>
<tr>
<td>E-470 (toll)</td>
<td>15,000 – 36,000</td>
</tr>
<tr>
<td>I-76</td>
<td>50,000 – 76,000</td>
</tr>
<tr>
<td>I-270</td>
<td>50,000 – 75,000</td>
</tr>
<tr>
<td>I-225</td>
<td>100,000 – 128,000</td>
</tr>
<tr>
<td>Colorado Blvd</td>
<td>60,000</td>
</tr>
<tr>
<td>Parker Road (SH83)</td>
<td>76,000</td>
</tr>
<tr>
<td>Federal Blvd.</td>
<td>40,000</td>
</tr>
<tr>
<td>Wadsworth Blvd.</td>
<td>25,000 – 55,000</td>
</tr>
<tr>
<td>Foothills Pkwy./119</td>
<td>45,000</td>
</tr>
</tbody>
</table>

Source: CDOT DTD
It should be noted that I-70 is substantially different in character on the western side of the Denver Regional Area. It travels through mountainous terrain west of the Denver area and is the major access route to ski areas in Clear Creek County and Summit County and other western recreational areas. As such it has high recreational traffic use on weekends through much of the year. Even so, ADT, ranges from 30,000 to 70,000 vehicles, depending on distance west of Denver. East of Denver, I-70 passes through the primarily rural and agricultural areas of the eastern plains with an ADT of about 25,000 vehicles. I-25 is a major north-south interstate highway that connects major Colorado cities along the Front Range including Pueblo and Colorado Springs, south of Denver, and Fort Collins to the north. It extends from New Mexico through the state to Wyoming. Outside the Denver Regional Area, I-25 traffic volumes drop to less than half of what it carries through central Denver.

As the regional population has grown, so has traffic. Not only have traffic volumes increased, but trip lengths (per capita Vehicle Miles Traveled - VMT) have increased as well, due in part to growth in outlying communities. As a result many major highways experience severe traffic congestion, especially near the major employment and activity centers (see Figure 6).
Figure 6 – Key Congested Locations
Transit
The primary provider of public transit within the Denver - Boulder area is the Regional Transportation District (RTD). The Regional Transportation District was created in 1969 and serves all or parts of Denver, Broomfield, Boulder, Jefferson, Adams Arapahoe and Douglas Counties which are within the District’s area. RTD operates and maintains or leases over one thousand ADA compliant busses serving over ten thousand bus stops and stations with 174 regular fixed routes. RTD also operates special handicap accessible, call for pickup, special event, and special destination bus line services.

Additionally, RTD operates a light rail transit system with 6 different lines on four corridors. RTD originally built the 5.3 mile long Central Corridor Light Rail Line in 1994 which runs from Denver’s Five Points District through Central Downtown to Broadway at I-25. In 2000, the Southwest line was constructed from the I-25/ Broadway Station south along Santa Fe Drive to Mineral Avenue. The Central Platte Valley Line spur was added in 2002; which connects to Union Station. As part of the Transportation Expansion (T-REX) project (from 1999 to 2006), which widened I-25 through Denver, the Southeast transit line was constructed and opened in 2006. It connects the I-25/Broadway Station southeast along I-25 to Lincoln Avenue in Douglas County with a spur from I-25 along I-225 to Parker Road. As part of this project, light rail stations were constructed and Park-n-Ride locations were added or expanded. Automated fare collection systems, variable message signs and public enunciator systems were installed at the stations.

RTD will be expanding light rail and transit coverage in the Regional Area under the FasTracks project. The Gold Line, North Metro, Northwest Rail, West, East and I-225 Corridors are scheduled to be added to the light rail system by 2015 (see Figure 7). The Central, Southeast and Southwest Lines are scheduled to be extended, and the US 36 Bus Rapid Transit (BRT) Corridor added in two phases through 2016. The project also plans to renovate the existing Union Station in Downtown Denver into a new Transit hub, add parking system-wide and expand bus service regionally. Information about the project can be found at www.rtd-fastracks.com.

City of Boulder Transportation (GO Boulder) operates the Community Transit Network in partnership with RTD and Boulder County. Boulder County also partners with private operators and non profit organizations to promote the county wide Special Transit. These systems operate several local routes serving in and around Boulder.
Figure 7 – RTD FasTracks System Map
The City of Colorado Springs is providing a regional bus service to Denver called FREX (Front Range Express) with stops in Fountain, Colorado Springs, Monument, Castle Rock and Denver (3 stops). The service is targeted at inter-regional commuters and offers a relatively low cost fare ranging from $2.00 to $6.00 for a one-way fare. FREX offers a variety of pre-pay options and schedule information through its website with links to other regional transportation providers (http://www.frontrangeexpress.com).

The Denver Regional Council of Governments discusses other regional transit providers in the Transit Element section of the Regional Transportation Plan (RTP). The plan is available through the DRCOG website at http://www.drcog.org/documents/2030TransitElementFinal.pdf. The report provides a more comprehensive discussion of regional transit providers, their inventories and short and long term service needs and goals.

Aviation

Several General and Overflow Aviation airport facilities, and one major commercial service airport exist within the Region. The region's airports sustain a significant portion of the area economy and include the following airports: Denver International, Boulder, Centennial, Erie, Tri-County, Front Range, Rocky Mountain Metro (Jefferson County), Front Range and Vance Brand. These airports contribute to the area’s mobility and provide access to services, as well as help support economic activity. General Aviation services include fixed base operators, flight instruction, fueling, aircraft repair and maintenance, air taxi/charter, corporate flight departments, airport maintenance and administration, and other services. The Denver International Airport is located in Denver County and is the busiest (commercial) airport in the state. It is also the fourth busiest airport in the United States. In 2006, DIA reported serving 47.3 million passengers with 1,670 daily flights. In addition, one military aviation facility is located in the Denver Regional Area at Buckley Air Force Base in Aurora (Arapahoe County) Colorado.

Rail

Numerous rail facilities exist throughout the Denver Regional Area. The most represented railroad companies in the Regional area are the Burlington-Northern/Santa Fe Railway Company (BNSF) and the Union-Pacific Railroad (UP). Both companies own and operate major rail lines and facilities in the Denver Region. There are several major freight yards and intermodal facilities operated or owned by these companies in Denver. UP operates the North and Burnham Yards, the 36th Street Yard, and the 40th Street Intermodal facility. BNSF operates the 31st Street Yard and a Trailer on Flat Car (TOFC) intermodal facility. RTD and CDOT are currently studying which rail technologies will be used in the expansion of the commuter rail system in the Region and whether or not there will be a need to relocate some of these heavy rail facilities to other locations in conjunction with the FasTracks expansion. RTD’s light rail system currently shares ROW with heavy rail tracks along Santa Fe Drive from central Denver to Mineral Avenue, which includes the Central Platte Valley line and Southwest light rail line. Future RTD commuter rail corridors built under FasTracks may share ROW or track facilities in heavy rail corridors depending, among other things, on the technologies finally determined to be best suited for these lines.


II.C. **Existing ITS Services and Infrastructure**

**ITS Services**
The following section describes the ITS services and infrastructure that currently exist in the Denver Regional Area. The service areas identified are grouped in the National ITS Architecture User Service Areas.

**Traveler Information**
The CDOT ITS Branch has implemented the Colorado Transportation Management System (CTMS), a statewide transportation management and traveler information system. The CTMS is a multi-year program to expand, enhance and augment deployment and integration of the state’s transportation information systems. The CDOT ITS Branch also operates the CTMC, which is primarily responsible for statewide traveler information collection and dissemination functions. This information is collected from CCTVs, vehicle probes, roadway vehicle detectors, and weather stations located within the state. It is supplemented with information from other sources such as the CDOT Regions, Colorado State Patrol (CSP), National Weather Service, Data Transmission Network (DTN) Weather Services, and ports of entry. The information is disseminated using the website www.cotrip.org, DMS, Highway Advisory Radio (HAR), and broadcast fax capability. The Interactive Voice Response (511) statewide traveler information system disseminates information about statewide road conditions and scheduled maintenance/construction activities. RTD also operates a public information website www.rtd-denver.com which gives route and schedule information for bus, light rail, call-n-Ride and special event transportation services. RTD also operates some DMS signs and public address systems at light rail Park-n-Ride stations. Some local jurisdictions currently share information with the public directly and also with the CTMC which is subsequently disseminated using CDOT facilities. Denver uses DMS and HAR to distribute traveler information on their arterials. Lakewood is installing DMS on their arterials near US 6 to provide traveler information regarding roadway closures. The E-470 and Northwest Parkway Public Highway Authorities also offer some transportation information capabilities through website, phone and DMS. DRCOG provides access to the travel demand management alternatives through their website with connections to the websites of the transportation management organizations.

**Freeway Management**
Three CDOT Regions operate within the Denver Regional Area. Both CDOT Region 1 and Region 4 primarily operate surface street traffic signals, however Region 1 also operates several ramp meters on I-70 west and Region 4 also operates several ramp meters on US 36. CDOT Region 6 operates the majority of the ramp meters with a recently upgraded computerized traffic signal system to allow central control and monitoring. Region 6 also operates DMS and access gates within the HOV/HOT lanes.

**Arterial Management**
Twenty-eight cities and counties in the Denver Regional Area operate traffic signals using a computerized traffic signal system. The DRCOG Traffic Operations Program is enabling the implementation of arterial corridor management strategies across jurisdictional boundaries. The City and County of Denver, Englewood, Littleton, Lakewood, CDOT ITS (CTMC), CDOT Region 6 and RTD have dedicated Advanced TMCs with capabilities to better coordinate traffic signal operations and monitor traffic conditions with CCTV cameras and roadway traffic surveillance equipment. A few other agencies have smaller more basic functioning TMCs that are primarily shared use or office cubicle type facilities. These facilities are multi-use office spaces and are not dedicated solely to house and operate traffic signal systems. Aurora, Arapahoe
County, Boulder, Commerce City, Douglas County, Greenwood Village, Longmont, CDOT Region 1, CDOT Region 4 and Westminster are jurisdictions with this type of facility. A definition of the level of TMC functionality and associated ITS elements likely to be linked to it are summarized in the following (Table 5). Region 6 upgraded computerized traffic signal system is used to control and coordinate traffic signals on surface streets and ramps. None of the three regions currently operate a dedicated Transportation Management Center (TMC). However, Regions 1 and 6 have some degree of central control (i.e. computer-servers/workstations) which primarily operates computerized traffic signal systems.

**Table 5 – Transportation Management Center Functionality**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description/Functions</th>
<th>Architecture Subsystems</th>
<th>Current Jurisdictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>No ITS</td>
<td>• No signal system&lt;br&gt;• No other ITS functions</td>
<td>• None</td>
<td>Clear Creek County, Gilpin County, Brighton, Centennial, Edgewater, Federal Heights, Glendale, Golden, Lonetree, Sheridan</td>
</tr>
<tr>
<td>Base-Level Traffic Signal Operations</td>
<td>• Base-level signal system operations&lt;br&gt;• No real-time traffic conditions data available¹&lt;br&gt;• No other ITS functions</td>
<td>• Roadway Subsystem (all traffic signal equipment as well as any interconnect infrastructure)</td>
<td>Adams County, Boulder County, Broomfield, Jefferson County, Arvada, Boulder, Castle Rock, Lafayette, Louisville, Northglenn, Parker, Superior, Thornton, Wheat Ridge</td>
</tr>
<tr>
<td>TMC</td>
<td>• Base-level signal system operations&lt;br&gt;• Real-time traffic conditions data available²&lt;br&gt;• May have center-to-center connection to another TMC&lt;br&gt;• No Other ITS functions * (i.e. CCTV, DMS, ramp meters, etc.)</td>
<td>• Traffic Management Center&lt;br&gt;• Roadway Subsystem (all ITS field devices and communications infrastructure)</td>
<td>Arapahoe County, Aurora, Commerce City*, Greenwood Village, Longmont, Westminster, CDOT R4</td>
</tr>
</tbody>
</table>
 ITS Architecture for Denver Regional Area

### Advanced TMC

- Base-level signal system operations
- Real-time traffic conditions data available
- Has center-to-center connection to another TMC
- Other ITS functions (i.e. CCTV, DMS, ramp meters, etc.)

<table>
<thead>
<tr>
<th>Traffic Management Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Subsystem (all ITS field devices and communications infrastructure)</td>
</tr>
</tbody>
</table>

| Denver , Douglas County , Englewood, Lakewood , Littleton, CDOT R1, CDOT R6, CDOT ITS (CTMC) , RTD (TOC) |

- Real-time traffic conditions data includes volume, occupancy and/or speed data collected by system detectors. Data collected in support of regular traffic operations (i.e. queue detection and stop bar calls) is not included.
- If a jurisdiction does not have a traffic signal system and or is not collecting real-time traffic condition, but has deployed other ITS functions that are controlled remotely, the remote location would be considered a TMC.
- These are Dedicated TMCs (or TOC), which are purpose-built facilities dedicated to the monitoring and management of that jurisdiction’s transportation system.

In the future, the CTMC may become a regional management/operations center for the purpose of operating other TMC facilities and infrastructure outside of their normal business hours. This would most likely require that the local TMCs share in providing resources in order to accommodate this additional functionality at the CTMC. Center-to-Center (C2C) communications exist between most of the TMCs currently, with extensions to C2C communications to Boulder, Northglenn and Thornton currently under construction.

### Incident Management

Within the region, incident management plans have been developed for specific freeway segments and plans for coordinated response to incidents. The plans require technology component that provides for the near real-time sharing of incident information and transportation system condition information between traffic and emergency management agencies to enable quicker detection and verification of incidents and implementation of a coordinated and efficient response. In some cases, traffic signal timing plans have also been developed for specific incident scenarios.

### Public Transportation Management

The Regional Transportation District (RTD) is the primary transit agency in the Denver Regional Area and is leading the deployment of transit-related ITS programs. RTD currently operates separate Transit Operations Centers to manage control of bus and light rail operations. Transit security is also separate but is connected to the operations centers. RTD is currently using a number of ITS technologies and management strategies including: automatic vehicle location (AVL), route scheduling, information kiosks, vehicle maintenance monitoring and transit signal priority. Additionally, RTD is considering the implementation of an automated parking management and pricing system which will manage parking fee collection and implement regional pricing strategies.

RTD is also coordinating with the City of Boulder and Boulder County to improve the AVL systems on local transit facilities and transit traveler information systems. The Boulder transit system currently has some DMS and AVL systems in use and is planning to develop an Automated Transit Information System (ATIS) for Boulder’s HOP route using NextBus.
technology. The HOP ATIS project will utilize GPS and AVL technology to provide real-time automated annunciated and visually displayed stop announcements. Both Boulder and RTD plan to install Automatic Passenger Counters (APC) and security cameras.

The Black Hawk and Central City Tramway is a free public bus system which serves the Towns of Blackhawk and Central City in Gilpin County, Colorado. Each vehicle is fitted with NextBus AVL satellite tracking. Sixteen BH & CC Tramway stops are equipped with NextBus technology providing real-time bus arrival information. The information is also made available via the internet (http://www.nextbus.com). Short range transit needs of the BH & CC Tramway system are to: “improve security and increase use of surveillance”.

DRCOG’s RideArrangers, the Transportation Management Organizations and partner agencies conduct several travel demand management programs to reduce SOV travel while facilitating mobility options. These programs promote and facilitate alternative modes of travel such as ridesharing, vanpooling, transit, bicycling, and walking. RideArrangers also promotes alternative work schedules and telecommuting. These programs have a heavy reliance on the internet for both promotion and other interaction with the public.

Maintenance and Construction Management
CDOT has recently implemented a statewide program for maintenance of ITS infrastructure. In addition, CDOT uses ITS extensively to predict winter maintenance needs and treatments, and to determine maintenance scheduling. Both CDOT and the City of Denver have Maintenance Decision Support System (MDSS) capabilities, and have outfitted maintenance vehicles with AVL and other detectors. CDOT is also requiring large construction projects to include a work-zone management plan during construction. Other systems are in use by CDOT and some local jurisdictions, which use them to schedule maintenance actions and track and prioritize repairs on equipment.

Data Management
Currently, CDOT ITS acts to a limited extent as a clearinghouse for much of the regional data that is collected and shared between jurisdictions in the Denver area. However, there is a considerable amount of data that is not shared or stored regionally because agreements or communication links do not exist. Data is being stored and managed locally. As a result, data is distributed throughout the Regional area between local jurisdictions and may also be held within different departments in a single agency. CDOT and some local jurisdictions, mostly those larger jurisdictions with TMC facilities, are currently sharing some data and communication resources while others are planning to do so when C2C connectivity is expanded. Wireless communications and high speed C2C communications links are being constructed that will allow better data sharing between centers. CDOT ITS Branch has also defined the standards for data exchange and is leading the software development that will support and maintain the ability to share and store data between agencies. Local agencies (such as Denver) are deploying a wireless Digital Trunk Radio (DTR) and fiber-optic systems within their local areas to support intra-City communications, to coordinate between maintenance, law enforcement, and emergency services, ITS functions, and Advanced Transportation Management Systems (ATMS). These network resources can be shared regionally and used for data exchange between local and regional TMCs.

Emergency Management
Colorado has recently completed an extensive statewide emergency management planning effort in response to several Homeland Security initiatives. Many of the local emergency management groups have already or are in the process of developing joint operations centers. Many of these agencies are also migrating, along with CDOT, to a statewide digital trunk radio (DTR) system to
facilitate on sight coordination of emergencies and incidents. The Colorado Division of Emergency Management (CDEM) is responsible for the state’s comprehensive emergency management program. The program coordinates state response to emergencies and supports other state and local agencies. The Denver Regional Area, as described previously, and additionally Elbert County, are included in the North-Central All Hazards Region which has been established by the CDEM – Department of Local Affairs, to promote homeland security, disaster and emergency response planning and coordination. The Multi-Agency Coordination Center (MACC), operated by the CDEM, is located in Centennial Colorado, and has been created for this purpose. The Center is designed to meet National Incident Management System (NIMS) requirements and is used as a central command and control center in the event of regional emergencies or disasters. The center is linked to CDOT CTMC, has cellular, satellite, radio and regular phone service communication capabilities.

### Other ITS Infrastructure Elements

ITS elements which are either currently deployed in the Denver Regional Area, or are in the process of being implemented are shown in the following Figures. Figure 8 shows three key ITS service areas which are currently or imminently deployed: Network Surveillance, Real-Time Traffic Management (employing a dedicated TMC with active traffic monitoring), and Information Dissemination.
Figure 8 – ITS Elements Inventory Map – Traffic Management Inventory

Real-time management is provided on arterials by interconnected traffic signal systems. Seventy-six percent of signals along the regional roadway system are on a signal system.
There are currently five dedicated TMCs in the region: Denver, Lakewood, Commerce City, Douglas County and the CTMC. RTD also operates a dedicated Transit Operations Center (TOC). Other TMCs and Advanced TMCs are not shown. These centers perform traffic surveillance along major corridors including surface highways and freeways. These corridors are equipped with cameras that provide video surveillance and vehicle detection (i.e. ATRs, pavement loop detectors, video vehicle detection, radar vehicle detection, etc.). Vehicle probe surveillance (travel time probes), currently operating only on I-70 west of I-25, involve data collection from the ExPress Toll tags to calculate travel time. Information is disseminated via DMS located along freeways and HAR.

Figure 9 shows ITS elements deployed regionally for transit. Transit traveler information kiosks, Park-n-Ride facilities and Light-Rail stations are shown located throughout the region. Demand transit areas (areas in which call-n-Ride services are available) are also shown on the Region map. All the elements on the map are owned or operated by the RTD; the Region’s main transit provider. RTD is coordinating with Boulder and Boulder County to improve transit vehicle tracking and transit traveler information. The TOC is operated by the Regional Transportation District. The TOC monitors transit system performance, demand transit dispatch, and transit security functions.

An inventory map of other field elements for services including incident management, environmental conditions monitoring, and weigh-in-motion data collection are shown in Figure 10. Weigh-in-motion scales are used to mainly weigh commercial vehicle traffic for vehicle weight enforcement and pavement monitoring purposes; although traffic count and classification data may also be obtained. Weigh-in-motion scales are incorporated as part of the by-pass technology at all fixed Port-of-Entry (POE) facilities to obtain advance vehicle weight information. Vehicles that participate in the PrePass program can by-pass the Port of Entry provided that their vehicle’s weight and their credentials are in proper order. Weather monitoring stations are located throughout the region to help determine environmental conditions and the need for maintenance services such as roadway treatments. Weather information and data is used by CTMC, maintenance and construction, and information service providers. Regional courtesy patrols perform an incident management purpose on regional freeways by reducing impacts to traffic flow by disabled vehicles. These vehicles may also be used for the dual purpose of obtaining vehicle probe surveillance data in the future.
Figure 9 – ITS Elements Inventory Map – Transit Management Inventory
Figure 10 – ITS Elements Inventory Map – Traffic and Environmental Monitoring
II.D. Stakeholder Needs and Issues Identified

A broad overview of needs and issues identified by research and results of the stakeholder workshops is provided below.

Regional Traveler Information

In November 2006, CDOT implemented a statewide 511 traveler information system that provides road condition, weather and construction related information. In the near future, CDOT intends to incorporate real-time travel times as the application is expanded to corridors throughout the region. Additionally, CDOT would like to incorporate other types of transportation related information such as; transit, airports, tourism and other local traffic/traveler information. Information regarding travel demand management alternatives such as the programs offered by DRCOG’s RideArrangers will also be accessible through this system. This will probably take several years to implement and will require additional resources to accomplish. There may be opportunities for establishing additional revenue sources from private information service providers (ISPs) through advertising or other operational agreements, which could aid in the completion and expansion of the 511 statewide traveler information system. The following are issues brought up and/or discussed by the working group on the Regional Traveler Information topic:

Technical Issues

- Current web presence does take advantage of 511 branding.
- Current web presence needs improvement to include access to all modes of transportation and focus on Denver Regional Area network.
- There needs to be data quality, reliability and timeliness assurance.
- System sizing is an issue as it will be largely consolidated at CDOT ITS; the consolidation of available information especially focused on the urban areas may increase utilization.
- Allow public information input to 511 system for non emergency information
- Need to include archived data in 511 system or link to it.
- Section 1201 of SAFETEA-LU requires that the state and local governments develop ITS architectures that explicitly address real-time highway and transit information needs.

Legal/Jurisdictional Issues

- Agreements are required between agencies to coordinate/integrate traveler information systems.
- Multiple third party systems using public information sources are competing to provide traveler information. This introduces problems with consistency of information presented to the public and reduces potential revenue stream that public agencies can generate from the traveler information system.
- Revenue-sharing agreements may be necessary if a revenue stream is created.
- Video recording and video use policies differ between agencies (i.e.: transportation and public safety).

Financial Issues

- There is insufficient funding to complete the development of the traveler information system.
- CDOT ITS with its system management, operation and maintenance responsibilities will face additional financial challenges.
• Consider licensing the public information to private ISPs. The information may be copyrighted so that it cannot be reproduced without license.
• Advertising could be used as another form of revenue to offset costs of traveler information system.
• Provide fee-based value-added services.
• Consider using design-build operate and manage contracts for information system.

Regional Transportation Operations & Management

Communication and coordination between local traffic and transit operations centers and the CDOT CTMC is currently limited. Just a few of the larger centers are currently coordinating traffic management functions and scheduling. Little or no collaborative control exists now. However, as more jurisdictions build functioning TMC facilities and add high speed communications to support field elements, center to center communication capabilities may also be added. Individual jurisdictions will have the ability to share information and control between centers. While jurisdictions may prefer to have local facilities with local control over functions on a daily basis, it may be desirable to have the capability to transfer control to a central location during off-hours and for special events. Advantages of this would be that staffing resources could be shared among many localities and regional coordination would be easier. Some disadvantages including IT security, and compatibility issues would need to be addressed. Implementation strategies and intergovernmental cooperation agreements would also need to be worked out. A regional plan for operations, management and control needs to be developed so a comprehensive regional TMC vision can go forward. The issues discussed by the working group on the Transportation Operations topic include:

Technical Issues
• Not all regional jurisdictions are equipped to share data or use shared data.
• CDOT’s backbone communications network faces capacity issues.
• Regional transportation management strategies need to be defined.
• A central control methodology would be needed which shares all the signal control data for the region.
• A materials compatibility lab, could serve the purpose of testing equipment for all regional partners to certify their use as part of regional systems certification program.
• Regional guidelines for the deployment of signal priority/preemption are required. Mutual aid agreements between jurisdictions would allow public safety forces to cross jurisdictional boundaries to operate compatible priority/preemption systems. Deployment of more sophisticated or incompatible systems by some jurisdictions may be an issue.
• Partnering with commercial radio/TV for traveler information is a challenge as the commercial entities do not place the same priority on the distribution of the traveler information as the transportation agencies.
• IT Department requirements for security, firewalls, and virus checking.
Legal/Jurisdictional Issues

- Regional transportation management will require cooperative agreements to allow operational control in multiple jurisdictions, list system maintenance responsibilities, defining funding/budget and other resource responsibilities, management responsibilities.
- Regional transportation management strategies need to be defined that describe who will make transportation management decisions and how actions will be implemented.
- A standard boilerplate for the IGAs needs to be developed which will be required for jurisdictions to work together.
- CTMC is currently not comfortable with taking control of equipment of local jurisdictions. They may require specific agreements with the local jurisdictions to consider the implementation of prepared signal timing plans.
- Larger existing, dedicated TMCs may share space with other smaller jurisdictions.
- Shared software resources and shared standards mean that greater regional coordination is required when considering system upgrades and replacement.
- A regional data exchange network could be part of the 511 system.
- Regional ITS maintenance and TMC operators programs could be of interest to smaller jurisdictions who do not have resources to address the ITS maintenance or TMC staffing requirements.
- Support at the CTMC for local jurisdiction operations is mainly required during off-hours.
- Software licensing issues for regional centers.

Financial Issues

- Consolidating traffic operations at the CTMC will increase funding requirements at that facility.
- The establishment of a regional transportation management center will require significant capital outlay and on-going funding requirements for operations.
- Funding for a TMC with advanced functions is a challenge for some jurisdictions and funding for TMC staffing is a challenge for all TMCs.
- CMAQ funding source is limited (consider connection to other funding sources (i.e. STP)).
- There is general difficulty in finding and keeping transportation operator talent.

Regional Traffic Incident Management System

Currently, several individual plans are in place for several highways and freeways in the Denver Regional Area. Since Denver is a large metropolitan area with high-traffic congestion, incidents have region-wide consequences and need to be addressed in a plan that accounts for this impact. It was suggested that a unified regional incident management plan may be an easier plan to maintain and use. The plan will have to be carefully prepared to account for the specifics of each facility (i.e. the specific diversion routes depend on the facility involved and the location and nature of the incident) and the different agencies involved based on the incident location. Currently, many jurisdictions maintain 911 call centers or individual emergency response centers associated with public safety departments. Regional planning and cooperation will require connectivity and agreements between jurisdictions and emergency response centers concerning protocols and inter-jurisdictional cooperation. The Denver Regional Area also has many large venues for special planned events such as professional sports stadiums, convention centers, amusement parks and event centers all of which can place heavy short-term demand on the
transportation system. Inclusion of these facilities and event promoters in the planning process for incident or “event” management is also important. Specific issues discussed by the working group on Incident Management include:

**Technical Issues**
- Automated incident detection is a technical challenge.
- US 6 incident management plan involving coordination with CDOT ITS, Denver and Lakewood may be a model for incident management utilizing technology.
- Public safety field staff often do not close incidents with dispatch as soon as they are complete.
- Technical issues in sharing CAD information between agencies.
- Currently do not have incident management plans for any facility other than freeways.
- Within the region several, separate incident management plans are maintained. A unified regional response manual would be more efficient.
- The unified plan should build off of existing structure (and structure prescribed by homeland security), including: incident command structure, incident management plans, resource ordering and status system (ROSS program used by National Wildfire Coordinating Group (NWCG)) , call down lists, and undocumented elements. The latter element is an issue with a lack of documentation of information that is generally only known by key field staff.
- Even though the CTMC is in operation 24/7, manager level resources are not available at all times in order to make key decisions and coordinate response activities.
- CDOT ITS is planning to test two technologies: a wireless, in-ground traffic monitoring device, and a travel speed information service which could provide the speed information on roadway segments at a flat rate cost to the customer (i.e. no maintenance or replacement costs).

**Legal/Jurisdictional Issues**
- Currently do not have courtesy patrols serving anywhere but freeways. To be efficient, some sort of multi-agency agreement may be required.
- There may be legal issues with sharing CAD information between agencies.
- Multiple contacts at multiple agencies are a communications challenge. Each agency should define an incident management contact list which follows the model adopted by both Denver and Lakewood for the US 6 incident management plan.
- The state maintains the Resource Ordering and Status System (ROSS). The public works elements have not yet been entered into that database.
- Courtesy patrol on arterials in the vicinity of highway interchanges is an interest to the local jurisdictions. Agreements to cover scope and cost would be necessary.
- Issues involving branding and advertising on courtesy patrol vehicles needs to be resolved.

**Financial Issues**
- Additional costs for incident management: increased staffing, increased requirements for incident detection and management.
- Additional training may be required to have public safety and transportation operations better understand each other’s methods.
- Additional staffing/training may be required for public safety dispatch so that the regional transportation display could be used to provide routing assistance.
- Additional DHS funding may be available but public safety may have trouble coming up with matching funds.
• Resources for unified incident management plan development and management need to be made available.

**Transit Operations & Management**

The Denver Regional Area has recently seen a significant expansion in transit services with completion of the T-REX project and the opening of the Southeast Transit Corridor. The planned FasTracks expansion will add seven more rail corridors over the next 12 years. Expanding transit service and sophistication requires that ITS technologies will be a necessary part of this effort. Transit agencies seek to deploy fleet tracking systems, passenger counting and fare collection systems, remote and interactive transit traveler information systems and transit security systems. For such a large and diverse public transportation system as the RTD, an operations center is necessary to control and monitor operations of the system, security functions and monitor weather information and forecasting. The specific issues discussed by the working group on Transit Operation & Management include:

**Technical Issues**

• Current technology used for AVL is inadequate.
• Different functions have different needs from the AVL data system (i.e. a 30 second reporting frequency vs. real-time). The AVL system must be flexible enough to meet the needs of several functions.
• RTD’s demand-responsive routes are not dispatched. There needs to be a means by which those routes can coordinate with connecting fixed and demand-responsive routes.
• Transit vehicle to traffic control system are required which can provide vehicle ID, schedule adherence, passenger load data.
• Inter-connectivity between the transit systems (i.e. main RTD operations with Boulder and Boulder County) providing information about schedule adherence, arrival time, passenger load data is needed.
• Transit system connections are needed to transit traveler information systems (i.e. personal devices, bus stop DMS) to provide transit stop locations, transit schedule information, schedule adherence and arrival time information.
• Regional weather information needs to be accessible to the transit system. Weather information that will impact operations needs to be sent to operations dispatch and to transit travelers.
• Need to provide an automated system that allows transit operators to communicate traffic and roadway conditions back to the Transit Operations Center.
• Transit system connectivity to the traffic control system, transmitting speed and travel time data for signal coordination and transit vehicle priority preemption systems
• Consider providing WiFi connectivity to passengers on board regional and local service routes.
• Improved passenger count systems which can provide origin-destination data and transfer information. This information can be integrated with a passenger fare collection system.

**Legal/Jurisdictional Issues**

• FCC is requiring RTD to “narrow-band” their radio system by 2013.

**Financial Issues**

• Upgrade to AVL system is programmed and partially funded for 2013.
Transit agencies may coordinate with procurement. An excellent example is the AVL system replacement.
There is a need for coordinated planning for seeking grant funding.

Maintenance and Construction

Several regional jurisdictions currently have or are planning on installing maintenance vehicle monitoring systems. These systems are mounted in the vehicle and give feedback on vehicle position, status, environmental conditions, and functions (plowing, chemical dispersal, etc). Several jurisdictions also operate systems which schedule maintenance activities and equipment repair. Weather station information in the region is not always shared or disseminated between jurisdictions and could be better coordinated. Often weather stations are remote and require frequent maintenance and repair. Currently, construction zone safety systems using ITS technology with locating and warning capabilities are not in widespread use. Maintenance and Construction issues brought up in the workshop and discussed by the group members on this topic include:

Technical Issues
- There are multiple weather services in the region that are not integrated (i.e. CDOT ITS, CDOT GIS and Denver).
- Clarus, a national initiative to coordinate weather data collection and processing, is something to consider for the future.
- Weather data sharing is challenged by competing vendor incompatibility and other sharing restrictions.
- Airport weather stations are another source of information that are not utilized.
- MDSS has been identified as a useful tool to help schedule work for winter storms and for other parts of the year (i.e. forecasts of improper environmental conditions could postpone work and reschedule resources more quickly).
- Each of the jurisdiction’s permitting offices should be a source of construction and maintenance activities information.
- CDOT currently uses a system which identifies non-functioning equipment at the end of the day. Work orders are generated using the list and priorities assessed. System could be used generally to assist in maintenance.

Legal/Jurisdictional Issues
- All jurisdictions are not benefiting from weather information that is currently collected region wide and statewide.
- CDOT ITS is working on a project to integrate MDSS weather information and provide it to the public through the cotrip web site.
- Regional weather collection system plan could eliminate duplication and gaps in weather monitoring coverage.
- Weather data could be valuable when used in cooperation with emergency management to track hazardous releases.
- Jurisdictional issues with incorporating airport weather station information.
- Local permitting offices could provide construction and maintenance operations location and schedule information to CTMC, 511 system and CDOT Permitting Office. This information could be used to aid project coordination by local agencies, trip planning by travelers, and OS/OW vehicle routing and permitting by heavy haulers.
Financial Issues
- Costs to expand and maintain parallel systems versus costs required to integrate systems.
- Cost of resources for road weather information systems (RWIS), environmental sensor stations (ESS) and truck equipment.
- Cost of resources to pull together maintenance and construction awareness.

Regional Parking Management

Regional parking management strategies have been proposed for Denver and RTD parking facilities. RTD is planning on implementing a parking pricing strategy at its Park-n-Ride locations, which bases parking fees on license plate origination. Vehicles from outside the RTD service area would be charged additional fees for parking in RTD facilities. Parking fees could also be varied by time of day to manage parking demand in peak periods. The system is still in the planning stages but $10M is remaining in T-REX funding to pay for the project. City and County of Denver has proposed participating in a regional parking management system but as a public agency, it would be competing directly with private parking operators within the city. A parking management system with public and private operators participating by providing information about occupancy, pricing and reservations would be problematic due to the competitive nature of parking services. Information posted to websites and reservation systems may not be accurate or current. Automatic payment options may not be available at all locations and would be costly for smaller operations to implement. The Parking Management issues discussed at the workshop include:

Technical Issues
- Parking fee collection system compatibility (or capability with adoption of new payment method).
- Feasibility of electronic fee collection due to facility configuration or size.
- Incorporation of on-street parking fee collections system(s) into system concept.
- Express Toll tags are battery-powered. If they are used for other functions (i.e. parking payment) the subsequent increase in tag reads will require more frequent battery replacements.
- The main interest of jurisdictions is to provide better information to potential parking customers. Although the same infrastructure required for parking information systems will support parking management strategies, there is not a broad interest in deploying parking management strategies at this time.

Legal/Jurisdictional Issues
- Competitive environment of the industry and conflicting interests between public and private operators presents a challenge to information sharing.
- Concept promotes the use of an existing system, which limits competition for the service.
- Selective participation in Can parking management strategies may give an unfair commercial advantage to some facilities.

Financial Issues
- There are additional parking fee collection costs (capital costs, operational costs, maintenance costs) for advanced systems.
- Back office administration fees for billing and administration.
- Potentially additional fees required for transponder replacement.
$10M in T-REX funding remains to upgrade the parking management system for that project. RTD is intending to expand the parking information system to key areas such as Mineral and Dry Creek.

Regional Data Management

The region currently has no centralized Regional Data Warehouse for storage and maintenance of transportation and ITS related data. Individual agencies and jurisdictions currently maintain their own individual data files and information storage. Most agencies are willing to share information, but it may not be in a standard format, and the quality and latency of the data may vary. Several departments within a single agency may collect and store information; making it difficult to catalogue, manage and distribute information. It has been suggested that a single regional agency take responsibility for managing transportation data regionally, setting standards for data quality, doing data filtering and maintenance functions. Data from local jurisdictions would be collected and managed centrally and would be available regionally. It was suggested that regional stakeholder such as DRCOG assume this function possibly with an Academic Institution as a partner. The issues brought up by the working group on this topic include:

Technical Issues
- The amount of data being archived needs to be managed in order to strike a balance between cost and the usefulness of the data warehouse.
- A regional data user’s group could be implemented to assist in the development of the data management planning.
- USDOT will be establishing data exchange formats (section 1201 from SAFETEA-LU) that must be incorporated by states and local governments in order to both share data, and make the data available to the traveling public.
- Examples of data of interest include: volume, speed and travel time by link; incident data (location, type, etc.); all movement data for critical intersections; traffic signal timing plan information by signal.
- IT Department requirements for security, firewalls, and virus checking.

Legal/Jurisdictional Issues
- There may be issues with sharing performance data outside of a jurisdiction.
- Local jurisdictions may prefer to store data in ways which are incompatible with the regional system.
- Some data is made publicly available (i.e. Denver makes 24-hour counts available), but other data may still have value to the private sector.

Financial Issues
- The costs of participation will vary by the amount of data collected, yet everyone would have equal access. Cost share between agencies needs to be defined prior to program implementation.
- It was noted that developers expend a lot of money to collect data sometimes multiple times for the same location. This represents a potential revenue stream to offset the cost of collecting regional data.
Regional Emergency Management

There has been increased emphasis on homeland security issues, disaster management and evacuation plans in recent years. The North Central All-Hazards Region is currently preparing a comprehensive regional disaster management and evacuation plan for the Denver Regional Area. Expansion of existing systems and building upon existing infrastructure assets used for wildfire control and incident management, connectivity with the CTMC and public information systems has been ongoing. Infrastructure monitoring is also a necessary component of regional security both from a security and infrastructure health standpoint. Monitoring of critical infrastructure needs to be coordinated with local jurisdictions and operations centers. The following are the issues brought up by the working group during the workshop:

Technical Issues

- Security communications infrastructure and protocols may not be consistent from jurisdiction to jurisdiction.
- There are multiple GIS efforts/capabilities across the region. Efficiencies may be found through coordination of data. North Central All-Hazards Region is leading an effort to consolidate the GIS information from each of its 10 counties.
- 

Legal/Jurisdictional Issues

- Some security planning is sensitive information, which may conflict with the goal of distributing traveler information.
- Training may be required to educate transportation professionals of security responsibilities and vice versa.
- Concepts related to evacuation are still being developed. It has not been established who is going to give the evacuation orders or if there will be a Regional Unified Command Center for evacuation events.
- There are requirements for the use of the National Incident Management System (NIMS) and the Incident Command Structure (ICS) for all incidents. Training and new coordination issues may exist.

Financial Issues

- Coordination between two funding streams (DHS and DOT) may allow efficient investment benefiting both transportation and security.

Commercial Vehicle Operations

Administration of Commercial Vehicle Operations is a state-level responsibility. Port of Entry facilities in Colorado (of which only one exists in the DRCOG region) are currently undergoing improvements to computer systems at port facilities and having roadside DMS replaced. Other improvements are needed to increase efficiency, expand capabilities and provide permitting and traveler information services. Connectivity with CDOT CTMS and central data systems are needed for CVO safety inspection, driver authentications and vehicle permitting and verification functions. The following is a list of issues discussed by the working group on this topic:

Technical Issues

- Oversize and overweight permitting is not tied into the weigh-in-motion (WIM) stations or the PrePass program.
• CDOT Permitting is currently unable to track movements of vehicles on annual permits.
• Maintenance of pavement around the WIM sites on the highways is an issue impacting proper operations of the port-of-entry bypass system.
• Magnesium Chloride (MgCl) use is an issue with roadway electronics.
• Increase the amount of travel information collected from PrePass and WIM stations.

Legal/Jurisdictional Issues
• Motor Carrier Services needs access to vehicle and driver records in real-time. This requires coordination within the Division of Motor Vehicles.
• Ports of Entry, State Patrol and CDOT Permitting – all critical elements of CVO – are under different organizations.
• There is a need to better distribute HAZMAT travel information to transportation and public safety agencies.
• Denver and Broomfield have their own permitting systems.

Financial Issues
• Commercial vehicle permitting fees in Colorado have not changed for decades.
• Insufficient funding is available to maintain the port-of-entry bypass program. There is currently a field equipment failure rate of about 50%. 
III. Market Package Plan

Market packages are the building blocks of the National ITS Architecture. The process of identifying local issues, needs, and plans, and correlating them to ITS market packages provides the systems engineering perspective that is crucial to ITS planning (and required by the FHWA and FTA). Market packages provide an accessible, deployment-oriented perspective to the National ITS Architecture and are tailored to fit - separately or in combination - real world transportation problems and needs. Market packages identify physical ITS elements (infrastructure, equipment and devices) that are required to implement a particular transportation service. A description of all the National ITS Architecture version 6.0 based market packages including graphic can be found on the USDOT National ITS Architecture website at http://www.iteris.com/itsarch/html/mp/mpindex.htm.

Market packages for the Denver Regional Area were selected to address the issues and needs as identified through the stakeholder process.

Market packages are grouped in the National ITS Architecture based upon the type of transportation service provided, as follows:

- **Archived Data Management (AD):** Store and retrieve transportation system information for future analysis.
- **Advanced Public Transportation Systems (APTS):** Manage transit operations and make transit use more convenient and safe.
- **Advanced Traveler Information Systems (ATIS):** Provide real-time information to travelers.
- **Advanced Traffic Management Systems (ATMS):** Manage operation of the roadway network.
- **Advanced Vehicle Safety Systems (AVSS):** In vehicle technologies to improve safety and vehicle control.
- **Commercial Vehicle Operations (CVO);** Manage Commercial vehicle operations, safety and permitting.
- **Emergency Management (EM):** Manage emergency response operations.
- **Maintenance and Construction Management (MC):** Manage maintenance and construction activities and operations.

Market packages in the tables on the following pages are listed as being either “E” for “existing”, “P” for “planned” (for near-term future deployment), “C” for “considered” for (longer term) possible future deployment, or “blank” if there is no requirement for the market package.

### III.A. Archived Data Management

Most ITS applications (i.e., traffic signal control systems) automatically generate information on transportation network performance and use. The implication is that each ITS application should include the ability to gather information to help develop improved operational plans and responses. The ITS Data Mart market package provides the basic data quality, data privacy, and data management common to all ITS archives and provides general query and report access to archive data users. This market package establishes a common framework to collect and archive
data for each entity. In the Denver Regional Area, existing ITS Data Marts include such things as the CDOT ITS DMS logs and weather station data, traffic volume and speed monitoring data and traffic signal timing plans. Table 6 lists the Archived Data market packages.
Table 6 – AD Market Package Deployment

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III.B. Advanced Public Transportation Systems

The Regional Transportation District, the primary regional transit agency in the Denver Regional Area, has deployed or planned to deploy many of the Advanced Public Transportation Systems market packages. Transit Vehicle Tracking, Transit Fixed Route Operations, Transit Security, Multi-Modal Coordination, Transit Traveler Information, and Transit Passenger Counting technologies have been deployed in the Denver Regional Area. Others have been planned for deployment or are being considered to address service areas not currently deployed. Transit related market packages deployed of planned by all the regional stakeholders are shown Table 7.
Table 7 – APTS Market Package Deployment

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III.C. Advanced Traveler Information Systems

The two primary market packages for providing traveler information are Broadcast Traveler Information, which relies on existing, low-cost broadcast communications to “push” information out to travelers (such as via fax or public television), and Interactive Traveler Information, which provides customized information in response to a request, such as via a web site or through an Interactive Voice Response (IVR) phone system. There are several existing broadcast and interactive traveler information systems existing and planned, including city and CDOT web sites, Highway Advisory Radio (HAR), CDOT road conditions faxes, and CDOT 511 phone system. Table 8 lists the selected ATIS market packages for the Denver Regional Area.

Table 8 – ATIS Market Package Deployment

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III.D. Advanced Traffic Management Systems

Many ATMS market packages are already in deployment in the region either by CDOT, the City of Denver or other regional stakeholders. There are several locations where Automatic Traffic Recorders (ATRs) or Weigh-in-Motion (WIM) scales are in use along I-70, I-25 and other major highways. Several jurisdictions in the region use video cameras for surveillance and detection, all
major jurisdictions in the Region operate traffic signal systems; several with traffic signal – railroad signal coordinated grade crossings (Standard Railroad Grade Crossing). Several jurisdictions are using lane use control signs and variable message signs are in use throughout the Metro area on freeways. Variable message signs and highway advisory radio are used to provide traveler information and to advise drivers of unsafe speeds. CDOT and local jurisdictions provide incident management along I-25, I-70, US 6 and US 36 within the Denver Regional Area. (Northwest Parkway also has an incident management plan). CDOT Region 6 employs road closure and lane closure technology on SH 93 and along I-25 and US-36 HOV/HOT facilities. CDOT has discussed coordinating traffic signals between jurisdictions within the Region and collecting and sharing real-time traffic signal data. Table 9 lists the selected ATMS market packages for the study area and the extent of the deployments.
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III.E. Advanced Vehicle Safety Systems

Advanced Vehicle Safety Systems (AVSS) is not included in this regional architecture. Market packages for Advanced Vehicle Safety Systems (AVSS) include systems which are primarily in the vehicle and monitor driver condition, vehicle position, and warn the driver when a collision may be imminent. AVSS may also take control of the vehicle in the latter case. AVSS technology is rapidly evolving and changing as manufacturers continue to improve the technology and the safety of these systems. In the future AVSS may come into more widespread use and become more applicable in the for regional ITS. Currently, they do not require direct interface with the Denver Regional Area ITS infrastructure. It is anticipated that this trend will continue; however, it is important to note that the Vehicle Infrastructure Integration (VII) initiative, a cooperative effort between Federal and State DOTs and automobile manufacturers to provide the capability for cars and the transportation network to communicate with each other. As VII and the AVSS systems develop, AVSS market packages may be reevaluated for subsequent revisions of the Regional ITS Architecture.

III.F. Commercial Vehicle Operations

The role of intelligent transportation systems (ITS) in commercial vehicle operations is to support existing efforts to improve the safety and efficiency of commercial vehicle operations. Currently, the main element implemented in Colorado is an electronic clearance (PrePass) system at the Ports of Entry fixed locations. There are other safety-related systems deployed (i.e. truck speed station on Floyd Hill) and intended to be deployed (i.e. hot brakes detection). In the National ITS Architecture, there are several market packages identified to improve the safety of commercial vehicle operations, which may require technology improvements and coordination between stakeholders. Table 10 below shows market package deployment existing or planned for the Regional area.

Table 10 – CVO Market Package Deployment

<table>
<thead>
<tr>
<th>Market Package</th>
<th>CV01</th>
<th>CV02</th>
<th>CV03</th>
<th>CV04</th>
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<th>CV11</th>
<th>CV12</th>
<th>CV13</th>
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<tr>
<td>Jurisdiction</td>
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<td>Colorado Department of Public Health</td>
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</table>
III.G. Emergency Management

The Emergency Management market packages include the dispatch and routing of emergency vehicles, support for roadway service patrols, and response to major disasters such as floods, earthquakes and terrorist attacks. Several of the Emergency Management market packages include functionality to access existing traveler information systems to disseminate emergency information. An example would be the use of CDOT DMS to post “Amber Alert” messages on behalf of emergency management agencies. All the Emergency Management market packages exist to varying degrees. The North Central All-Hazards region is currently preparing a regional evacuation plan that will involve cooperation between the public safety and transportation communities. The major challenge is integrating the emergency management centers with the traffic management centers where many of the devices are monitored and controlled. Table 11 lists the selected EM market packages for the study area.

Table 11 – EM Market Package Deployment

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>EM01</th>
<th>EM02</th>
<th>EM04</th>
<th>EM05</th>
<th>EM06</th>
<th>EM08</th>
<th>EM09</th>
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<tr>
<td>Arvada</td>
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<td>Aurora</td>
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<tr>
<td>City and County of Broomfield</td>
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<td>City &amp; County Denver</td>
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<td>Douglas County</td>
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</tbody>
</table>

III.H. Maintenance and Construction Management

Market packages in this service area may be linked to issues and needs concerning maintenance vehicles, work zones, and collecting/distributing weather and road conditions data. Currently, all
three CDOT regions have deployed weather stations that are interconnected and can share data. Additionally, CDOT has deployed a statewide network of weather stations, the data from which are available on the Co-Trip web site as well as more detailed information available separately for CDOT maintenance. Separately, several local agencies have also deployed weather stations, but little to no coordination exists with the state systems. CDOT is further exploring instrumenting maintenance vehicles to collect more real-time road condition data and dispatch maintenance vehicles even sooner. In addition, as Clarus, a federal initiative to integrate the data collected by all environmental sensor stations progresses, CDOT and other regional agencies will have to consider participation in that program. CDOT is also trying to expand the locations where automatic deicing systems are employed. Table 12 lists the selected MCM market packages for the study area.

Table 12 – MC Market Package Deployment

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Market Package</th>
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</thead>
<tbody>
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<td>MC01</td>
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<td>Arapahoe County</td>
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<td>Arvada</td>
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<tr>
<td>Aurora</td>
<td>E</td>
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<tr>
<td>Boulder</td>
<td>E</td>
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<tr>
<td>Boulder County</td>
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<tr>
<td>City and County of Broomfield</td>
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<tr>
<td>Castle Rock</td>
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<td>CDOT ITS</td>
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<tr>
<td>CDOT R1</td>
<td>E</td>
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<td>CDOT R4</td>
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<td>CDOT R6</td>
<td>P</td>
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<td>Commerce City</td>
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<tr>
<td>City &amp; County Denver</td>
<td>E</td>
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<td>Douglas County</td>
<td>P</td>
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<td>DRCOG</td>
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<td>E-470</td>
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<tr>
<td>Edgewater</td>
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<td>Englewood</td>
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<td>Glendale</td>
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<tr>
<td>Greenwood Village</td>
<td>C</td>
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<tr>
<td>Jefferson County</td>
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<td>Lafayette</td>
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<td>Lakewood</td>
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<td>Littleton</td>
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<td>Market Package</td>
<td>MC01</td>
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<tr>
<td>Jurisdiction</td>
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<td>Longmont</td>
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<td>Louisville</td>
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<td>Northglenn</td>
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<td>Northwest Parkway</td>
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<td>Parker</td>
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<td>RTD</td>
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<td>Superior</td>
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<td>Thornton</td>
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<tr>
<td>Westminster</td>
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<tr>
<td>Wheat Ridge</td>
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</tbody>
</table>

C: Coordinate; E: Equipment; P: Property
IV. Operational Concept

The previous section identified the ITS market packages that address the most critical transportation issues in the Denver Regional Area. The Operational Concept identifies the stakeholders that will be responsible for implementing those services and their roles and responsibilities for those services. A detailed list of the stakeholders and their roles and responsibilities was developed in Turbo Architecture.

This section provides an overview of stakeholder roles and responsibilities based on service area including status of stakeholder roles and the associated market packages included in each service area. The analysis of ITS Needs and Services identified nine Transportation Service Areas to focus on in the Denver Regional Area. These are:

- Regional Traveler Information
- Regional Transportation Operations and Management
- Regional Traffic Incident Management System
- Transit Operations & Management
- Maintenance and Construction
- Regional Parking Management
- Regional Data Management
- Regional Emergency Management
- Commercial Vehicle Operations

Stakeholder roles and responsibilities are described for each of the following Transportation Service Areas:

IV.A. Regional Traveler Information

Associated Market Packages for This Transportation Service Area:

- **ATMS01**: Network Surveillance
- **ATMS06**: Traffic Information Dissemination
- **MC03**: Road Weather Data Collection
- **MC04**: Weather Information Processing and Distribution
- **MC10**: Maintenance and Construction Activity Coordination
- **APTS8**: Transit Traveler Information
- **ATIS1**: Broadcast Traveler Information
- **ATIS2**: Interactive Traveler Information
- **ATIS8**: Dynamic Ridesharing
- **EM06**: Wide-Area Alert
- **EM10**: Disaster Traveler Information
### Stakeholder Roles and Responsibilities:

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Implementation</th>
<th>Operation</th>
<th>Management</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>APCD</td>
<td>Implement emissions monitoring equipment.</td>
<td>x</td>
<td>Participate in emissions management planning for the region.</td>
<td>x</td>
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<td></td>
<td>Implement RapidScreen and AirCare Colorado - two elemental programs of auto emissions inspection.</td>
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<td></td>
<td>Maintain emissions monitoring equipment.</td>
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<td></td>
<td>Maintain emissions monitoring equipment.</td>
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<td></td>
<td>Integrate existing broadcast and interactive traveler information systems into the CoTrip/511 system. Establish regional partner access to CoTrip/511 system.</td>
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<td></td>
<td>Enhance data interpretation to provide intelligence about future weather related conditions.</td>
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<td></td>
<td>Maintain field monitoring systems.</td>
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<td></td>
<td>Maintain core CoTrip/511 system, including database, website, and phone system.</td>
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<td>Maintain regional partner access to CoTrip/511 database.</td>
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<td></td>
<td>Maintain existing broadcast and interactive traveler information systems.</td>
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<td></td>
<td>Develop a regional strategic plan for CoTrip/511 system deployment and operation.</td>
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<td></td>
<td>Establish and promote standards and protocols for CoTrip/511 system.</td>
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<td></td>
<td>Assist in the promotion of the CoTrip/511 system both with other agencies and with the public.</td>
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<td></td>
<td>Support development of system elements by other entities that are compatible with the CoTrip/511 system.</td>
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<td></td>
<td>Review the potential of public-private initiative to advertise before traveler info is provided.</td>
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<tr>
<td></td>
<td>Explore the potential of pushing traveler information into vehicle as they travel.</td>
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<tr>
<td></td>
<td>Serve as the regional ISP, a clearinghouse for traveler information. This will mainly be achieved through the CoTrip/511 system, which will be automatically or manually updated by regional partners.</td>
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<tr>
<td></td>
<td>Serve as the regional link to private information service providers (ISP) with an interest in encouraging consistency in traveler information available to the public.</td>
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<td></td>
<td>Coordinate with Public Safety the wide area alert messaging (i.e. Amber alert and evacuation messaging) to be included in CoTrip/511 system.</td>
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</tbody>
</table>
3. **Colorado Tourism Organizations**

**Implementation:**
- Implement system of support for stakeholders looking for information other than traveler information. **Planned**

**Management:**
- Coordinate with CoTrip/511 system to provide links to tourist-related information systems. **Planned**

4. **DRCOG**

**Implementation:**
- Deploy rideshare and telework services (RideArrangers). **Existing**
- Prepare bicycle and pedestrian traveler information resources. **Existing**
- Develop and deploy alternative travel options educational and promotional material. **Existing**

**Maintenance:**
- Maintain RideArrangers telephone number and website. **Existing**

**Management:**
- Support the development of a regional strategic plan for CoTrip/511 system deployment and operation. **Planned**
- Lead public promotion of the CoTrip/511 system regionally. **Planned**
- Support the 511 branding and the development of effective and attractive public interfaces. **Planned**

**Operations:**
- Operate RideArrangers services. **Existing**
- Coordinate access RideArrangers services through CoTrip/511 system. **Planned**
- Coordinate access to educational and promotional travel options information through CoTrip/511 system. **Planned**

5. **Event Centers and Parking**

**Management:**
- Develop methods to coordinate with local jurisdictions to automatically update 511 database sharing information about local special events and parking availability. **Planned**

6. **Local Jurisdictions**

**Implementation:**
- Deploy traffic monitoring systems elements on major and regional arterials. **Existing**
- Deploy weather monitoring systems elements. **Existing**
- Deploy highway-rail interface systems to update CoTrip/511 system on train disruptions. **Planned**

**Maintenance:**
- Maintain field monitoring systems. **Existing**
- Maintain TMC operations. **Existing**
- Maintain communications with the CTMC and CoTrip/511 system. **Planned**
- Maintain communications with other external entities. **Planned**

**Management:**
- Coordinate with local special event centers. **Existing**
• Use CoTrip/511 systems standards in storage of data and sharing of information feeds with both the CTMC and other entities. Planned
• Develop methods to automatically update 511 database from other entities. Planned

Operations:
• Monitor field monitoring systems and detect transportation system issues. Existing
• Update 511database with traffic conditions, incident information, weather conditions and construction and maintenance work details. Planned
• Coordinate with local event centers and update 511 database with event details and projected impacts on transportation system. Planned
• Provide transportation-based public information in other forms. Planned

7. North Central All-Hazards Region

Operations:
• Coordinate wide area alert messaging to be included in 511 with CDOT ITS. Planned

8. Public Safety

Operations:
• Coordinate with CDOT ITS for wide area alert messaging to be included in CoTrip/511 system. Planned
• Pass emergency routing information to CoTrip/511 system. Planned

9. Railroad Companies

Operations:
• Send freight train schedule and real-time information to CoTrip/511 system. Planned
• Provide AMTRAK passenger arrival and departure information to the CoTrip/511 system. Planned

10. Regional Transportation District (RTD)

Implementation:
• Deploy fleet monitoring systems. Existing
• Deploy multimodal trip planner (both website and telephone). Planned
• Deploy network of information kiosks. Planned
• Deploy real-time bus arrival information system. Planned

Maintenance:
• Maintain equipment and software supporting the real-time bus arrival system. Planned
• Maintain equipment and software supporting the transit traveler information system. Planned

Management:
• Support integration of CDOT and transit traveler information systems. Planned
• Use CoTrip/511 systems standards in storage of data and sharing of information feeds with both the CTMC and other entities. Planned

Operations:
• Operate real-time bus arrival time system. Planned
• Operate web and phone information systems providing: fixed route schedules, real-time bus arrival information, other transit traveler information. Existing
• Coordinate access to transit traveler information (web and phone) through CoTrip/511 system.  

IV.B. Regional Transportation Operations and Management

Associated Market Packages for This Transportation Service Area:

ATMS01: Network Surveillance
ATMS02: Probe Surveillance
ATMS03: Surface Street Control
ATMS04: Freeway Control
ATMS05: HOV Lane Management
ATMS07: Regional Traffic Control
ATMS09: Traffic Forecast and Demand Management
ATMS10: Electronic Toll Collection
ATMS11: Emissions Monitoring and Management
ATMS13: Standard Railroad Grade Crossing
ATMS18: Reversible Lane Management
ATMS19: Speed Monitoring
ATMS21: Roadway Closure Management
APTS7: Multi-modal Coordination
EM05: Transportation Infrastructure Protection
EM06: Wide-Area Alert

Stakeholder Roles and Responsibilities:

1. CDOT ITS Branch

Implementation:
• Deploy new traffic monitoring system elements on freeways and major state highways.  
• Deploy new travel time monitoring system elements on freeways and major state highways.  
• Deploy traffic information dissemination system elements on freeways and major state highways.

Maintenance:
• Maintain traffic and travel monitoring equipment.  
• Maintain CTMC.  
• Maintain backbone communications system connecting with other traffic management centers.  
• Maintain shared software agreements (i.e. video and camera control sharing software).

Management:
• Develop modular travel time monitoring and display system specific to an urban area.

• Develop a plan for a regional backbone communications system.  
• Develop standards for communications system.  
• Develop DMS and HAR use policy (specifically considering how non-freeway messages can be posted).
- Develop a plan for the design and deployment of regional transportation operations display. Planned
- Develop a plan to establish purchasing contracts for equipment that any jurisdiction can use. Planned
- Develop a plan to improve maintenance and operation level of service by reducing cost and response time. Planned

**Operations:**
- Monitor freeway and other state highway operations including both congestion and traffic incident detection. Existing
- Use DMS and HAR for post freeway control messages. Existing
- Post other information to DMS and HAR upon request from regional partners. Existing
- Dispatch Service Patrols using computer-aided dispatch (CAD) who can serve as another form of traffic operations monitoring. Planned
- Serve as concentration points for Regional Traffic Control, consolidating links from other traffic management centers in the region and presenting a regional view for both traffic conditions and system health - the regional transportation operations display. Planned
- Support stakeholders with TMCs with after-hours monitoring and operations of local elements. Planned
- Improve after-hours decision making for non-recurring, non-scheduled events supporting a distributed management system during business hours and scheduled events. Planned

2. **CDOT Region 1**

**Implementation:**
- Deploy ramp metering system elements on freeways. Existing
- Deploy interconnected traffic signal system elements along state highways. Existing
- Deploy reversible lane systems elements on freeways. Existing
- Expand coverage of service patrols to arterials in immediate interchange area. Planned

**Maintenance:**
- Maintain field system elements. Existing
- Maintain communications to CTMC. Existing

**Management:**
- Develop deployment plan for ramp meters. Existing
- Assist CTE in development of a plan for management and operations of managed lanes. Planned
- Manage Service Patrol(s) IGA(s). Existing

**Operations:**
- Monitor and operate ramp meter system. Existing
- Monitor and operate traffic signal system. Existing
- Monitor and operate reversible system(s), HOV lane system(s), and HOT lane system(s). Existing
- Feed system health and traffic conditions data to regional transportation operations display. Existing

3. **CDOT Region 4**

**Implementation:**
• Deploy ramp metering system elements on freeways. Existing
• Deploy interconnected traffic signal system elements along state highways. Existing
• Deploy reversible lane systems elements on freeways. Planned
• Expand coverage of service patrols to arterials in immediate interchange area. Planned

**Maintenance:**
• Maintain field system elements. Existing
• Maintain communications to CTMC. Existing

**Management:**
• Develop deployment plan for ramp meters. Existing
• Assist CTE in development of a plan for management and operations of managed lanes. Planned
• Manage Service Patrol(s) IGA(s). Existing

**Operations:**
• Monitor and operate ramp meter system. Existing
• Monitor and operate traffic signal system. Existing
• Monitor and operate reversible system(s), HOV lane system(s), and HOT lane system(s). Existing
• Feed system health and traffic conditions data to regional transportation operations display. Existing

4. **CDOT Region 6**

**Implementation:**
• Deploy ramp metering system elements on freeways. Existing
• Deploy interconnected traffic signal system elements along state highways. Existing
• Deploy reversible lane systems elements on freeways. Planned
• Expand coverage of service patrols to arterials in immediate interchange area. Planned

**Maintenance:**
• Maintain field system elements. Existing
• Maintain communications to CTMC. Existing

**Management:**
• Develop deployment plan for ramp meters. Existing
• Assist CTE in development of a plan for management and operations of managed lanes. Planned
• Manage Service Patrol(s) IGA(s). Existing

**Operations:**
• Monitor and operate ramp meter system. Existing
• Monitor and operate traffic signal system. Existing
• Monitor and operate reversible system(s), HOV lane system(s), and HOT lane system(s). Existing
• Feed system health and traffic conditions data to regional transportation operations display. Existing

5. **Colorado Tolling Enterprise**

**Implementation:**
• Deploy toll collection and violation enforcement system elements. Existing

**Maintenance:**
• Maintain toll collection and violation enforcement system elements. Existing
Management:
- Establish a plan for managed lane deployment and operations. Existing
- Establish design and operational standards for the deployment of managed lanes. Planned

Operations:
- Conduct tolls and violation enforcement. Existing

6. DRCOG
Management:
- Develop signal timing plans for major regional arterials. Existing
- Lead development of a plan for the development and deployment of TSP. Planned
- Lead development of a plan for performance monitoring of regional system operations. Planned
- Develop with stakeholders an operations concept for after-hours center-to-center communication and operational protocols. Planned
- Develop with stakeholder’s specifications and lead purchasers for ITS equipment and contractors. Planned
- Develop a process to test products and develop acceptable products list. Planned

7. E-470 PHA
Implementation:
- Deploy new traffic monitoring system elements on freeways. Existing
- Deploy new travel time monitoring system elements on freeways. Existing
- Deploy traffic information dissemination system elements on freeways. Existing
- Deploy toll collection and violation enforcement system elements. Existing
- Deploy Service Patrols. Existing
- Deploy communications elements to support center-to-center interfaces with adjacent jurisdictions and CTMC. Planned

Maintenance:
- Maintain field system elements. Existing
- Maintain communications to CTMC. Planned
- Maintain toll collection and violation enforcement system elements. Existing

Operations:
- Monitor freeway operations including both congestion and traffic incident detection. Existing
- Use DMS and HAR for post freeway control messages. Existing
- Post other information to DMS and HAR upon request from regional partners. Planned
- Conduct tolls and violation enforcement. Existing
- Dispatch Service Patrols using computer-aided dispatch (CAD) who can serve as another form of traffic operations monitoring. Planned
- Feed system health and traffic conditions data to regional transportation operations display. Planned

8. Local Jurisdictions
Implementation:
- Deploy interconnected traffic signal system elements on major regional arterials. Existing
- Deploy traffic monitoring system elements on major regional arterials. Existing
- Deploy field system elements necessary to support TSP operations. Existing
- Deploy communications elements to support center-to-center interfaces with adjacent jurisdictions and CTMC, including after-hours operational protocols. Planned

Maintenance:
• Maintain traffic signal system. Existing
• Maintain traffic monitoring system. Existing

Management:
• Define local transportation management strategies. Existing
• Develop DMS and HAR use policy (specifically considering how non-freeway messages can be posted). Planned
• Coordinate with regional transportation management strategies. Planned
• Improve after-hours response to non-recurring, non-scheduled events. Planned
• Assist the development of after-hours operational protocols. Planned

Operations:
• Implement signal timing plans for regional arterials, as defined by DRCOG. Existing
• Monitor traffic signal system health and traffic conditions on the local network. Existing
• Feed system health and traffic conditions data to regional transportation operations display. Planned

9. North Central All-Hazards Region
Operations:
• Include information contained on regional transportation operations display in decision-making during emergencies. Planned

10. Northwest Parkway PHA
Implementation:
• Deploy new traffic monitoring system elements on freeways. Existing
• Deploy new travel time monitoring system elements on freeways. Existing
• Deploy traffic information dissemination system elements on freeways. Existing
• Deploy toll collection and violation enforcement system elements. Existing
• Deploy Service Patrols. Planned
• Deploy communications elements to support center-to-center interfaces with adjacent jurisdictions and CTMC. Planned

Maintenance:
• Maintain field system elements. Existing
• Maintain communications to CTMC. Planned
• Maintain toll collection and violation enforcement system elements. Existing

Operations:
• Monitor freeway operations including both congestion and traffic incident detection. Planned
• Use DMS and HAR to post freeway control messages. Existing
• Post other information to DMS and HAR upon request from regional partners. Existing
• Conduct tolls and violation enforcement. Existing
• Dispatch Service Patrols using computer-aided dispatch (CAD) who can serve as another form of traffic operations monitoring. Planned
• Feed system health and traffic conditions data to regional transportation operations display. Planned

11. Public Safety
Operations:
• Dispatch emergency vehicles based on information available from the regional transportation operations display. Planned
• Feed emergency routing information to the regional transportation operations display. Planned
12. **Regional Transportation District (RTD)**

**Implementation:**
- Deploy fleet monitoring systems. Existing
- Deploy fleet equipment elements necessary to support TSP operations. Planned
- Deploy fleet management CAD systems. Planned
- Deploy communications elements to support center-to-center interfaces with adjacent jurisdictions and CTMC. Planned

**Maintenance:**
- Maintain fleet systems elements. Existing
- Maintain fleet management CAD systems. Planned

**Management:**
- Define transit system management strategies. Existing
- Coordinate with regional transportation management strategies. Planned

**Operations:**
- Monitor transit system operations. Existing
- Coordinate real-time schedule issues between transit agencies. Planned
- Feed CAD system data to regional transportation operations display. Planned

**IV.C. Regional Traffic Incident Management**

**Associated Market Packages for This Transportation Service Area:**

- ATMS01: Network Surveillance
- ATMS02: Probe Surveillance
- ATMS03: Surface Street Control
- ATMS04: Freeway Control
- ATMS06: Traffic Information Dissemination
- ATMS07: Regional Traffic Control
- ATMS08: Traffic Incident Management System
- ATIS1: Broadcast Traveler Information
- ATIS2: Interactive Traveler Information
- EM01: Emergency Call-Taking and Dispatch
- EM02: Emergency Routing
- EM04: Roadway Service Patrols

**Stakeholder Roles and Responsibilities:**

1. **CDOT ITS Branch**

**Implementation:**
- Deploy incident detection on freeway corridors. Existing
- Deploy public safety CAD display at CTMC. Planned
- Assist in deployment of regional transportation operations display at public safety dispatch. Planned

**Maintenance:**
- Maintain incident detection and verification systems. Existing
• Maintain contact list related to incident management. Maintain regional transportation operations display.  

Management:
• Lead development of a unifying Regional Incident Management Plan.  
• Develop incident detection and verification protocol.  
• Develop a plan to increase staff in the CTMC to assist local jurisdictions with traffic management. Coordinate notification protocol with regional partners.  
• Improve ties to public safety agencies.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Dispatch courtesy patrol throughout region.  
• Update regional transportation operations display.  
• Lead traveler information response.  
• Contact other CDOT resources required to respond to the incident.  
• Implement alternate routes as determined by incident management plan.  
• Notify jurisdictions impacted by alternate route.  
• Track incident for clearance; close incident on regional transportation operations display when incident is cleared.  
• Utilize Resource Ordering and Status System (ROSS) to identify equipment needed during incident response.  

2. CDOT Region 1

Maintenance:
• Maintain Resource Ordering and Status System (ROSS) database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

3. CDOT Region 4

Maintenance:
• Maintain ROSS database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

2. CDOT Region 1

Maintenance:
• Maintain Resource Ordering and Status System (ROSS) database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

3. CDOT Region 4

Maintenance:
• Maintain ROSS database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

2. CDOT Region 1

Maintenance:
• Maintain Resource Ordering and Status System (ROSS) database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

3. CDOT Region 4

Maintenance:
• Maintain ROSS database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

2. CDOT Region 1

Maintenance:
• Maintain Resource Ordering and Status System (ROSS) database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

3. CDOT Region 4

Maintenance:
• Maintain ROSS database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

2. CDOT Region 1

Maintenance:
• Maintain Resource Ordering and Status System (ROSS) database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

3. CDOT Region 4

Maintenance:
• Maintain ROSS database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

2. CDOT Region 1

Maintenance:
• Maintain Resource Ordering and Status System (ROSS) database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

3. CDOT Region 4

Maintenance:
• Maintain ROSS database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

2. CDOT Region 1

Maintenance:
• Maintain Resource Ordering and Status System (ROSS) database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

3. CDOT Region 4

Maintenance:
• Maintain ROSS database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

2. CDOT Region 1

Maintenance:
• Maintain Resource Ordering and Status System (ROSS) database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

3. CDOT Region 4

Maintenance:
• Maintain ROSS database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

2. CDOT Region 1

Maintenance:
• Maintain Resource Ordering and Status System (ROSS) database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.  

3. CDOT Region 4

Maintenance:
• Maintain ROSS database with availability of incident management equipment.  
• Maintain a ready stock of incident management equipment.  

Management:
• Assist in development of a unifying Regional Incident Management Plan.  
• Manage courtesy patrol.  
• Ensure staff is adequately trained in National Incident Management System (NIMS).  

Operations:
• Region Maintenance assists in incident response and clearance.
4. **CDOT Region 6**

**Maintenance:**
- Maintain ROSS database with availability of incident management equipment. Planned
- Maintain a ready stock of incident management equipment. Planned

**Management:**
- Assist in development of a unifying Regional Incident Management Plan. Planned
- Manage courtesy patrol. Existing
- Ensure staff is adequately trained in National Incident Management System (NIMS). Planned

**Operations:**
- Region Maintenance assists in incident response and clearance. Existing

5. **Local Jurisdictions**

**Implementation:**
- Deploy incident detection on arterials. Existing
- Deploy public safety CAD display at TMC. Planned

**Maintenance:**
- Maintain ROSS database with availability of incident management equipment. Planned
- Maintain incident detection and verification systems. Planned
- Maintain contact list related to incident management. Existing

**Management:**
- Assist in development of a unifying Regional Incident Management Plan. Planned
- Develop incident management plans for key arterial corridors or entire jurisdiction. Existing
- Develop incident detection and verification protocol. Planned
- Coordinate notification protocol with regional partners. Planned
- Ensure staff is adequately trained in National Incident Management System (NIMS). Planned

**Operations:**
- Update regional transportation operations display. Planned
- Review diversion routes to be sure they are clear of incidents and roadwork prior to the diversion. Existing
- Implement signal timing plan that supports the diverted traffic. Existing
- Lead traveler information response locally - coordinate with regional traveler information response. Planned
- Contact other local jurisdiction resources (i.e. public safety) required to respond to the incident. Existing
- Track incident for clearance; close incident on regional transportation operations display when incident is cleared. Existing

6. **Public Safety**

**Implementation:**
- Support deployment of CAD display at CTMC. Planned
- Deploy regional transportation operations display at dispatch. Existing

**Maintenance:**
• Maintain Resource Ordering and Status System (ROSS) database that tracks the availability of incident management equipment and resources. Planned
• Maintain CAD system. Existing

Management:
• Assist in development of a unifying Regional Incident Management Plan. Planned
• Train both field and dispatch staff to update dispatch and CAD in a timely manner at the change of status of the event. Planned
• Educate transportation operations staff on public safety operations. Planned
• Ensure staff is adequately trained in National Incident Management System (NIMS). Planned

Operations:
• Field staff communicate with their dispatch. Existing
• Dispatch update the CAD system. Planned
• Access regional transportation operations display to provide public safety emergency vehicle route guidance. Planned
• Alert field staff to transportation network issues while dispatching. Existing

IV.D. Transit Operations & Management

Associated Market Packages for This Transportation Service Area:

ATMS02: Probe Surveillance
ATMS03: Surface Street Control
APTS1: Transit Vehicle Tracking
APTS2: Transit Fixed-Route Operations
APTS3: Demand Response Transit Operations
APTS4: Transit Passenger and Fare Management
APTS5: Transit Security
APTS6: Transit Maintenance
APTS7: Multi-modal Coordination
APTS8: Transit Traveler Information

Stakeholder Roles and Responsibilities:

1. Regional Transportation District (RTD)

Implementation:
• Deploy fleet tracking system for both fixed-route and demand-responsive services. Existing
• Deploy computer-aided dispatch (CAD). Planned
• Deploy automated dispatch for demand responsive systems. Planned
• Deploy transit security system elements. Existing
• Deploy passenger counting system elements. Planned
• Deploy automated transit vehicle conditioning monitoring elements that meet multiple needs (i.e. fare collection and passenger data, schedule info, arrival times). Planned
• Deploy fare collection system. Planned

Maintenance:
• Maintain fleet tracking system. Existing
• Maintain CAD. Planned
• Maintain automated dispatch for demand responsive systems. Planned
• Maintain transit security system elements. Existing
• Maintain passenger counting system elements. Planned
• Update radio equipment. Planned
• Update other communication equipment. Planned

Management:
• Coordinate fleet tracking procurement amongst transit agencies and transportation agencies. Planned
• Coordinate fare collection procurement amongst transit agencies, tolling agencies, and parking management entities. Planned
• Coordinate traveler information sharing directly between transit agencies. Planned
• Coordinate with other agencies to deploy communications to serve multiple agencies. Planned

Operations:
• Collect data from transit operations (i.e. schedule adherence, passenger counts, security issues, etc.) and share data with regional transportation operations display. Planned
• Collect data from transit operations and disseminate to both transit passengers and to regional traveler information system. Planned
• Push traveler information to transit travelers including bus arrival information, schedule change information, route connection information, roadway conditions, and weather conditions. Planned
• Integrate the weather, speed, construction, and maintenance information gathered by others into the transit agency's systems. Planned
• Link bus driver observations to the appropriate agency. Planned
• Automate functions of call-n-ride services, install laptops with broadband service. Planned

IV.E. Maintenance and Construction

Associated Market Packages for This Transportation Service Area:

| ATMS01: Network Surveillance |
| ATMS02: Probe Surveillance |
| ATMS21: Roadway Closure Management |
| MC01: Maintenance and Construction Vehicle and Equipment Tracking |
| MC02: Maintenance and Construction Vehicle Maintenance |
| MC03: Road Weather Data Collection |
| MC04: Weather Information Processing and Distribution |
| MC05: Roadway Automated Treatment |
| MC06: Winter Maintenance |
| MC08: Work Zone Management |
| MC10: Maintenance and Construction Activity Coordination |

Stakeholder Roles and Responsibilities:

1. CDOT ITS Branch

Implementation:
• Deploy Environmental Sensor Stations (ESS) system elements.  
• Deploy central weather data processing system elements.  
• Deploy Maintenance Decisions Support System (MDSS) roadside elements.  

**Maintenance:**  
• Maintain MDSS server and software.  
• Maintain central weather data processing system elements.  
• Maintain ESS system elements.  
• Management: Develop a regional deployment plan for ESS network  
• Develop coordination plan for other initiatives (i.e. CLARUS, MDSS, Weatherbug.com, airport weather stations).  
• Develop coordination plan for the traveler information system (consider multiple weather data sources, consider display requirements, etc.).  

**Operations:**  
• Collect and process weather data and send to traveler information system.  
• Collect and process weather data to be used as part of MDSS.  
• Coordinate roadway permitting system information to coordinate roadway maintenance and construction closures and restrictions.  
• Share this information with the regional transportation operations display.  

2. **CDOT Region 1**  
**Implementation:**  
• Deploy MDSS elements on maintenance fleet.  
• Deploy MDSS elements to courtesy patrol.  

**Maintenance:**  
• Maintain MDSS elements on maintenance fleet.  

**Management:**  
• Assist in the development of a regional deployment plan for ESS network.  
• Monitor performance measures to confirm or identify ESS locations.  

**Operations:**  
• Coordinate maintenance operations with MDSS program.  
• Coordinate roadway permitting system information to coordinate roadway maintenance and construction closures and restrictions.  
• Share roadway maintenance and construction closures information with the regional transportation operations display.  

3. **CDOT Region 4**  
**Implementation:**  
• Deploy MDSS elements on maintenance fleet.  
• Deploy MDSS elements to courtesy patrol.  

**Maintenance:**  
• Maintain MDSS elements on maintenance fleet.  

**Management:**  
• Assist in the development of a regional deployment plan for ESS network.  
• Monitor performance measures to confirm or identify ESS locations.  

**Operations:**  
• Coordinate maintenance operations with MDSS program.  
• Coordinate roadway permitting system information to coordinate roadway maintenance and construction closures and restrictions.
• Share roadway maintenance and construction closures information with the regional transportation operations display. Planned

4. CDOT Region 6
Implementation:
• Deploy MDSS elements on maintenance fleet. Planned
• Deploy MDSS elements to courtesy patrol. Planned
Management:
• Maintain MDSS elements on maintenance fleet. Planned
Operations:
• Coordinate maintenance operations with MDSS program. Planned
• Coordinate roadway permitting system information to coordinate roadway maintenance and construction closures and restrictions. Planned
• Share roadway maintenance and construction closures information with the regional transportation operations display. Planned

5. DRCOG
Management:
• Assist in planning for deployment of ESS coordinating the location of stations regionally. Planned

6. Local Jurisdictions
Implementation:
• Deploy ESS system elements. Planned
• Deploy central weather data processing system elements. Planned
• Deploy MDSS field and vehicle elements. Planned
• Deploy maintenance fleet vehicle tracking. Existing
Maintenance:
• Maintain MDSS elements. Maintain central weather data processing system elements. Planned
• Maintain ESS system elements. Planned
• Maintain maintenance fleet vehicle tracking. Existing
Management:
• Assist in the development of a regional deployment plan for ESS network. Planned
• Monitor performance measures to confirm or identify ESS locations. Planned
• Assist in development of coordination plan for other initiatives (i.e. CLARUS, MDSS, Weatherbug.com, airport weather stations). Planned
• Assist in development of coordination plan for the traveler information system (consider multiple weather data sources, consider display requirements, etc.). Planned
Operations:
• Collect and process weather data and send to traveler information system. Existing
• Collect and process weather data to be used as part of MDSS. Planned
• Coordinate roadway permitting system information to coordinate roadway maintenance and construction closures and restrictions. Planned
• Share this information with the regional transportation operations display. Planned

**IV.F. Regional Parking Management**

Associated Market Packages for This Transportation Service Area:

ATMS06: Traffic Information Dissemination
ATMS07: Regional Traffic Control
ATMS10: Electronic Toll Collection
ATMS16: Parking Facility Management
ATMS17: Regional Parking Management
APTS8: Transit Traveler Information
ATIS1: Broadcast Traveler Information
ATIS2: Interactive Traveler Information

Stakeholder Roles and Responsibilities:

1. **Colorado Tolling Enterprise**

   **Implementation:**
   • Deploy back office administrative system to serve as a clearinghouse for parking fee transactions. Planned

   **Maintenance:**
   • Operate back office administrative system. Planned

   **Management:**
   • Establish standards for parking fee collection. Planned

   **Operations:**
   • Operate back office administrative system. Planned

2. **E-470 PHA**

   **Implementation:**
   • Deploy back office administrative system to serve as a clearinghouse for parking fee transactions. Planned

   **Maintenance:**
   • Operate back office administrative system. Planned

   **Management:**
   • Establish standards for parking fee collection. Planned

   **Operations:**
   • Operate back office administrative system. Planned

3. **Event Centers and Parking**

   **Implementation:**
   • Deploy parking monitoring elements at parking facilities. Planned
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4. Local Jurisdictions

Implementation:
- Deploy parking monitoring elements at parking facilities. Existing
- Deploy parking fee collection system elements at parking facilities. Existing
- Deploy traveler information system elements to push/pull information to motorists in vehicle, on DMS, and on the web. Planned
- Deploy a parking reservation system. Planned

Maintenance:
- Maintain parking fee collection system elements. Existing
- Maintain communications with back office administration. Existing
- Maintain parking reservation system. Planned
- Establish agreements with event centers and private parking facilities to collect and display parking facility status information. Planned

Management:
- Establish parking facility pricing and rules for use. Existing
- Coordinate with parking fee collection standards. Planned
- Establish agreements with event centers and private parking facilities to collect and display parking facility status information. Planned

Operations:
- Monitor the parking facility operations and status. Planned
- Operate parking reservation system. Planned
- Using transit traveler information system elements, post parking facility status. Planned
- Feed parking facility status to CTMC for purpose of traveler information. Planned

5. Regional Transportation District (RTD)

Implementation:
- Deploy parking monitoring elements at parking facilities. Planned
- Deploy parking fee collection system elements at parking facilities. Planned
- Deploy traveler information system elements to inform motorists about travel time to downtown and available space. Planned
• Deploy a parking reservation system. Planned

**Maintenance:**
• Maintain parking fee collection system elements. Planned
• Maintain parking reservation system. Planned
• Maintain communications with back office administration. Planned

**Management:**
• Establish parking facility pricing and rules for use. Existing
• Coordinate with parking fee collection standards. Planned

**Operations:**
• Monitor the parking facility operations and status. Planned
• Operate parking reservation system. Planned
• Using transit traveler information system elements, post parking facility status. Planned
• Feed parking facility status to CTMC for purpose of traveler information. Planned

### IV.G. Regional Data Management

**Associated Market Packages for This Transportation Service Area:**

- AD1: ITS Data Mart
- AD2: ITS Data Warehouse

**Stakeholder Roles and Responsibilities:**

1. **Academic Institutions**

   **Implementation:**
   • Assist in the development and procurement of data warehouse. Planned
   • Assist in the deployment of data collection points. Planned

   **Maintenance:**
   • Assist in the maintenance of the regional data warehouse and hardware that supports it. Planned

   **Management:**
   • Assist in the development of the standards and agreements required to define the central data warehouse. Planned

2. **DRCOG**

   **Implementation:**
   • Lead development of a plan defining data needs, including: location, type of data, format for data storage, data quality and data reliability requirements. Planned
   • Lead the development and procurement of a regional data warehouse. Planned
   • Lead development of the web-based software that can access and manipulate regional performance data for planning, operations and research. Planned

   **Maintenance:**
   • Maintain the regional data warehouse database and hardware that supports it. Planned
   • Assist in the deployment of software modifications and upgrades for the regional partners. Planned

   **Management:**
   • Lead the development of data management requirements. Planned
• Lead the development of the standards and agreements required to define the virtual data warehouse.

**IV.H. Regional Emergency Management**

**Associated Market Packages for This Transportation Service Area:**

- ATMS01: Network Surveillance
- MC04: Weather Information Processing and Distribution
- EM06: Wide-Area Alert
- EM08: Disaster Response and Recovery
- EM09: Evacuation and Reentry Management
- EM10: Disaster Traveler Information

**Stakeholder Roles and Responsibilities:**

1. **CDOT ITS Branch**

   **Implementation:**
   - Deploy communications link to State EOC. Planned
   - Assist in the deployment of infrastructure to support emergency planning. Planned

   **Maintenance:**
   - Maintain transportation system infrastructure. Existing

   **Management:**
   - Support emergency planning exercises. Planned
   - Participate in ROSS to support tracking of emergency resources. Planned
   - Develop center to center communications and protocol. Planned
   - Tap into traveler information sources. Existing
   - Assist in public education. Planned

   **Operations:**
   - Operate transportation system infrastructure. Existing
   - Disseminate traveler information as directed by public safety during emergency events. Existing
   - Share transportation conditions data with EOC, as appropriate. Existing

2. **CDOT Region 1**

   **Implementation:**
   - Acquire portable DMS for use during evacuation. Planned
   - Deploy resource location equipment on portable devices. Planned

3. **CDOT Region 4**

   **Implementation:**
   - Acquire portable DMS for use during evacuation. Planned
   - Deploy resource location equipment on portable devices. Planned
4. CDOT Region 6

Implementation:
- Acquire portable DMS for use during evacuation. Planned
- Deploy resource location equipment on portable devices. Planned

5. Local Jurisdictions

Implementation:
- Deploy communications link to local EOC. Planned
- Assist in the deployment of infrastructure to support emergency planning. Planned
- Deploy communications link to State EOC. Planned
- Deploy communications link to Regional Unified Command Center. Planned

Maintenance:
- Maintain transportation system infrastructure. Planned
- Maintain EOC. Existing

Management:
- Support emergency planning exercises. Support evacuation planning. Planned
- Participate in ROSS to support tracking of emergency resources. Planned

Operations:
- Disseminate traveler information as directed by public safety during emergency events. Planned
- Share transportation conditions data with EOC, as appropriate. Planned
- Respond to requests for traffic control support during emergency. Planned
- Activate/operate EOC when required. Existing
- Respond to requests for traffic control support during emergency Existing

6. North Central All-Hazards Region

Implementation:
- Deploy State Emergency Operations Center (EOC). Existing
- Deploy Multi-Agency Coordination Center (MACC). Existing
- Deploy Resource Ordering and Status System (ROSS) Existing

Maintenance:
- Maintain EOC/MACC. Existing
- Maintain Resource Ordering and Status System (ROSS) Existing

Management:
- Provide financial and technical support to local and state agency emergency management. Planned
- Provide training resources to local and state agencies. Planned
- Develop public education campaign. Planned

Operations:
- Activate/operate EOC when required. Existing

7. Public Safety

Management:
- Support emergency planning exercises. Existing
• Support evacuation planning. Planned
• Participate in ROSS to support tracking of emergency resources. Planned

**Operations:**
• Respond to evacuation order. Existing
• Coordinate communications between public safety field staff and transportation operations. Planned

**IV.I. Commercial Vehicle Operations**

**Associated Market Packages for This Transportation Service Area:**

ATMS06: Traffic Information Dissemination  
CVO03: Electronic Clearance  
CVO04: CV Administrative Processes  
CVO06: Weigh-In-Motion  
CVO10: HAZMAT Management  
CVO12: CV Driver Security Authentication  
CVO13: Freight Assignment Tracking

**Stakeholder Roles and Responsibilities:**

1. **CDOR Motor Carrier Service Division**

  **Implementation:**
  • Deploy port-of-entry bypass system elements. Existing  
  • Deploy DMS at ports-of-entry. Planned  
  • Connect DMS to CTMC. Planned  
  • Link to CDOT Permits to aid in PrePass and safety reviews. Planned

  **Maintenance:**
  • Maintain equipment at ports-of-entry that support traveler information (i.e. DMS, kiosks, communications link). Planned

  **Management:**
  • Coordinate with FMCSA to implement CVISN at state level. Planned  
  • Develop means to allow automated permitting through port-of-entry kiosks. Planned  
  • Coordinate with PrePass to expand the use of the transponders on the commercial vehicles. Planned  
  • Coordinate with CDOT to include annual and one-trip permitting information in the PrePass program. Planned  
  • Include safety scores as an element to determine polling rates. Planned  
  • Consider other technologies to collect weight information. Planned

  **Operations:**
  • Port-of-Entry staff conduct motor carrier safety inspections. Existing

2. **CDOT ITS Branch**

  **Implementation:**
• Deploy commercial vehicle operations safety systems.
• Deploy kiosks at ports-of-entry.

**Maintenance:**
• Deploy commercial vehicle operations safety systems.

**Management:**
• Coordinate with Colorado State Patrol regarding safety issues determined by safety systems.
• Coordinate with CDOR to allow traveler information to be posted on port-of-entry DMS, on kiosks, and other means.

**Operations:**
• Monitor the status of safety systems and send driver and traveler information to ports-of-entry.

3. CDOT Permitting

**Implementation:**
• Link the permitting system to the traveler information system including closure and weather information, travel and weight restrictions.

**Management:**
• Coordinate with CDOR to include annual and one-trip permitting information in the PrePass program.
• Continue to work on an automated routing program for permitting.

4. CDOT Region 1

**Implementation:**
• Assist in the deployment of port-of-entry bypass system elements.
• Deploy commercial vehicle operations safety systems.

**Maintenance:**
• Maintain commercial vehicle operations safety systems.

**Management:**
• Coordinate with Colorado State Patrol regarding safety issues determined by safety systems.

**Operations:**
• Monitor status of safety systems.

5. CDOT Region 4

**Implementation:**
• Assist in the deployment of port-of-entry bypass system elements.
• Deploy commercial vehicle operations safety systems.

**Maintenance:**
• Maintain commercial vehicle operations safety systems.

**Management:**
• Coordinate with Colorado State Patrol regarding safety issues determined by safety systems.

**Operations:**
• Monitor status of safety systems.

6. CDOT Region 6
Implementation:
- Assist in the deployment of port-of-entry bypass system elements.  Existing
- Deploy commercial vehicle operations safety systems.  Planned

Maintenance:
- Maintain commercial vehicle operations safety systems.  Planned

Management:
- Coordinate with Colorado State Patrol regarding safety issues determined by safety systems.  Planned

Operations:
- Monitor status of safety systems.  Planned

7. Colorado Dept. of Public Health and Environment (CDPHE)

Management:
- Develop system to share HAZMAT travel information with public safety, port operations, traffic operations, and other entities that may benefit from the information.  Planned

Operations:
- Issue Permits for HAZMAT travel.  Existing

8. Public Safety

Operations:
- Be responsible for motor carrier safety inspections.  Existing

9. Trucking Companies

Implementation:
- Install port-of-entry bypass system elements on commercial vehicles.  Existing
- Install other safety-related electronic equipment as required by Colorado State Patrol.  Planned
- Expand deployment of safety devices/systems as part of the federal Vehicle Infrastructure Integration (VII) initiative.  Planned

Maintenance:
- Maintain equipment on commercial vehicles.  Planned

Operations:
- Maintain appropriate credentialing information.  Planned
V. Agreements

The operational concept presented in the previous section defines the overall relationships between transportation and safety agencies within the Denver Regional Area. In order to fully implement the operational concept, formal agreements are necessary to define the roles and responsibilities of the agencies involved including such items as performance requirements, funding arrangements, data sharing arrangements, etc. Note that these agreements may have technological and operational impacts on the development of some of the systems. This section discusses existing, planned and potential agreements. The following are ITS program areas and implementations that require establishment of formal agreements:

**Regional Traveler Information:** The Federal Communications Commission (FCC) has designated 511 as the nationwide telephone number for traveler information. CDOT implemented a statewide 511 phone access information system and website (www.cotrip.org) in 2004. CDOT ITS has formal agreements with several local wireless communications companies to provide 511 services statewide. In general, for regional traveler information, there are some informal agreements in place between local jurisdictions to share information within the region. However CDOT ITS also has many formal agreements to exchange video images and website information with local and inter-regional jurisdictions, private information providers and news media organizations. As local agencies deploy additional ITS elements within their jurisdictions and centralize operations by building dedicated TMC facilities, additional information sharing agreements will need to be formalized with CDOT and other regional partners. For example, entities such as DRCOG’s RideArrangers and RTD will need to prepare agreements defining the agency responsibilities for providing access to travel demand management and transit traveler information, respectively.

**Regional Transportation Operations and Management:** As the network of ITS implementations grow along each of the highway corridors and across the region, many agencies will be responsible for operation and maintenance of additional ITS devices such as traffic signals, vehicle detectors, CCTV cameras, DMS and Road Weather Information Systems (RWIS) stations. Agreements that detail ownership, performance or level-of-service requirements, priorities for shared operation, roles and responsibilities regarding maintenance and other operations and liability will be necessary to share current and future ITS implementations. This is especially important for devices with which agencies have sensitivities regarding shared control (i.e. traffic signals). Interim agreements to support interagency signal coordination and control and to use existing ITS systems to their full effectiveness should be the primary set of agreements. The degree with which agencies cooperate may vary based on the size of the jurisdiction and resources available. Smaller jurisdiction may form agreements with other jurisdictions which have greater depth of resources rather than building their own systems. Several degrees of interagency relationships are defined in the following (Table 13). The table shows the range of potential institutional interactions that might occur between two organizations desiring to cooperate in the operation of an ITS element. Agreements between two jurisdictions for operative control of TMCs during off-hours or temporary control of traffic signals, DMS, video surveillance, or information sharing might be made to follow one or more of the following relationship models.
### Table 13 – Agency-to-Agency Relationships

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Definition</th>
<th>“From/To” Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Independent</td>
<td>Parties operate independently with no interaction</td>
<td>No interaction.</td>
</tr>
<tr>
<td>2 Consultation</td>
<td>One party confers with another party, in accordance with an established process, about an anticipated action and then keeps that party informed about the actions taken. No electronic sharing of information.</td>
<td>FROM agency provides information on activities to interested TO agencies.</td>
</tr>
<tr>
<td>3 Cooperation</td>
<td>The parties involved in carrying out the planning, project development and operations processes work together to achieve common goals or objectives. No electronic sharing of information.</td>
<td>Both agencies cooperate in the development and execution of common plans, projects, and operational procedures.</td>
</tr>
<tr>
<td>4 Information Sharing</td>
<td>The electronic exchange of data and device status information between parties, for the purposes of coordinated operations, planning, and analysis.</td>
<td>FROM agency will provide status, data, and/or video information from the FROM agency’s field devices (e.g. detectors) to the TO agency.</td>
</tr>
<tr>
<td>5 Control Sharing</td>
<td>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</td>
<td>FROM agency is allowed by the TO agency to control the TO agency’s field devices (e.g. DMS, select signal timing patterns) for specified defined occurrences</td>
</tr>
<tr>
<td>6 Only Operational Responsibility Shifted</td>
<td>One party operates the field equipment of a second party on a full time basis.</td>
<td>FROM agency will operate the field devices of the TO agency (e.g. County operates a City’s traffic signals but the City is responsible for maintenance and repairs.)</td>
</tr>
<tr>
<td>7 Only Maintenance Responsibility Shifted</td>
<td>One party maintains the field equipment of a second party.</td>
<td>FROM agency maintains the field devices of the TO agency, but the TO agency is responsible for operations.</td>
</tr>
<tr>
<td>8 Full Responsibility Shifted</td>
<td>One party has full responsibility for the field equipment of a second party including operations and preventative and emergency maintenance.</td>
<td>FROM agency operates and maintains the field devices of the TO agency.</td>
</tr>
</tbody>
</table>

In order to implement center-to-center coordination, formal agreements between the agencies with control centers must be developed to define a plan for compliance with the NTCIP standards for center-to-center communications. The CTMC is involved in a number of such agreements, which may serve as the basis for agreements in the regional area. Currently, there are Memorandum of Understanding (MOU) agreements for communications resource sharing between jurisdictions located in the T-REX southeast corridor and the CTMC operated by CDOT ITS. No formal agreements exist between organizations operating TMCs for joint control. Existing agreements are for infrastructure sharing and maintenance, and for integration for video...
and data sharing thus far. It is important that agencies currently operating or anticipating deployment of new traffic management centers are involved in the development of new agreements for regional cooperation.

**Traffic Incident Management System:** Agreements are currently in place for cooperation on incident response plans for major highways and freeways in the Denver Regional Area. There are several major highways and freeways which have plan agreements. I-70 and I-25 in Denver, US 36, the Northwest Parkway, DIA – Pena Boulevard, and US 6 all have incident management plans. These plans define the roles of key agencies in responding to incidents along the freeways based on the incident location and severity. There is an interest in expanding the coverage of incident management plans to consider other major highways within the Denver Regional Area and to establish a region-wide incident management plan. Incident responses include the use of existing and future ITS deployments (i.e. signal timing plans and DMS messaging). The sharing of ITS devices can be critical as some local incidents have region-wide effects. Agreements must be in place to address device availability as well as the means by which control conflicts (i.e. competing messages on a DMS) can be resolved.

**Transit Operations and Management:** RTD is leading regional efforts to coordinate deployment of ITS by transit providers. Formal agreements are not maintained, but there is a combined interest in deploying consistent and compatible systems. In the future, there may be opportunities for agreements with other regional stakeholders (i.e. traffic management agencies) on infrastructure and information sharing, parking operations administration, or multi-modal coordination.

**Maintenance and Construction:** The agencies within the Denver Regional Area have a great desire to improve the availability of information to assist the public in transportation decisions and to facilitate efficient application of maintenance resources. Of specific interest is weather station information, but the agreements for sharing other traveler information follow the same concept. CDOT and other local stakeholders all have access to their own weather stations. Some agencies are sharing, but most are not. Agreements that define the maintenance responsibilities and the means and format by which information will be shared will facilitate coordination of the existing and future information sources. The agreements should also detail how it will be distributed to the public. Currently existing formal agreements in maintenance and construction deal with access to communications infrastructure, franchise agreements and responsibilities for maintenance to field elements.

**Regional Data Management:** The basis for data sharing in the Region is a regional communications backbone. As the communication networks in the Denver Regional Area grow, there will be additional opportunities for sharing of communications infrastructure and information. The purpose of the agreements is to define the ownership, standards, responsibilities for maintenance, and repair of networks. Provision in these agreements should be made to accommodate new participants as the network grows. CDOT ITS currently has many agreements in place to integrate communications infrastructure and share fiber capacity. Little is currently done within the Region to formally share data other than that which has been discussed in Regional Traveler Information above. However, CDOT ITS does have an agreement to obtain from E-470 PHA toll-tag information for the purpose of calculating travel times. Information must be encrypted however and discarded after two hours.

**Emergency Management:** While no formal agreements have been identified between the nongovernmental North-Central All Hazards Emergency Management Region (public safety) and the local cities and counties (transportation) that make up the Denver Regional Area, regional
collaboration is important to all emergency management efforts. Future coordination between the public safety community and the transportation community (e.g. ROSS) may require that mutual-aid agreements (as are common in the public safety community) will need to be developed.

**Commercial Vehicle Operations:** The Colorado Department of Revenue (DOR) is primarily responsible for Commercial Vehicle operation of the State’s Ports of Entry. Agreements between CDOR and CDOT and the PrePass electronic screening equipment vendor exist. Current agreements define operational guidelines, responsibilities for maintenance, and conditions relevant to access and handling of data. Additional agreements between CDOT and CDOR to enhance information and infrastructure sharing and coordination will be needed to improve efficiency and expand services as CDOR’s ITS capabilities and technology are improved. CDOR may also revise or add agreements with vendors to provide additional information from the PrePass and HELP truck bypass systems.
VI. Functional Requirements

The definition of functional requirements is a mandatory component of a regional ITS architecture as identified in the FHWA/FTA rules and policies. Functional requirements identify the tasks or activities that are, or will be, performed by each system or subsystem in the region. Detailed functional requirements are generally best left to project architectures or individual designs. At the regional architecture level, these functional requirements are high-level descriptions of the tasks derived from the operational concept. In the context of the National ITS Architecture, functional requirements can be stated in terms of Equipment Packages and implementable groupings of processes within a given subsystem (Equipment packages are the building blocks of the physical architecture subsystems and group similar processes of a particular subsystem together into an “implementable” package).

The major physical entities in the regional architecture and the equipment packages that define the functional requirements are:

**CDOT ITS Branch**

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

**Colorado Transportation Management Center**

- **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.
- **Collect Traffic Surveillance** - This equipment package remotely monitors and controls traffic sensors and surveillance (e.g., CCTV) equipment, and collects, processes and stores the collected traffic data. Current traffic information and other real-time transportation information is also collected from other centers. The collected information is provided to traffic operations personnel and made available to other centers.
- **Traffic Maintenance** - This equipment package monitors the operational status of field equipment and detects failures. It presents field equipment status to Traffic Operations Personnel and reports failures to the Maintenance and Construction Management Subsystem. The equipment package tracks the repair or replacement of the failed equipment. The entire range of ITS field equipment may be monitored by this equipment package including sensors (traffic, infrastructure, environmental, security, speed, etc.) and devices (highway advisory radio, dynamic message signs, automated roadway treatment systems, barrier and safeguard systems, cameras, traffic signals and override equipment, ramp meters, beacons, security surveillance equipment, etc.).
• **TMC Freeway Management** - This equipment package provides center monitoring and control of freeway traffic control systems including ramp control, interchange control, and mainline lane control systems. Approaches covered include ramp metering, interchange connector metering, overhead lane control signals, freeway mainline metering, and variable speed control systems.

• **TMC Traffic Information Dissemination** - This equipment package disseminates traffic and road conditions, closure and detour information, incident information, driver advisories, and other traffic-related data to other centers, the media, and driver information systems. It monitors and controls driver information system field equipment including dynamic message signs and highway advisory radio, managing dissemination of driver information through these systems.

• **TMC Incident Detection** - This equipment package identifies and reports incidents to Traffic Operations Personnel. It remotely monitors and controls traffic sensor and surveillance systems that support incident detection and verification. It analyzes and reduces the collected sensor and surveillance data, external alerting and advisory and incident reporting systems, anticipated demand information from intermodal freight depots, border crossings, special event information, and identifies and reports incidents and hazardous conditions.

• **TMC Incident Dispatch Coordination/Communication** - This equipment package formulates and manages an incident response that takes into account 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 Speed Monitoring** - This equipment package remotely monitors and controls speed monitoring and speed warning systems. It remotely monitors vehicle speeds and presents this information to traffic operations personnel. It configures and controls the speed monitoring and warning equipment that provides safe speed advisories to the motorist. This equipment package can also notify an enforcement agency if excessive speeds are identified.

• **Barrier System Management** - This equipment package remotely monitors and controls barrier systems for transportation facilities and infrastructure under control of center personnel. Barrier systems include automatic or remotely controlled gates, barriers and other access control systems. The equipment package also provides an interface to other centers to allow monitoring and control of the barriers from other centers (e.g., public safety or emergency operations centers).

• **TMC Evacuation Support** - This equipment package supports development, coordination, and execution of special traffic management strategies during evacuation and subsequent reentry of a population in the vicinity of a disaster or major emergency. A traffic management strategy is developed based on anticipated demand, the capacity of the road network including access to and from the evacuation routes, and existing and forecast conditions. The strategy supports efficient evacuation and also protects and optimizes movement of response vehicles and other resources that are responding to the emergency. This equipment package coordinates the evacuation with the Traffic Management Subsystem (representing centers in other affected jurisdictions) and the Emergency Management Subsystem.

• **TMC Environmental Monitoring** - This equipment package assimilates current and forecast road conditions and surface weather information using a combination of weather service provider information, information collected by other centers such as the Maintenance and Construction Management Subsystem, and data collected from environmental sensors deployed on and about the roadway. The collected environmental...
ITS Architecture for Denver Regional Area

information is monitored and presented to the operator. This information can be used to
issue general traveler advisories and support location specific warnings to drivers. Other
equipment packages process the collected information and provide decision support.

- **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 Traveler Data Collection** - This equipment package collects traveler-related data
  from other centers, consolidates, verifies, and refines the collected data, and makes this
data available in a consistent format to applications that deliver traveler information. A
broad range of traveler-related data is collected including traffic and road conditions,
transit data, emergency information and advisories, weather data, special event
information, traveler services, parking, multimodal data, and toll/pricing data. This
equipment package also shares data with other information service providers.

- **Traveler Telephone Information** - This equipment package services voice-based
  traveler requests for information that supports traveler telephone information systems like
511. The equipment package takes requests for traveler information, which could be
voice-formatted traveler requests, dual-tone multi-frequency (DTMF)-based requests, or
a simple traveler information request, and returns the requested traveler information in
the proper format. In addition to servicing requests for traveler information, this
equipment package also collects and forwards alerts and advisories to traveler telephone
information systems.

- **ISP Emergency Traveler Information** - This equipment package provides emergency
  information to the public, including wide-area alerts and evacuation information. It
  provides emergency alerts, information on evacuation zones and evacuation
  requirements, evacuation destinations and shelter information, available transportation
  modes, and traffic and road conditions at the origin, destination, and along the evacuation
  routes. In addition to general evacuation information, personalized information including
tailored evacuation routes, service information, and estimated travel times is also
  provided based on traveler specified origin, destination, and route parameters. Updated
  information is provided throughout the evacuation and subsequent reentry as status
  changes and plans are adapted.

- **MCM Work Activity Coordination** - This equipment package disseminates work
  activity schedules and current asset restrictions to other agencies. Work schedules are
  coordinated with operating agencies, factoring in the needs and activities of other
  agencies and adjacent jurisdictions. Work schedules are also distributed to Information
  Service Providers for dissemination to the traveling public.

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- **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.

- **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
ITS Architecture for Denver Regional Area

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 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 Traveler Data Collection** - This equipment package collects traveler-related data from other centers, consolidates, verifies, and refines the collected data, and makes this data available in a consistent format to applications that deliver traveler information. A broad range of traveler-related data is collected including traffic and road conditions, transit data, emergency information and advisories, weather data, special event information, traveler services, parking, multimodal data, and toll/pricing data. This equipment package also shares data with other information service providers.

- **Infrastructure Provided Dynamic Ridesharing** - This equipment package provides dynamic rideshare matches for eligible travelers, connecting riders and drivers for specific trips based on preferences. This ridesharing/ride matching capability also arranges connections to transit or other multimodal services for portions of a multi-segment trip that includes ridesharing. Reservations and advanced payment are also supported so that each segment of the trip may be confirmed.

**CDOT Region 1, 4 and 6 Traffic Operations**

- **Traffic Maintenance** - This equipment package monitors the operational status of field equipment and detects failures. It presents field equipment status to Traffic Operations Personnel and reports failures to the Maintenance and Construction Management Subsystem. The equipment package tracks the repair or replacement of the failed equipment. The entire range of ITS field equipment may be monitored by this equipment package including sensors (traffic, infrastructure, environmental, security, speed, etc.) and devices (highway advisory radio, dynamic message signs, automated roadway treatment systems, barrier and safeguard systems, cameras, traffic signals and override equipment, ramp meters, beacons, security surveillance equipment, etc.).

- **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 and are responsive to traffic conditions and adapt to support incidents, preemption and priority requests, pedestrian crossing calls, etc.

- **TMC HOV Lane Management** - This equipment package provides center monitoring and control of HOV lanes. It coordinates freeway ramp meters and connector signals with HOV lane usage signals to provide preferential treatment to HOV lanes. In advanced implementations, it automatically detects HOV violators.

- **TMC Regional Traffic Management** - This equipment package supports coordination between traffic management centers in order to share traffic information between centers as well as control of traffic management field equipment. This coordination supports wide area optimization and regional coordination that spans jurisdictional boundaries; for example, coordinated signal control in a metropolitan area or coordination between freeway operations and arterial signal control within a corridor.

- **Barrier System Management** - This equipment package remotely monitors and controls barrier systems for transportation facilities and infrastructure under control of center
personnel. Barrier systems include automatic or remotely controlled gates, barriers and other access control systems. The equipment package also provides an interface to other centers to allow monitoring and control of the barriers from other centers (e.g., public safety or emergency operations centers).

- **Standard Railroad 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 of an approaching train by interfaced wayside equipment. 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 Multimodal Coordination**—This equipment package supports center-to-center coordination between the Traffic Management and Transit Management Subsystems. It monitors transit operations and provides traffic signal priority for transit vehicles on request from the Transit Management Subsystem.

- **TMC Work Zone Traffic Management**—This equipment package coordinates work plans with maintenance systems so that work zones are established that have minimum traffic impact. Traffic control strategies are implemented to further mitigate traffic impacts associated with work zones that are established, providing work zone information on driver information systems such as dynamic message signs.

**CDOT Region 1, 4 and 6 Maintenance**

- **MCM Data Collection**—This equipment package collects and stores maintenance and construction information that is collected in the course of operations by the Maintenance and Construction 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.

- **MCM Incident Management**—This equipment package supports maintenance and construction participation in coordinated incident response. Incident notifications are shared, incident response resources are managed, and the overall incident situation and incident response status is coordinated among allied response organizations.

- **MCM Vehicle Tracking**—This equipment package tracks the location of maintenance and construction vehicles and other equipment. Vehicle location and associated information is presented to the operator.

- **MCM Vehicle and Equipment Maintenance Management**—This equipment package monitors vehicle and equipment condition, tracks maintenance history, and schedules routine and corrective maintenance based on vehicle utilization and availability schedules.

- **MCM Environmental Information Collection**—This equipment package collects current road and weather conditions using data collected from environmental sensors deployed on and about the roadway. In addition to fixed sensor stations at the roadside, this equipment package also collects environmental information from sensor systems located on Maintenance and Construction Vehicles as well as the broader population of vehicle probes. It also collects current and forecast environmental conditions information that is made available by other systems. The equipment package aggregates the sensor system data and provides it, along with data attributes to meteorological systems.
• MCM Automated Treatment System Control—This equipment package remotely monitors and controls automated road treatment systems that disperse anti-icing chemicals or otherwise treat a road segment. The automated treatment system may be remotely activated by this equipment package or it may include environmental sensors that activate the system automatically based on sensed environmental conditions. This equipment package monitors treatment system operation, sets operating parameters, and directly controls system activation if necessary.

• MCM Work Zone Management—This equipment package remotely monitors and supports work zone activities, controlling traffic through dynamic message signs (DMS), Highway Advisory Radio (HAR), gates and barriers, and informing other groups of activity (e.g., ISP, TM, other maintenance and construction centers) for better coordination management. Work zone speeds, and delays, and closures are provided to the motorist prior to the work zones. This equipment package provides control of field equipment in all maintenance areas, including fixed and portable field equipment supporting both stationary and mobile work zones.

• MCM Work Activity Coordination—This equipment package disseminates work activity schedules and current asset restrictions to other agencies. Work schedules are coordinated with operating agencies, factoring in the needs and activities of other agencies and adjacent jurisdictions. Work schedules are also distributed to Information Service Providers for dissemination to the traveling public.

CDOT Maintenance Vehicles

• MCV Vehicle Location Tracking—This on-board equipment package tracks vehicle location and reports the position and timestamp information to a dispatch center.

• MCV Environmental Monitoring—This on-board equipment package collects current road and surface weather conditions from sensors on-board the maintenance and construction vehicle or by querying fixed sensors on or near the roadway. Environmental information including road surface temperature, air temperature, and wind speed is measured and spatially located and time stamped, and reported back to a center.

CDOT Roadside Devices

• Roadway 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.

• Roadway Signal Priority—This equipment package includes the field elements that receive signal priority and/or signal preemption requests from vehicles approaching a signalized intersection and controls traffic signals accordingly. Depending on the type of request and implementation, this equipment package may override (preempt) current signal timing or delay phase transition. In signal priority systems, the request for priority may or may not be granted, based on the overall traffic situation at the intersection.

• Roadway Basic Surveillance—This equipment package monitors traffic conditions using fixed equipment such as loop detectors and CCTV cameras.

• Roadway Equipment Coordination—This equipment package supports direct communications between field equipment. It includes field elements that control and send data to other field elements. This includes coordination between remote sensors and field devices (e.g., Dynamic Message Signs) and coordination between the field devices.
themselves (e.g., direct coordination between traffic controllers that are controlling adjacent intersections.).

- **Roadway Signal Controls** - This equipment package includes the field elements that monitor and control signalized intersections. It includes the traffic signal controllers, signal heads, detectors, and other ancillary equipment that supports traffic signal control. It also includes field masters, and equipment that supports communications with a central monitoring and/or control system, as applicable. The communications link supports upload and download of signal timings and other parameters and reporting of current intersection status. This equipment package represents the field equipment used in all levels of traffic signal control from basic actuated systems that operate on fixed timing plans through adaptive systems. It also supports all signalized intersection configurations, including those that accommodate pedestrians.

- **Roadway Freeway Control** - This equipment package includes the field equipment used to control traffic on freeways including ramp meters, interchange connector meters, mainline meters, and lane control signals.

- **Roadway Traffic Information Dissemination** - This equipment package includes field elements that provides information to drivers, including dynamic message signs and highway advisory radio.

- **Roadway Speed Monitoring** - This equipment package includes the field elements that monitor vehicle speeds. If the speed is determined to be excessive, then roadside equipment can suggest a safe driving speed. Environmental conditions may be monitored and factored into the safe speed advisories that are provided to the motorist. The operational status (state of the device, configuration, and fault data) is provided to the center. This equipment package can also provide an enforcement function, reporting speed violations to an enforcement agency.

- **Field Barrier System Control** - This equipment package includes the field equipment that controls barrier systems used to control access to transportation facilities and infrastructure. Barrier systems include automatic or remotely controlled gates, barriers and other access control systems.

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**Denver TMC**

- **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.

- **Collect Traffic Surveillance** - This equipment package remotely monitors and controls traffic sensors and surveillance (e.g., CCTV) equipment, and collects, processes and stores the collected traffic data. Current traffic information and other real-time transportation information is also collected from other centers. The collected information is provided to traffic operations personnel and made available to other centers.

- **Traffic Maintenance** - This equipment package monitors the operational status of field equipment and detects failures. It presents field equipment status to Traffic Operations Personnel and reports failures to the Maintenance and Construction Management Subsystem. The equipment package tracks the repair or replacement of the failed equipment. The entire range of ITS field equipment may be monitored by this equipment package including sensors (traffic, infrastructure, environmental, security, speed, etc.) and devices (highway advisory radio, dynamic message signs, automated roadway treatment systems, barrier and safeguard systems, cameras, traffic signals and override equipment, ramp meters, beacons, security surveillance equipment, etc.).
- **TMC Traffic Information Dissemination** - This equipment package disseminates traffic and road conditions, closure and detour information, incident information, driver advisories, and other traffic-related data to other centers, the media, and driver information systems. It monitors and controls driver information system field equipment including dynamic message signs and highway advisory radio, managing dissemination of driver information through these systems.

- **TMC Incident Detection** - This equipment package identifies and reports incidents to Traffic Operations Personnel. It remotely monitors and controls traffic sensor and surveillance systems that support incident detection and verification. It analyzes and reduces the collected sensor and surveillance data, external alerting and advisory and incident reporting systems, anticipated demand information from intermodal freight depots, border crossings, special event information, and identifies and reports incidents and hazardous conditions.

- **TMC Incident Dispatch Coordination/Communication** - This equipment package formulates and manages an incident response that takes into account 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 Speed Monitoring** - This equipment package remotely monitors and controls speed monitoring and speed warning systems. It remotely monitors vehicle speeds and presents this information to traffic operations personnel. It configures and controls the speed monitoring and warning equipment that provides safe speed advisories to the motorist. This equipment package can also notify an enforcement agency if excessive speeds are identified.

- **Barrier System Management** - This equipment package remotely monitors and controls barrier systems for transportation facilities and infrastructure under control of center personnel. Barrier systems include automatic or remotely controlled gates, barriers and other access control systems. The equipment package also provides an interface to other centers to allow monitoring and control of the barriers from other centers (e.g., public safety or emergency operations centers).

- **Safeguard System Management** - This equipment package remotely monitors and controls safeguard systems for transportation facilities and infrastructure. Safeguard systems include blast shielding, exhaust systems and other automatic or remotely controlled systems intended to mitigate the impact of an incident. When access to a transportation facility is impacted by the activation of a safeguard system, travelers and appropriate subsystems are notified.

- **TMC Evacuation Support** - This equipment package supports development, coordination, and execution of special traffic management strategies during evacuation and subsequent reentry of a population in the vicinity of a disaster or major emergency. A traffic management strategy is developed based on anticipated demand, the capacity of the road network including access to and from the evacuation routes, and existing and forecast conditions. The strategy supports efficient evacuation and also protects and optimizes movement of response vehicles and other resources that are responding to the emergency. This equipment package coordinates the evacuation with the Traffic Management Subsystem (representing centers in other affected jurisdictions) and the Emergency Management Subsystem.

- **TMC Environmental Monitoring** - This equipment package assimilates current and forecast road conditions and surface weather information using a combination of weather service provider information, information collected by other centers such as the Maintenance and Construction Management Subsystem, and data collected from
ITS Architecture for Denver Regional Area

environmental sensors deployed on and about the roadway. The collected environmental information is monitored and presented to the operator. This information can be used to issue general traveler advisories and support location specific warnings to drivers. Other equipment packages process the collected information and provide decision support.

- **Traffic Maintenance** - This equipment package monitors the operational status of field equipment and detects failures. It presents field equipment status to Traffic Operations Personnel and reports failures to the Maintenance and Construction Management Subsystem. The equipment package tracks the repair or replacement of the failed equipment. The entire range of ITS field equipment may be monitored by this equipment package including sensors (traffic, infrastructure, environmental, security, speed, etc.) and devices (highway advisory radio, dynamic message signs, automated roadway treatment systems, barrier and safeguard systems, cameras, traffic signals and override equipment, ramp meters, beacons, security surveillance equipment, etc.).

- **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 and are responsive to traffic conditions and adapt to support incidents, preemption and priority requests, pedestrian crossing calls, etc.

- **TMC Regional Traffic Management** - This equipment package supports coordination between traffic management centers in order to share traffic information between centers as well as control of traffic management field equipment. This coordination supports wide area optimization and regional coordination that spans jurisdictional boundaries; for example, coordinated signal control in a metropolitan area or coordination between freeway operations and arterial signal control within a corridor.

- **TMC Multimodal Coordination** - This equipment package supports center-to-center coordination between the Traffic Management and Transit Management Subsystems. It monitors transit operations and provides traffic signal priority for transit vehicles on request from the Transit Management Subsystem.

- **MCM Work Activity Coordination** - This equipment package disseminates work activity schedules and current asset restrictions to other agencies. Work schedules are coordinated with operating agencies, factoring in the needs and activities of other agencies and adjacent jurisdictions. Work schedules are also distributed to Information Service Providers for dissemination to the traveling public.

**CSP, City, and County Emergency Operations Centers (EOC)**

- **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 Response Management** - This equipment package provides the strategic emergency response capabilities and broad inter-agency interfaces that are implemented for extraordinary incidents and disasters that require response from outside the local community. It provides the functional capabilities and interfaces commonly associated with Emergency Operations Centers. This equipment package develops and stores emergency response plans and manages overall coordinated response to emergencies. It monitors real-time information on the state of the regional transportation system including current traffic and road conditions, weather conditions, special event and
incident information. 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 also coordinates with the public through the Emergency Telecommunication Systems (e.g., Reverse 911). This equipment package coordinates with public health systems to provide the most appropriate response for emergencies involving biological or other medical hazards.

- **Incident Command** - The equipment package provides tactical decision support, resource coordination, and communications integration for Incident Commands that are established by first responders at or near the incident scene to support local management of an incident. The equipment package supports communications with public safety, emergency management, transportation, and other allied response agency centers, tracks and maintains resource information, action plans, and the incident command organization itself. Information is shared with agency centers including resource deployment status, hazardous material information, traffic, road, and weather conditions, evacuation advice, and other information that enables emergency or maintenance personnel in the field to implement an effective, safe incident response. This equipment package supports the functions and interfaces commonly supported by a mobile command center.

- **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 Dispatch** - This equipment package tracks the location and status of emergency vehicles and dispatches these vehicles to incidents. Pertinent incident information is gathered from the public and other public safety agencies (see the Emergency Call-Taking equipment package) and relayed to the responding units. Incident status and the status of the responding units is tracked so that additional units can be dispatched and/or unit status can be returned to available when the incident is cleared and closed.

- **Emergency Early Warning System** - This equipment package monitors alerting and advisory systems, information collected by ITS surveillance and sensors, and reports from other agencies and uses this information to identify potential, imminent, or in-progress major incidents or disasters. Notification is provided to other equipment packages that provide the emergency response, including public notification using ITS traveler information systems, where appropriate.

- **Emergency Evacuation Support** - This equipment package coordinates evacuation plans among allied agencies and manages evacuation and reentry of a population in the vicinity of a disaster or other emergency that poses a risk to public safety. Where appropriate, the affected population is evacuated in shifts, using more than one evacuation route, and including several evacuation destinations to spread demand and thereby expedite the evacuation. All affected jurisdictions (e.g., states and counties) at the evacuation origin, evacuation destination, and along the evacuation route are informed of the plan. The public is provided with real-time evacuation guidance including basic information to assist potential evacuees in determining whether evacuation is necessary. Resource requirements are forecast based on the evacuation plans, and the necessary resources are located, shared between agencies if necessary, and deployed at the right locations at the
appropriate times. The evacuation and reentry status are monitored and used to refine the plan and resource allocations during the evacuation and subsequent reentry. This equipment package communicates with public health systems to develop evacuation plans and recommended strategies for disasters and evacuation scenarios involving biological or other medical hazards.

RTD TOC

- **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 Center Vehicle Tracking** - This equipment package monitors transit vehicle location. The location information is collected via a data communication link between the transit vehicles and the transit center. The location information is presented to the transit operator on a digitized map of the transit service area. The location data may be used to determine real time schedule adherence and update the transit system’s schedule in real-time. The real-time schedule information is provided to Information Service Providers and the Transit Center Information Services equipment package, which furnish the information to travelers.

- **Transit Center Fixed-Route Operation** - This equipment package manages fixed route transit operations. It supports creation of schedules, blocks and runs for fixed and flexible route transit services. The package allows fixed-route and flexible-route transit services to disseminate schedules and automatically updates customer service operator systems with the most current schedule information. This equipment package also supports automated dispatch of transit vehicles. Current vehicle schedule adherence and optimum scenarios for schedule adjustment are also provided. This equipment package also receives and processes transit vehicle loading data.

- **Transit Center Multimodal Coordination** - The equipment package supports transit service coordination between transit properties and coordinates with other surface and air transportation modes. As part of service coordination, this equipment package shares schedule and trip information, as well as transit transfer cluster (a collection of stop points, stations, or terminals where transfers can be made conveniently) and transfer point information between Multimodal Transportation Service Providers, Transit Agencies, and ISPs. An interface to Traffic Management also supports travel demand management strategies.

- **On-board Transit Signal Priority** - This on-board equipment package provides the capability for transit vehicles to request signal priority at signalized intersections, ramps, and interchanges through short range communication directly with traffic control equipment at the roadside.

- **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, yellow pages, and special events. In addition to general service information, tailored information (e.g., itineraries) are provided to individual transit users.

- **Transit Evacuation Support** - This equipment package manages transit resources to support evacuation and subsequent reentry of a population in the vicinity of a disaster or
other emergency. It supports coordination of regional evacuation plans, identifying the transit role in a regional evacuation and identifying transit resources that would be used. During an evacuation, this equipment package coordinates the use of transit and school bus fleets, supporting evacuation of those with special needs and the general population. Transit service and fare schedules are adjusted and updated service and fare information is made available through traveler information systems. This equipment package coordinates the functions in other Transit equipment packages to support these requirements.

- **Transit Environmental Monitoring** - This equipment package assimilates current and forecast road conditions and surface weather information from a variety of sources, including both weather service providers and vehicle probes. The collected environmental information is monitored and forwarded to other agencies to more effectively manage transit operations.
VII. Interface Requirements

The Federal Rule requires that interface requirements and information exchanges be addressed with the context of a regional architecture. The National ITS Architecture defines information exchange or flow and architecture flow as terms that are used interchangeably regarding information that is exchanged between subsystems and terminators in the physical view of the National ITS Architecture, and the architecture flows are the primary tool that is used to define the regional ITS architecture interfaces. It would be impossible to show every relevant interface requirement and architecture flow in this Architecture associated with each agency’s respective identified Market Packages and Equipment Packages, however they are available in the Turbo Architecture software package. As an example, Figure 11 illustrates the interface requirements and data flows for the Market Package ITS Data Mart (AD1) and associated Equipment Packages. The Turbo Architecture database for the Denver Regional Area is available to the ITS Working Group on the ITS Program SharePoint website (https://sharepoint.drcog.org/sites/ITS/default.aspx)

Figure 11 – ITS Data Mart Architecture Flow Chart

Source: National ITS Architecture Version 6.0
VIII. ITS Standards

ITS Standards facilitate interoperability and integration of ITS devices and systems

“The U.S.DOT ITS Standards Program is working toward the widespread use of standards to encourage the interoperability of ITS systems. Through cooperative agreements with five standards development organizations (SDOs), the Standards Program is accelerating development of about 100 non-proprietary, industry-based, consensus ITS standards, and is encouraging public-sector participation in the development process.

The Standards Program is maturing from a primarily standards development program to a standards deployment program by rapidly moving into standards deployment support. Such support includes helping to build credibility in the standards through testing and case studies, providing standards resource information, supporting training and technical assistance to deployers, developing deployment experience-based guidance such as ‘lessons learned’, and assessing the readiness of standards for deployment.”

In addition, the federal regulations require that ITS projects funded with federal funds must use USDOT federally-adopted ITS standards:

“All ITS projects funded with highway trust funds shall use applicable ITS standards and interoperability tests that have been officially adopted through rulemaking by the DOT.”

To date, none of the ITS standards have been adopted by the USDOT, but it behooves the region to prepare for that action. This does not, however, suggest that the region will immediately migrate to all available standards, only that the region understand the impact of adoption of standards within the deployment cycle for an ITS system. For example, choosing to use a standard related to systems not yet deployed will potentially be less of an impact than for systems that are already deployed with equipment and communications that do not conform to the standard.

The ITS standards govern communications between the interfaces listed in Table 14 between various ITS subsystems as defined in the National ITS Architecture. The ITS standards are also grouped into 21 application areas of which only two (Rail Coordination and Lighting Management) are not addressed in this regional architecture.

Several of the data flows between subsystems identified in the National ITS Architecture are associated to appropriate ITS standards. For example, the DMS sign controller software developed for CDOT is compliant with the standard “National Transportation Communications for ITS Protocol (NTCIP) 1203 – Object Definitions for Dynamic Message Signs”. Use of this standard enables one software driver to communicate with NTCIP-compliant DMS signs from different vendors.

In Table 15, candidate standards (or standards that may be applicable to this architecture) have been identified. The table also lists candidate standards that have been identified in the Colorado ITS Standards Plan – Statewide (Version 0.1) as standards adopted for use by the state will impact this region directly. The standards currently in use are also identified. Finally, a priority is assigned to each of the candidate standards. The priority indicates the level of consideration to

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6 Code of Federal Regulations Section 23, Part 940.11 (f)
be applied to the standard during ITS project development in the region. The priority ranking was developed based on the following general guidance:

- **H**
  - highest strategic priority for subsystem interconnection related to standard
  - communications link does not yet exist and no standards in the region have been established, which is an opportunity to consider the standard for use before development begins
  - involves interagency communications

- **M**
  - not the highest strategic priority for subsystem interconnection related to standard
  - a (non-conforming) standard may already be established in the region
  - involves interagency communications

- **L**
  - lowest strategic priority for subsystem interconnection related to standard
  - a (non-conforming) standard may already be established in the region
  - does not involve interagency communications

- **N/A**
  - standard not applicable to this architecture at this time

**Table 14 – ITS Standards Application Areas Table**

<table>
<thead>
<tr>
<th>National ITS Architecture Interface Class</th>
<th>Standards Application Areas</th>
</tr>
</thead>
</table>
| **Center to Center** – This class of application areas includes interfaces between transportation management centers. | Data Archival  
Incident Management  
Rail Coordination  
Traffic Management  
Transit Management  
Traveler Information |
| **Center to Field** – This class of application areas includes interfaces between a management center and its field equipment (e.g., traffic monitoring, traffic control, environmental monitoring, driver information, security monitoring, and lighting control). | Data Collection/Monitoring  
Dynamic Message Signs  
Environmental Monitoring  
Lighting Management  
Ramp Metering  
Traffic Signals  
Vehicle Sensors  
Video Surveillance |
| **Center to Vehicle/Traveler** – This class of application | Mayday |

Source: US DOT ITS Standards Program web site (http://standards.its.dot.gov/learn_Application.asp)

Note: Not all possible application areas in the National ITS Architecture are included in the table. This is because not all application areas are currently represented by an approved or published ITS standard. As additional standards become available, USDOT will add more application areas to the table.
areas includes interfaces between a center and the devices used by drivers or travelers. It includes interfaces with motorists and travelers for exchange of traveler and emergency information as well as interfaces between management centers and fleet vehicles to support vehicle fleet management.

<table>
<thead>
<tr>
<th><strong>Transit Vehicle Communications</strong></th>
<th><strong>Traveler Information</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Field to Field</strong> – This class of application areas includes interfaces between field equipment, such as between wayside equipment and signal equipment at a highway rail intersection.</td>
<td><strong>Highway Rail Intersection (HRI)</strong></td>
</tr>
</tbody>
</table>
| **Field to Vehicle** – This class of application areas includes wireless communication interfaces between field equipment and vehicles on the road. | **Probe Surveillance**  
**Signal Priority**  
**Toll/Fee Collection** |

The regional stakeholders will carry forward ITS deployment while tracking the status of the candidate standards. When potentially applicable to an ITS project, stakeholders will evaluate the feasibility and suitability of adopting use of the standards. This is the initial step in an on-going process to identify and adopt ITS standards. The next update of the architecture will further define the process in a specific standards plan that will identify:

- An assessment of current standards use – this will be an inventory of the use of each standard both in the region and statewide.
- An assessment to prioritize subsystem interfaces – this will be a comprehensive evaluation and prioritization of the subsystem interfaces.
- An assessment of the potential standards use – this will be an assessment of the applicability of each standard to the architecture. Also, it will include an assessment of the “maturity” of the standard. Maturity will be defined by factors such as the level of adoption by vendors and other users, standard testing results, pending adoption by the USDOT, and the stability of the version of the standard (i.e. are significant amendments anticipated?)
- A migration strategy – the migration strategy will define the new standards that will be adopted and deployed and it will define the transition plan to new standards for existing system. Several factors will be considered in the development of the migration strategy, including: migration strategy of standards at the state level, standard maturity, cost implications of standard adoption (or not adopting), and project sequencing.
<table>
<thead>
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<th>Status</th>
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IX. Strategic Project Application Implementation

The ITS Working Group identified several transportation service areas in which ITS can directly address the regional transportation problems. These transportation services areas are listed below in the priority to be considered for deployment. Further detail is provided in Figure 12, which summarizes the priorities for deployment of the ITS applications within the region, grouped by transportation service area. Priority is suggested by the location of the item in the figure: Items nearer to the top left corner of the figure have higher emphasis for implementation than items nearer to the bottom right corner.

1. **Regional Traveler Information** – Regional traveler information involves a variety of systems that collect and process transportation data then distribute the information to the public. It includes such information as: traffic conditions, travel times, incident locations, construction closures, weather condition, transit operations, and alternative travel options. The regional vision is to consolidate access to all traveler information sources through CDOT’s traveler information system consisting of the 511 phone system and the CoTrip.org website. This information will also be available for redistribution through other means such as traveler information kiosks, personalized e-mail or text messaging, mobile access, third party traveler information, etc.

2. **Regional Transportation Operations & Management** – Regional transportation management provides coordinated transportation monitoring, response, and control functions. Regional partners will collect local data and control their local transportation systems while sharing the data through a display system that offers a regional view of traffic operations (e.g. website). This view will give transportation managers the opportunity to cooperate and respond quickly with management strategies that benefit regional travelers.

3. **Regional Traffic Incident Management** – Traffic incident management requires coordination between transportation managers as well as the cooperation of the public safety community. Currently, they have cooperated in the development and use of corridor-level incident management plans (IMPs), but one regional-level incident management plan is envisioned for the future. This plan will have the transportation managers using ITS devices to detect and verify incidents and will disseminate traveler information regarding the incident. Public safety personnel will be responsible for incident site management and incident clearance while coordinating with transportation managers.

4. **Transit Operations & Management** – Specific coordination between transit operations and other transportation managers is key to the regional traveler information and the regional transportation operations service areas above. ITS investment in transit operations is intended to improve the operational efficiency and public attractiveness of transit.

5. **Maintenance and Construction** – ITS activities will include: coordination in planning and notification for maintenance and construction activity; roadway maintenance systems that are supported by weather data collection; and, the capability to monitor ITS devices from remote locations, thus allowing quick and managed dispatch for repair.

6. **Regional Parking Management** – ITS parking management strategies include pricing mechanisms and the distribution of real-time information regarding the availability of parking. Parking facilities will be equipped to automatically track the parking
availability. This information may also be tied to electronic parking fee collection systems, possibly integrated with systems used on regional toll highways.

7. **Regional Data Management** – ITS inherently collects a lot of data that may be useful to operators, traffic engineers, planners, and researchers. A regional network of data collection sites will be the source of transportation data to be archived in a central web-based data warehouse hosted by DRCOG.

8. **Regional Emergency Management** – Regional Emergency management includes security and evacuation to support Department of Homeland Security initiatives including the *National Response Framework* and the *National Infrastructure Protection Plan*. The public safety community leads these initiatives in this region; the transportation community offers support through traveler information and transportation operations.

9. **Commercial Vehicle Operations** – Activities may involve the implementation of additional ITS devices and systems to improve traveler information, operational safety, commercial vehicle monitoring and inspections and administration of commercial vehicle operations.
ITS Architecture for Denver Regional Area

Figure 12 – ITS Transportation Service Area Project Application Summary

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<th>Type</th>
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<th>Medium Term 5-10 Years</th>
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| Regional Traveler Information | • consolidate access to regional traveler information (include freeways, arterials, transit and transportation alternatives)  
• expand probe surveillance on freeways  
• implement pilot probe surveillance on arterials | • implement dynamic real-time traveler information  
• expand participation in consolidated traveler information  
• expand network surveillance coverage on freeways  
• expand network surveillance on emphasis arterials  
• expand probe surveillance on arterials  
• deploy additional DMS of freeways and emphasis arterials | • expand participation in regional operations display and coordination (as new TMCs are deployed)  
• expand ramp meters as warranted  
• expand TSP deployment as desired  
• deploy speed monitoring as needed |
X. Architecture Maintenance Process

Federal regulations require the preparation of a regional ITS architecture also define procedures and processes to maintain the architecture as needs and conditions evolve in the region. As ITS projects are implemented, the regional needs and priorities may change and evolve and new ITS projects that were not be reflected in the regional ITS architecture may be identified. This section describes the procedures and processes to maintain the ITS Architecture for the Denver Regional Area.

The ITS Architecture for the Denver Regional Area consists of two items:

- Turbo Architecture Database version 4.0: The Turbo Architecture database is the key element describing the ITS architecture.

The architecture maintenance process has two types of updates as described below: annual administrative updates and full document updates.

Annual Administrative Update Process

The annual administrative update process involves relatively minor updates to the regional ITS architecture (i.e. a municipality identifies a project involving ITS that is not reflected in the regional ITS architecture). These updates will recorded only in the Turbo Architecture database – the ITS architecture document will not be updated.

All ITS stakeholders, members of the ITS Working Group, share the responsibility for maintaining the Regional ITS Architecture. DRCOG will lead the process and will be responsible for recording the changes that are adopted. The ITS stakeholders will be responsible for making change requests to DRCOG, as required. They will also be responsible for reviewing and commenting on the proposed change requests that DRCOG distributes for review.

A small Change Management Team (CMT) composed of staff from DRCOG, CDOT and FHWA will assist in annual administrative update. The CMT will evaluate change requests and determine the impacts to the regional ITS architecture.

There are four steps involved in the annual administrative update process:

1. The ITS Stakeholder submits a change request form to DRCOG: Examples of the types of changes that may be submitted are:
   - Changes in regional boundaries
   - Addition of stakeholders
   - Changes in operational concepts
   - ITS deployment update
   - Changes in projected definition
   - Changes in element names
   - Changes in regional needs
   - Change in application of standards
2. The CMT evaluates the change request for impacts on the regional ITS architecture and considers the change within the context of the Denver Regional Intelligent Transportation Systems Strategic Plan. The results of the evaluation are recorded in the change management database, which is updated on the SharePoint website and notification of the proposed change is issued to the ITS Working Group.

3. For each approved change request, a change request summary is circulated to the ITS Working Group for review. The review period is 4 weeks. All comments on the change request summary are returned to DRCOG for further review by the CMT. If the ITS Stakeholder comments result in minor revisions to the change request, the CMT will proceed to make the change. If the comments result in major revisions, the CMT will revise the change request summary accordingly and reissue the summary for another review.

4. DRCOG will record approved change requests in the Turbo Architecture database, which will be updated on the SharePoint website. The ITS Working Group will be notified of the change.

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**Full Document Update Process**

A full document update involves the complete review and potential update of all elements of the regional ITS architecture including both the Turbo Architecture database and the ITS Architecture for the Denver Regional Area document. These updates will be prompted by any of the following three events:

- the National ITS Architecture is updated (updates are completed as required);

- the DRCOG Regional Intelligent Transportation Systems Pool allocation exercise (the next allocation exercise is scheduled for fall 2008); or,

- the Denver Regional Intelligent Transportation Systems Strategic Plan is updated (the next update is scheduled for spring of 2011).

When any of these events occur, DRCOG will set up a workshop to allow the ITS Working Group to discuss changes in any element of the regional ITS architecture.

**Administrative Support Tools**

To assist in the leadership of the architecture maintenance process, DRCOG will make available the following documents on a secure website that will provide access to only ITS stakeholders. The following items will be made available on the SharePoint website:

- a change request form;

- a current summary of the change management database;
• the current Turbo Architecture database (which will be denoted by version numbers);
• the current version of the ITS Architecture for the Denver Regional Area;
• the current version of the Denver Regional Intelligent Transportation Systems Strategic Plan; and,
• the library of currently available ITS Standards.
## Appendix A – ITS working Group (Regional Stakeholders)

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✓ indicates participation in the workshop.