REGIONAL ARCHITECTURE FOR WESTERN COLORADO
INTELLIGENT TRANSPORTATION SYSTEM
Colorado Department of Transportation
Regional ITS Architecture for Western Colorado

November 2006
Regional Intelligent Transportation Systems Architecture for Western Colorado

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URS Project Number 22237128
November 2006
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# ACRONYMS AND ABBREVIATIONS

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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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<tr>
<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>AVL</td>
<td>Automated Vehicle Location</td>
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<td>AVSS</td>
<td>Advanced Vehicle Safety Systems</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>COGJ</td>
<td>City of Grand Junction</td>
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<td>CSP</td>
<td>Colorado State Patrol</td>
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<tr>
<td>CSTMC</td>
<td>Colorado Springs Traffic Management Center</td>
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<td>CTMC</td>
<td>Colorado Transportation Management Center</td>
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<tr>
<td>CVO</td>
<td>Commercial Vehicles Operations</td>
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<td>DOIT</td>
<td>Department of Information Technology</td>
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<tr>
<td>DRCOG</td>
<td>Denver Regional Council of Governments</td>
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<tr>
<td>DTR</td>
<td>Digital Truck Radio</td>
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<tr>
<td>DVR</td>
<td>Digital Video Recorders</td>
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<td>ECO</td>
<td>Eagle County Regional Transportation Authority</td>
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<td>EJ</td>
<td>Eisenhower-Johnson Tunnel</td>
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<td>EM</td>
<td>Emergency Management</td>
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<td>Emergency Operations Center</td>
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<td>ES</td>
<td>Executive Summary</td>
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<td>FHWA</td>
<td>Federal Highway Administration</td>
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<td>FTA</td>
<td>Federal Transit Authority</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>Grand Valley Transit</td>
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<td>HAR</td>
<td>Highway Advisory Radio</td>
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<td>HLT</td>
<td>Hanging Lake Tunnel</td>
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<td>ITS</td>
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<td>MCM</td>
<td>Maintenance and Construction Management</td>
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<tr>
<td>MP</td>
<td>Market Package</td>
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<tr>
<td>MPO</td>
<td>Metropolitan Planning Organization</td>
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<tr>
<td>NRF</td>
<td>North Front Range</td>
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<tr>
<td>O&amp;M</td>
<td>Operations and Management</td>
</tr>
<tr>
<td>PDA</td>
<td>Personal Digital Assistant</td>
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<tr>
<td>POE</td>
<td>Port of Entry</td>
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<td>Roaring Fork Transit Authority</td>
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<td>RWIS</td>
<td>Road and Weather Information Systems</td>
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<td>STIP</td>
<td>Statewide Transportation Improvement Plan</td>
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<td>SWTTPR</td>
<td>Southwest Transportation Planning Region</td>
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<tr>
<td>TPR</td>
<td>Transportation Planning Region</td>
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<tr>
<td>UP</td>
<td>Union Pacific</td>
</tr>
<tr>
<td>VMS</td>
<td>Variable Message Sign</td>
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<tr>
<td>WIM</td>
<td>Weigh-In-Motion</td>
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Executive Summary

This architecture for intelligent transportation systems (ITS) in Western Colorado 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 CDOT Region 3 and Region 5 over the next 10 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.

Based on discussion with stakeholders during the architecture process the vision for ITS in Western Colorado is to:

*Improve the mobility, safety, and comfort of the multi-modal transportation system and support economic development in the Project Area while protecting the natural environment through real-time management of the transportation system and providing reliable, timely and accurate traveler information to all users of the system.*

A. Project Area

The project area consists of CDOT Region 3 and Region 5 (Figure ES-1), and includes all of the counties on the Western Slope within these two Regions. It also includes the areas of North Park, the San Luis Valley, and the Upper Arkansas River Valley. Region 3 and Region 5 have been combined for this plan since all the ITS devices that CDOT manages and operates are controlled from the Hanging Lake Tunnel Transportation Management Center (HLT TMC). Furthermore, due to the geography, Region 3 and Region 5 have similar issues and needs with respect to ITS. Combining the two CDOT Regions creates a number of synergies for ITS planning purposes. Western Colorado is a mix of rural, small urban areas and one urbanized area characterized by the following:

- The Project Area is predominantly mountainous and rural, with a sparse roadway network and lack of extensive power and communications infrastructure;
- Western Colorado is known for its scenic and natural resources, drawing visitors from around the world;
- The tourism and recreation industries provide significant economic benefits to the Project Area, as well as generate significant travel demands;
- A large array of wildlife abounds, including several large animal species such as moose, elk, deer, bear and mountain lion, which has resulted in significant numbers of animal/vehicle collisions;
- Due to the geography of the area, characteristics such as steep grades, sharp curves, and narrow roads with minimal or no shoulders are common;
Every major corridor crosses one or more mountain passes, which are subject to sudden unexpected closures due to weather and other natural events, such as rockslides or avalanches;

There is a wide mix of users including: rural-based travel, urban-based travel, through travel, and commercial travel;

I-70 is the dominant east-west corridor, carrying almost half of all east-west vehicular travel, while major state highways carry the overwhelming majority of the remaining east-west travel;

There are no continuous north-south corridors, which impacts and sometimes limits travel options;

Grand Junction is the only major urbanized area. The small urban population centers, of which Durango is the major hub in the southwestern part of the State, are mostly isolated mountain communities with few transportation links between population centers;

Long distances separate many destinations with varying levels of services in between;

There are few alternate or detour routes available;

Long-haul trucking represents a large percentage of travel on many routes;

Periodic congestion occurs in the built up areas, especially associated with holidays and weekends.
Figure ES-1. Project Area
(CDOT Regions 3 and 5)
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 Regional Transportation Plans (for more detail see Section II.C.) that were developed for each of the Transportation Planning Regions in the Project Area, and other local transportation plans.

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

- Weather and crash related incidents on I-70 cause major disruption to travel in the Project Area and statewide;
- Weather related closures on mountain passes occur frequently and sometimes suddenly, leading to delay and inconvenience for travelers and increased expense for freight trucking;
- Traffic congestion in Grand Junction is growing and will become a major issue if not proactively addressed;
- Traffic congestion is becoming a major issue in mountain communities—especially Durango, Steamboat Springs, Vail/Avon, and the State Highway 82 corridor from Glenwood Springs to Aspen – leading to delay, safety concerns and increased pollution emissions, and disruption to the economy;
- Transportation impacts due to special events, such as festivals, outdoor sporting events, and bicycle rides, affect participants in the events, local residents, and travelers passing through the area;
- Non-recurring congestion from incidents is a major problem due to limited alternate or detour routes;
- Limited law enforcement invites excess speed and other safety infractions;
- Long distances, limited route choices and geographic constraints impede rapid emergency response in rural areas;
- Collisions with wildlife are a significant safety issue endangering lives, damaging wildlife populations, and disrupting the transportation system. On some sections of road, such collisions represent as much as 50% of all accidents;
- Natural or manmade emergencies, such as wildfires, rock slides, and avalanches occur suddenly and without warning, disrupting the transportation system and leading to delay, inconvenience, and economic impacts;
- Homeland security issues have become a new concern for all transportation systems. ITS must be protected from intrusion and made available to security officials;
- Maintenance of ITS is a critical issue. As ITS becomes more common, the public relies on it more; therefore, downtime due to maintenance and repair becomes even more disruptive. Furthermore, by their very nature, the electronics required for ITS have greater ownership and maintenance costs (as a percentage of construction) than typical roadways and bridges.
Regional ITS Architecture for Western Colorado CDOT Region 3 and Region 5

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- Transit in the area is limited and does not allow for free access without private motor vehicles for many of the mountain communities;

- There exists a lack of power and communications infrastructure that would support timely notice of events through ITS technology and adds to traffic delays.

C. Core ITS Services

Based on analysis of the major needs in the Project Area, discussions with stakeholders, and review of other transportation and ITS plans as mentioned earlier, six core ITS services have been identified to address regional issues and needs.

Incident Management – Relates to the management of recurring and non-recurring disruptions to traffic due to crashes, weather, or other natural causes. The goals of incident management are to detect, verify and reduce the response time and the time required to clear the accident as well as using traveler information to suggest alternate routes for traffic during the incident. Due to the large distances and limited infrastructure, incident management in Western Colorado will be focused on I-70, major mountain passes, and locations of frequent special events. In rural areas, close coordination with county emergency management groups will facilitate incident management planning and responses.

Traveler Information – Refers to the collection and dissemination of road condition data so that travelers can make choices regarding the time, route and mode for their travel. This includes providing information before travelers depart as well as while en-route. CDOT currently operates a statewide traveler information system consisting of interactive web and an automated phone system, which is 511 capable, cell phone and PDA based services, as well as broadcast fax and e-mail announcements. Information is also disseminated in the field via message boards and highway advisory radios.

Arterial Traffic Management – Involves the management of traffic on arterial roadways to improve the efficiency of the system for all users. It includes active traffic signal management strategies, video surveillance, traffic volume and speed sensors, and the selective use of information dissemination through variable message signs and advisory radios.

Transit Management and Multi-modal Coordination – Transit agencies in Western Colorado vary greatly in the size, sophistication, and resources. Some agencies will employ highly sophisticated management strategies while others will choose simpler, less costly approaches. The types of transit management tools available include: automated fare collection, automated vehicle location, passenger security systems, real-time transit traveler information, automated annunciator systems, and automated scheduling systems. In addition, transit signal priority systems are a priority in heavy transit corridors such as SH-82 and possibly SH-6 through Eagle County.

Safety Management – Refers to the several strategies used to reduce the number and severity of crashes. In Western Colorado, a major focus is on reducing the response time for emergency services. Studies have shown that the ability to reduce the severity of accidents...
accidents increases dramatically as the response time approaches and exceeds one hour. Strategies are proposed to shorten the reporting time and to facilitate quicker dispatch and response. Also, a significant cause of crashes in Western Colorado is collisions with wildlife. Systems have been deployed and others are being developed. The goal of these systems is to automatically detect wildlife and alert drivers for the purpose of preventing crashes.

**Communications and Connectivity** – Intelligent transportation systems are dependent on communications to collect and transmit sensor data from the field to management centers where it can be processed and to transmit information between various centers. Providing high-speed communication between centers and along key corridors is essential for the effective operation of ITS. Also, the sharing of data, especially between different functional centers can significantly improve the quality of the ITS. Emergency Management Centers need video data from CDOT so they can rapidly assess situations and respond in the most appropriate way. Communities and transit agencies need more direct access to CDOT road and weather information so they can provide better, more user specific, travel information to their patrons. CDOT needs reliable, accurate local information from other stakeholders to improve the quality of the traveler information CDOT provides.

**D. Market Packages**

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 Architecture and are tailored to fit - separately or in combination - real world transportation problems and needs. Market packages identify physical ITS elements that are required to implement a particular transportation service.

Market packages for the study 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:

**Advanced Traffic Management Systems (ATMS):** Manage operation of the roadway network.

- Network Surveillance (exist.)
- Surface Street Control (exist.)
- Freeway Control (exist.)
- HOV Lane Management (prop.)
- Traffic Information Dissemination (exist.)
- Regional Traffic Control (proposed)
- Incident Management System (exist.)
- Standard Railroad Grade Crossing (exist.)
• Reversible Lane Management (exist.)
• Speed Monitoring (exist.)
• Roadway Closure Management (prop.)

**Advanced Traveler Information Systems (ATIS):** Provide real-time information to travelers.

• Broadcast Traveler Information (exist.)
• Interactive Traveler Information (exist.)

**Advanced Public Transportation Systems (APTS):** Manage transit operations and make transit use more convenient and safe.

• Transit Vehicle Tracking (prop.)
• Transit Fixed-Route Operations (exist.)
• Demand Response Transit Operations (exist.)
• Transit Passenger and Fare Management (prop.)
• Transit Security (prop.)
• Transit Maintenance (prop.)
• Multi-modal Coordination (prop.)
• Transit Traveler Information (exist.)

**Emergency Management (EM):** Manage emergency response operations.

• Emergency Response (exist.)
• Emergency Routing (prop.)
• Mayday Support (exist.)
• Transportation Infrastructure Protection (prop.)
• Wide-Area Alert (exist.)
• Early Warning System (exist.)
• Disaster Response and Recovery (exist.)
• Evacuation and Re-entry Management (exist.)
• Disaster Traveler Information (exist.)

**Maintenance and Construction Management (MCM):** Manage maintenance and construction activities and operations.

• Maintenance and Construction Vehicle and Equipment Tracking (prop.)
• Maintenance and Construction Vehicle Maintenance (prop.)
• Road Weather Data Collection (exist.)
• Weather Information Processing and Distribution (exist.)
• Roadway Automated Treatment (exist.)
• Winter Maintenance (exist.)
• Roadway Maintenance and Construction (exist.)
• Work Zone Management (prop.)
• Work Zone Safety Monitoring (prop.)
• Maintenance and Construction Activity Coordination (prop.)
Archived Data Management (AD): Store and retrieve transportation system information for future analysis.

- ITS Data Mart (prop.)
- ITS Virtual Data Warehouse (prop.)

The National ITS Architecture contains two additional service areas, Commercial Vehicle Operations and Advanced Vehicle Safety Systems, which are not included in this regional architecture. Commercial Vehicle Operations, while important, are a statewide issue and are more appropriately addressed in the statewide architecture. While Advanced Vehicle Safety Systems may become significant in the future, they do not directly interface with the infrastructure in Western Colorado at this time; hence, they are not relevant to this regional architecture within the stated time frame.

E. Roles and Responsibilities

Several stakeholders are involved in ITS in western Colorado. The principle stakeholders and their primary roles and responsibilities are given below:

The CDOT HLT TMC functions as the traffic management center for western Colorado and is responsible for control of all devices in the region except traffic signals. This includes collecting information from sensors and cameras, controlling gates and lane use signs, and posting messages on DMS and HAR. HLT TMC provides camera images and real-time travel information data to transit service providers. HLT TMC also functions as the single point of contact for CDOT for incident management purposes. This streamlines coordination between emergency response forces and CDOT resources.

The CTMC manages the statewide traveler information system as well as functioning as a surrogate for Information Service providers. In the latter role, public information offices at CTMC provide all coordination with media. CTMC staff also update the CoTrip website, disseminate broadcast fax and email, update the 511 and telephone advisory system, and place messages on DMS and HAR outside the region as needed. CTMC also will provide secure video images to the EOC to support real-time decision-making at the EOC or incident command post. The current vision is that these images would be available over a secure Internet link, but this detail requires further study.

County EOCs function as the Emergency Management Centers as described in the architecture. The EOCs are considered to include the 911-Dispatch from a logical perspective. While this may not be physical accurate, from a functional perspective, it is generally true and the difference has little effect on the architecture. The EOC is responsible for receiving reports of an incident and dispatching the appropriate response. The EOC is also responsible for incident command and coordination of needed resources.

Emergency responders and CSP are primarily concerned with response to and clearing of the incident. They provide an initial assessment of the incident, take control of the scene, and initiate the appropriate incident management plans. They also determine any
necessary lanes closures and when to reopen lanes to traffic. This includes determining
the need to establish detours and alternate routes.

**CDOT Region 3 and Region 5 Maintenance** forces provide resource 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. 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.

**Transit service providers** (RFTA, GVT, ECO) manage transit systems in the region.
They provides transit traveler information via a website and telephone. The vision for the
region also includes transit traveler information at stops and on vehicles. Providers will
also be responsible for communicating transit vehicle location to transit signal priority
system where appropriate. Providers may also acquire camera images and real-time
travel information from HLT TMC to use for estimating transit arrival times. In addition,
transit vehicles may be used as probes to provide travel data to HLT TMC.

**CDOT Region 3 and Region 5 Traffic** are responsible for operation and maintenance of
the traffic signals, including the signal side of the transit signal priority system. For
simplicity sake, this stakeholder is assumed to include the traffic signal maintenance
forces as well.

The **City of Grand Junction Traffic** manages the city’s traffic signal system as well as the
Riverside Parkway traffic management system, which includes cameras and traffic
volume and speed detectors. Grand Junction also manages several signals on the state
highway system. The City makes provides access to its fiber optic network to CDOT as
well as providing camera images and traffic data.

### F. Functional Requirements

Functional requirements are one of the mandatory components 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 design. At the regional architecture level these 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, implementable groupings of processes within a given subsystem.

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
- ITS Data Repository
Regional ITS Architecture for Western Colorado

CDOT Region 3 and Region 5

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- Traffic and Roadside Data Archival
- Virtual Data Warehouse Services

**Hanging Lake Tunnel TMC**

- Traffic Data Collection
- Collect Traffic Surveillance
- Traffic Maintenance
- TMC Freeway Management
- TMC HOV Lane Management
- TMC Traffic Information Dissemination
- TMC Incident Detection
- TMC Incident Dispatch Coordination/Communication
- TMC Reversible lane Management
- TMC Speed Monitoring
- Barrier System Management
- Safeguard System Management
- TMC Evacuation Support
- TMC Environmental Monitoring

**CDOT Region 3 and Region 5 Traffic**

- Traffic Maintenance
- TMC Signal Control
- TMC Regional Traffic Control
- TMC Multimodal Coordination
- TMC Work Zone Traffic Management

**The Colorado Transportation Management Center**

The CTMC functions as both an ISP and as a backup traffic management center. As backup traffic management center it requires all the Equipment Package that HLT TMC requires as well as the following:

- ISP Data Collection
- Basic Information Processing
- ISP Traveler Data Collection
- Traveler Telephone Information
- ISP Emergency Traveler Information

**CDOT Region 3 and Region 5 Maintenance**

- MCM Data Collection
- MCM Incident Management
- MCM Vehicle Tracking
- MCM Vehicle and Equipment Maintenance Management
- MCM Environmental Information Collection
- MCM Automated Treatment System Control
- MCM Work Zone Management
- MCM Work Activity Coordination

**CDOT Maintenance Vehicles**
- MCV Vehicle Location Tracking
- MCV Environmental Monitoring

**CDOT Roadside Devices**
- Roadway Data Collection
- Roadway Signal Priority
- Roadway Basic Surveillance
- Roadway Equipment Coordination
- Roadway Signal Controls
- Roadway Freeway Control
- Roadway HOV Control
- Roadway Traffic Information Dissemination
- Roadway Reversible Lanes
- Roadway Speed Monitoring
- Field Barrier System Control

**Grand Junction Traffic**
- Traffic Maintenance
- TMC Signal Control
- TMC Regional Signal Control
- TMC Multimodal Coordination

**CSP and County EOCs**
- Emergency Data Collection
- Emergency Response Management
- Incident Command
- Emergency Call-Taking
- Emergency Dispatch
- Emergency Early Warning System
- Emergency Evacuation Support

**Transit Management (GVT, RFTA, ECO)**
Each transit agency is somewhat different in the range ITS User Services it plans on deploying. Many of these services do not require any external coordination. Functional requirements derived from services requiring external coordination include:
- Transit Data Collection
- Transit Center Vehicle Tracking
- Transit Center Fixed-Route Operation
- Transit Center Multimodal Coordination
• On-board Transit Signal Priority
• Transit Center Information Services
• Transit Evacuation Support
• Transit Environmental Monitoring

G. **Recommended ITS Projects**

Based on the strategic objectives and the critical issues, a program of ITS strategic projects is recommended to address these issues, including:

**Projects of Statewide Significance**

1. Install fiber-optic cable along I-70 from Frisco to Glenwood Canyon including all equipment, connections with lateral devices and C2C connectively with CSP and local jurisdictions (the segment from Frisco to Vail is physically in Region 1, but is needed for Region 3).

2. Install fiber-optic cable along I-70 from Glenwood Springs to Grand Junction including all equipment, connections with lateral devices and C2C connectively with CSP and local jurisdictions.

3. Completion of the I-70 Incident Management Plan improvements from Vail to Grand Junction, including automated road closure for Glenwood Canyon.

4. Providing a secure interface so that participating agencies, such as transit providers or local governments, can access camera images and other data directly.

5. Developing a communications master plan for the rural areas of Western Colorado where existing communication infrastructure is inadequate.

6. Instrumenting maintenance vehicles to provide road and weather condition data.

**Projects of Regional Significance**

7. Installation of Automated Pass Management Systems and automated shoulder delineation systems on the major highway routes, including:
   
   7.1 US 550 between Durango and Ouray (Coal Bank Pass, Molas Divide, Red Mountain Pass),
   
   7.2 US 160 over Wolf Creek Pass,
   
   7.3 US 40 between Kremmling and Steamboat Springs (Muddy Pass and Rabbit Ears Pass),
   
   7.4 US 50 over Monarch Pass,
   
   7.5 SH 145 over Lizard Head Pass,
   
   7.6 US 24 over Tennessee Pass,
   
   7.7 US 50 over Cerro Summit,
   
   7.8 SH 91 over Fremont Pass,
   
   7.9 US 160 over La Veta Pass, and
7.10 US 50 in the Blue Mesa Reservoir area.

8. Implementation of a Transit Signal Priority System on State Highway 82 from Glenwood Springs to Aspen (this is separate from the arterial management system for SH 82).


10. Implementation of arterial management systems on:
   10.1 SH 82 from Glenwood Springs to Aspen,
   10.2 US 40 through Steamboat Springs,
   10.3 US 40 through Winter Park,
   10.4 US 550 and US 160 through Durango,
   10.5 US 160/US 285 through Alamosa,
   10.6 US 550 and US 50 through Montrose, and
   10.7 US 50 through Gunnison.


12. Developing communication links between the HLT TMC and major Emergency Operations Centers and other transportation providers.

13. Enhancing transit management systems for local transit operators, to include automatic vehicle location, automatic fare collection, and real-time transit passenger information.

H. Financial Summary

Based on the project priorities identified in the report, a financial summary was prepared to balance project funding through the program time frame. The costs, which are in 2005 dollars, to implement the recommended projects are summarized in the table below. Pass maintenance and management systems are assumed to be implemented in two stages, with a manual system implemented initially followed by an upgrade to a fully automated system.
Other Strategic ITS Initiatives
4: Provide a secure web interface to camera images
5: Develop a communications master plan
6: Instrument maintenance vehicles for RWS
11: Automated Wildlife Crossing Systems
12: Communication links between the Hanging Lake TMC and EOCs
13: Transit management systems for local transit operators

Figure ES-2. Recommended ITS Strategic Projects

- **Grand Junction**: Complete Regional Traffic Management System
- **Montrose**: Install Arterial Management System on US 50 and US 550
- **SH 145**: Install pass management system on Lizard Hood Pass
- **Durango**: Install Arterial Management System on US 550 and US 160
- **US 50: Gunnison to Montrose**: Install pass management system on Cerro Summit
- **SH 82: Aspen to Glenwood Springs**: Transit Signal Priority
- **US 50: Gunnison to Montrose**: Install Arterial Management System in the area of Blue Mesa Reservoir
- **US 50: Poncha Springs to Gunnison**: Install Pass Management System on Monarch Pass
- **US 160: South Fork to Pagosa Springs**: Install Pass Management System on Wolf Creek Pass
- **US 24 and SH 91**: Install pass management system on Fremont and Tennessee Passes
- **I-70: Vail to Grand Junction**: Complete Incident Management and Traveler Information System
- **I-70: Glenwood Springs to Grand Junction**: Install fiber optic cable and electronics
- **US 40: East of Steamboat Springs**: Install arterial management system on Rabbit Ears and Muddy Passes
- **I-70: Glenwood Canyon to Vail**: Install fiber optic cable and electronics
- **Steamboat Springs**: Install Arterial Management System on US 40
- **Winter Park**: Install Arterial Management System on US 40

**ITS Inventory - Regions 3 and 5**

**Legend**
- ATR
- ATR/Prizmo
- CCTV
- Callbox
- HAR
- VMIS
- VMIS Speed Control Radar
- Weather Station
- Weigh In Motion
<table>
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<th>Project Number</th>
<th>Project Name</th>
<th>Near Term (1 – 3 years)</th>
<th>Mid-Term (4 – 7 years)</th>
<th>Long Term (8 – 10 years)</th>
<th>Project Total</th>
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<tr>
<td>1</td>
<td>Fiber-optic cable along I-70 from Glenwood to Vail</td>
<td>840,000</td>
<td>5,000,000</td>
<td>500,000</td>
<td>840,000</td>
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<tr>
<td>2</td>
<td>Fiber-optic cable along I-70 from Grand Junction to Glenwood Springs</td>
<td>232,000</td>
<td>2,900,000</td>
<td>435,000</td>
<td>Not Quantified</td>
</tr>
<tr>
<td>3</td>
<td>I-70 Incident Management and Traveler Information System</td>
<td>232,000</td>
<td>2,900,000</td>
<td>435,000</td>
<td>Not Quantified</td>
</tr>
<tr>
<td>4</td>
<td>Provide a secure web interface to camera images</td>
<td>150,000</td>
<td>Not Quantified</td>
<td>Not Quantified</td>
<td>Not Quantified</td>
</tr>
<tr>
<td>5</td>
<td>Develop a communications master plan</td>
<td>150,000</td>
<td>Not Quantified</td>
<td>Not Quantified</td>
<td>Not Quantified</td>
</tr>
<tr>
<td>6</td>
<td>Instrument maintenance vehicle for road and weather information</td>
<td>150,000</td>
<td>Not Quantified</td>
<td>Not Quantified</td>
<td>Not Quantified</td>
</tr>
<tr>
<td>7.1</td>
<td>Pass maintenance and management system on Molas Divide, Red Mountain and Coal Bank passes</td>
<td>20,000</td>
<td>150,000</td>
<td>22,500</td>
<td>8,000</td>
</tr>
<tr>
<td>7.2</td>
<td>Pass maintenance and management system on Wolf Creek Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.3</td>
<td>Pass maintenance and management system on Muddy Pass and Rabbit Ears Pass</td>
<td>18,000</td>
<td>150,000</td>
<td>22,500</td>
<td>6,000</td>
</tr>
<tr>
<td>7.4</td>
<td>Pass maintenance and management system on Monarch Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.5</td>
<td>Pass maintenance and management system on Lizard Head Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.6</td>
<td>Pass maintenance and management system on Tennessee Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.7</td>
<td>Pass maintenance and management system on Cerro Summit</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.8</td>
<td>Pass maintenance and management system on Fremont Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.9</td>
<td>Pass maintenance and management system on La Veta Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.10</td>
<td>Pass maintenance and management system in the Blue Mesa Reservoir area</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>8</td>
<td>Transit Signal Priority on SH 82 from Glenwood to Aspen</td>
<td>60,000</td>
<td>500,000</td>
<td>75,000</td>
<td>60,000</td>
</tr>
<tr>
<td>9</td>
<td>Regional Traffic Management System in Grand Junction</td>
<td>40,000</td>
<td>500,000</td>
<td>75,000</td>
<td>40,000</td>
</tr>
<tr>
<td>10.1</td>
<td>Arterial traffic management system on SH 82 from Glenwood to Aspen</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.2</td>
<td>Arterial traffic management system on US 40 in Steamboat Springs</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.3</td>
<td>Arterial traffic management system on US 40 in Winter Park</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.4</td>
<td>Arterial traffic management system on US 550 and US 160 in Durango</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.5</td>
<td>Arterial traffic management system on US 160 and US 285 in Alamosa</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.6</td>
<td>Arterial traffic management system on US 550 and US 50 in Montrose</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.7</td>
<td>Arterial traffic management system on US 50 in Gunnison</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>11</td>
<td>Automated Wildlife Detection Systems on critical roadways sections</td>
<td>40,000</td>
<td>500,000</td>
<td>100,000</td>
<td>40,000</td>
</tr>
<tr>
<td>12</td>
<td>Develop communications links between HLT and EOCs</td>
<td>40,000</td>
<td>500,000</td>
<td>100,000</td>
<td>40,000</td>
</tr>
</tbody>
</table>

Table ES -1: Financial Summary (Cost are in 2005 dollars)
<table>
<thead>
<tr>
<th>13</th>
<th>Transit management systems for local transit operators</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1,448,000</td>
<td>10,150,000</td>
<td>1,297,500</td>
<td>1,282,000</td>
<td>15,300,000</td>
</tr>
</tbody>
</table>
I. Introduction

This regional architecture for the deployment of Intelligent Transportation Systems (ITS) Western Colorado is one portion of a larger effort to develop ITS architectures and strategic plans throughout the state. Intelligent transportation systems consist of the application of computers, electronic sensors, 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 timely and accurate information to travelers. CDOT has done considerable work planning, implementing and operating ITS in Colorado beginning with the Colorado Incident Management Coalition, the Denver Early Deployment Study, the Model Deployment Initiative, and the Colorado Transportation Management System. Several regional and project level architectures have been developed and many major corridors now have incident management plans. An architecture is a very 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 2002, CDOT ITS Branch, in consultation with the ITS Steering Group, developed a Statewide ITS Strategic Plan setting forth the vision and strategic goals for ITS investments statewide, describing organizational roles and responsibilities, and establishing strategies and implementation actions to achieve the CDOT goals for ITS investment. While there has been significant progress toward architecture development in Colorado, CDOT Regions 3 and 5 do not have strategic plans or regional architectures.

This report comprises the regional architecture for ITS in CDOT Region 3 and Region 5. This architecture 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 CDOT Region 3 and Region 5 over the next 10 years.

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 TEA-21 requiring that all ITS projects funded from the Highway Trust Fund be in conformance with the National ITS Architecture and appropriate standards. The rule/policy defines “Conformance with the National ITS Architecture” as developing a “regional ITS architecture” using the National ITS Architecture and tailoring it to the local conditions and transportation needs. Subsequent project then must adhere to the regional ITS architecture.
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 ensuring institutional agreement and technical integration for the implementation of ITS projects in 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. Both the Statewide ITS Strategic Plan and the Regional ITS Strategic Plan have been collaborative efforts involving CDOT, other federal, state, and local 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.

Goals of ITS
The goals of ITS are primarily to maximize transportation system management thereby enhancing mobility and safety for transportation users. More specifically, the Statewide ITS Strategic Plan identifies the following major goals for ITS.
“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. CDOT 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 business 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 Colorado.”

“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. CDOT 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 inter-modal connectivity and inter-jurisdictional coordination by promoting and supporting seamless connectivity between multiple modes of transportation and Colorado’s ITS systems. CDOT envisions information being managed as a resource that will enhance inter-modal connectivity between services provided by public and private transportation providers.”

The table below highlights the principal benefits and the 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 transportation system</td>
<td>• Increase in vehicle and passenger throughput.</td>
</tr>
<tr>
<td></td>
<td>• Reduction in total lost productivity due to incidents and congestion.</td>
</tr>
<tr>
<td>Increasing travel efficiency</td>
<td>• Use of travel information to select travel mode and reduce travel time and costs (through use of pre-trip and 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>
</tbody>
</table>

**I.B. Project Process**

The development of the ITS strategic plan and regional architecture follows a structured process to ensure proper coverage of relevant transportation issues, gather key input from transportation stakeholders within the Project Area, and identify cost-effective and
integrated solutions that can evolve as the technology progresses. The planning process moves from an identification of needs and objectives to the development of an implementation plan, which identifies projects for inclusion in the regional transportation plan and the Statewide Transportation Improvement Program (STIP). Within this process, there are a number of steps (or tasks) to perform to ensure that a thorough, strategic assessment is conducted.

The process began with a series of stakeholder workshops to identify an initial set of ITS Issues and Needs. These were supplemented by transportation issues and needs identified in the various regional transportation plans, as well as ITS strategies that had been selected for inclusion in the RTP’s. Based on this input, and input from the Statewide ITS Strategic Plan, a regional ITS vision and ITS goals were identified. These consist of ITS user services and ITS market packages to address the ITS issues and needs. From these, an operational concept was developed which identified roles and responsibilities of the stakeholders, and defined interfaces between subsystems and information flows. An implementation plan was then developed which identified projects and their relative sequence as well as agreements needed for implementation and critical ITS standards for compatibility and consistency.

Throughout the process, input was obtained via stakeholder workshops, the review of Transportation Planning Region (TPR) 2030 plans and other resources as indicated below to identify needs and issues that ITS could address. This process is illustrated in Figure 1: Project Process Flow Chart.
Figure 1: Project Process Flow Chart
Stakeholder Participation Process

A series of Stakeholder workshops was conducted in Alamosa, Durango, Glenwood Springs and Grand Junction from July 2004 to November 2004. At the first series of workshops an extensive list of ITS issues and needs was developed and subsequently expanded at follow-up workshops. In addition, draft Regional Transportation Plans for all of the Transportation Planning Regions were reviewed to further identify transportation issues and needs that warranted consideration in the Regional ITS Strategic Plan. The stakeholder participation and a summary of regional transportation plans for the study are provided below.

A public involvement process is part of this plan, and four rounds of ITS workshops were conducted. Each round of workshops included one meeting in CDOT Region 3 and another in CDOT Region 5. The dates and locations were as follows:

- CDOT Region 5, July 8, 2004 in Durango
- CDOT Region 3, July 9, 2004 in Grand Junction
- CDOT Region 5, August 24, 2004 in Durango
- CDOT Region 3, August 25, 2004 in Glenwood Springs
- CDOT Region 5, October 5, 2004 in Alamosa
- CDOT Region 3, October 6, 2004 in Glenwood Springs
- CDOT Region 3, November 17, 2004 in Glenwood Springs
- CDOT Region 5, November 19, 2004 in Durango

Some topic areas identified the goals that are desired for the regions and are consistent with the goals highlighted in the 2030 TPR plans (see upcoming section). Other items discussed include technological tools that are desired of the regions, and others are more specific requests for incident management tools or information dissemination mechanisms.

I.C. Related Planning Efforts

The following reports were referenced as a resource for this report:

- Design Guidelines for Including ITS on Projects, CDOT 2005
- 2030 Statewide Transportation Plan, Moving Colorado – Vision for the Future, CDOT 2004
- Statewide Intelligent Transportation Systems Strategic Plan, CDOT 2002
- Six 2030 Regional Transportation Plans, CDOT 2004
- Grand Junction/Mesa County Transportation Planning Region 2030 Plan
- Gunnison Valley Transportation Planning Region 2030 Plan
- Intermountain Transportation Planning Region 2030 Plan
- Northwest Transportation Planning Region 2030 Plan
As indicated earlier, a number of related planning efforts concern the Project Area. These reports were reviewed as part of the project to determine previously identified transportation needs and to identify ITS initiatives that have been recommended during other planning efforts. The following is a brief summary of the documents reviewed for this study:

**Design Guidelines for Including ITS on Projects**, CDOT 2005 - The purpose of these guidelines is to assist engineers and planners in selecting the appropriate ITS elements so that they may be included in the planning of transportation projects. These guidelines can be accessed at the following web link: www.cotrip.org/ITS/policyguide.htm.

**2030 Statewide Transportation Plan, Moving Colorado – Vision for the Future**, CDOT 2004 – This plan melded Colorado Transportation Commission policy and direction drawn from the state’s 15 Transportation Planning Regions (TPRs). The statewide plan identifies the following challenges:

- Rapid population growth,
- Growth of the 65 and older population,
- Increasing traffic congestion, and
- Funding shortfalls.

The goals identified in the draft statewide 2030 plan include the following Transportation Commission (TC) high priorities:

- Preserving, maintaining, and enhancing the existing transportation system.
- Judiciously expanding the system to respond to growth, and recognizing the opportunities provided by the Colorado Tolling Enterprise to incorporate new highways or additional lanes into the system.
- Recognizing the role of all modes of transportation in addressing mobility needs, and working with planning partners to leverage limited financial resources.

To meet these, CDOT focuses on four investment categories:

- **System Quality** – Maintaining the functionality and aesthetics of the existing transportation infrastructure.
- **Mobility** – Providing for the efficient movement of people, goods and information.
- **Safety** – Reducing fatalities, injuries and property damage for all users of the system through services and programs.
- **Program Delivery** – Providing for the successful delivery of CDOT projects and services.
ITS supports the TC high-priority goals and directly relates to the first three investment categories while this strategic plan and the accompanying architecture support the fourth category.

2030 Statewide Transportation Plan, Intelligent Transportation System (ITS) Technical Report, CDOT 2004 – This document provides a technical supplement to the statewide transportation plan regarding the role of ITS in the statewide plan. This document draws heavily on the ITS Strategic Plan, described below. The Technical Report identifies the current state of ITS statewide described in terms of:

Infrastructure, including more than 1200 devices and the network infrastructure to communicate with them,

- Centers, the four main centers as well as other supporting centers,
- Software Systems, primarily the Statewide Advanced Traffic Management System and the Advanced Traveler Information System,
- Owners, CDOT ITS Branch as well as CDOT regions, cities, counties, and transit agencies,
- Partners, the various agencies such as the State Patrol and the National Weather Service, that share information and resources with CDOT, and
- Users, including the traveling public as well as commercial vehicle operators and others.

This report also identifies the needs, funding and anticipated revenue for ITS in Colorado. Needs are identified in terms of 1) preventative maintenance and replacement of infrastructure, and 2) statewide enabling infrastructure (communications infrastructure including equipment and lateral connections on statewide corridors and improved and enhanced functionality at major TMCs) and strategic investments (infrastructure to deliver traveler information on statewide corridors). Preventative maintenance and replacement is anticipated to cost $10.3 million per year while needs for enabling infrastructure and strategic investments are estimated to be between $152 to $158 million over the next ten years, split between enabling infrastructure and strategic investments.

The Transportation Commission has allocated $3.5 million per year for operations and preventative maintenance, while CDOT has relied primarily on federal discretionary earmarks, which require state matching funds for new construction. This technical report also illustrates the benefits of several ITS deployments in Colorado, describes the performance monitoring system for ITS investments, and the ITS maintenance management system that is being developed.

Intelligent Transportation Systems Strategic Plan, CDOT 2002 – CDOT ITS Branch prepared a statewide strategic plan to provide guidance and direction for current and future ITS investment and implementation across the state. This document also identifies as a key element the need to institutionalize the ITS Core Services into CDOT’s current business areas and functions.
The primary goal of the CDOT ITS Branch is to provide an overall traveler information and traffic management system that effectively utilizes the existing system and seamlessly grows to incorporate future system elements, and one in which information is managed as an asset of value to transportation system users and transportation providers of all types. The elements of the vision adopted to achieve this goal include:

- Improve mobility through maximization of productivity of existing transportation system.
- Improve mobility through travel choice and travel efficiency.
- Increase traveler safety.
- Increase intermodal connectivity and inter-jurisdictional coordination.

In order to provide an integrated statewide traveler information traffic management system, the strategic investment described in the plan focuses on two areas: 1) preventative maintenance and replacement of the existing infrastructure, and 2) statewide expansion of the enabling infrastructure. The maintenance and replacement considers a 15-year life cycle for devices, requiring roughly $19 million. The expansion of the enabling infrastructure includes:

- Completion and update of four traffic management centers (~$28.4 million)
- Completion of a statewide fiber optic network (~$58.5 million)
- Implementations expanding the number of traveler information system related field devices (~$77.5 million).

The deployment timeframe is tied to the availability of funding. The highest priority elements are the traffic management centers and the deployment of the long haul high-speed communication system elements.

**Regional Transportation Plans**

As noted previously, six TPRs are contained in CDOT Regions 3 and 5:

- Grand Junction/Mesa County Transportation Planning Region 2030 Plan
- Gunnison Valley Transportation Planning Region 2030 Plan
- Intermountain Transportation Planning Region 2030 Plan
- Northwest Transportation Planning Region 2030 Plan
- San Luis Valley Transportation Planning Region 2030 Plan
- Southwest Transportation Planning Region 2030 Plan

As part of the needs assessment, the goals identified for each TPR were reviewed. The following summarizes the findings of this review.

Recurring themes in goals for the study area include:

- Promote economic growth
- Provide for multi-modal links
- Enhance quality of travel (quality of life)
- Increase and/or maintain safety, mobility and system quality
- Promote environmental preservation
- Maximize funds
- Obtain public support

At least four of the six TPRs indicated their desire for economic growth, and all requested consideration for multi-modal facilities except for the Gunnison Valley TPR whose goal list was the shortest, focusing on quality of life, retaining western values, maintaining sense of community, and supporting economic growth. Both the SWTPR and Grand Junction/Mesa County TPR specifically mention the development or enhancement of trail systems. The SWTPR went as far to make trails a standalone goal for the TPR. Overall, the TPRs of the Project Area appear to be similar in terms of what they desire for their transportation system.

**I-70 Mountain Corridor Incident Management Plan**, CDOT 2004 – This document defines the incident management procedures and protocols for I-70 from the Utah border to the west side of the Denver Metro area. Participating agencies and their roles and responsibilities are defined throughout the corridor. A detailed inventory of ITS devices along with proposed locations for future devices is provided. The Plan establishes criteria regarding incident levels, i.e. 1-3, identify alternative routes and addresses agency roles and responsibilities and contact personnel.

**Riverside Parkway Environmental Assessment**, City of Grand Junction 2004 – the document provides a description of the improvement for a new expressway across the south side of Grand Junction. A description of proposed ITS services and devices in the corridor is provided including fiber optic cable, traffic signal control, road and weather information and video surveillance.

**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 is to develop a Regional ITS Architecture and an ITS Strategic Plan to guide the deployment of ITS applications in the study area over the next ten years. These documents will be developed in conformance with the National ITS Architecture Version 5.0.

**Regional ITS Architecture**

The provisions of the Transportation Equity Act for the 21st Century (TEA-21) 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 study will address the elements noted in the Federal Highway Administration published rule 23 CFR Part 940, and the Federal Transit Administration’s parallel Policy.

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

This Architecture also has been incorporated into Turbo Architecture, which is a software tool that will provide users: enhanced functionality in working with the required Architecture elements (identified below), the ability to access physical and logical diagrams at multiple levels, and will facilitate consistency, version control, maintenance and updating of the Regional Architecture.
ITS Strategic Plan

This ITS Strategic Plan provides a guide for ITS deployment in the study area over the next 10 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.

This ITS Strategic Plan should be incorporated into the on-going transportation planning and programming activities in the study area. In this region this requirement means that the Regional Transportation Plans for the Transportation Planning Regions in Western Colorado, which are updated every three years. The ITS Strategic Plan will provide input to the TPR with regard to ITS projects and ITS deployment within the regions.

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

The region will need to investigate modifying the TIP/STIP process to incorporate checking for compliance with the federal ITS requirements. The compliance screening would only apply to those projects that have been identified as ITS. A common approach is based upon “self-certification” by project sponsors affirming 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, the applicable TPR would work with the project sponsor to modify the Regional ITS Architecture to encompass the project.

**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 CDOT and the ITS Working Group with 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. As with the architecture, the development of the next version of the Statewide ITS Strategic Plan will consider the projects and activities identified in this ITS Strategic Plan.

I.E. Organization of this Report

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

Section II – Description of the Project Area: This section provides a description of the geography and demographics of the Project Area along with a description of the transportation system and the current state of ITS services and infrastructure.

Section III – Transportation Issues and Needs: This section provides a description of transportation needs and issues related to ITS as they were identified through associated planning studies, particularly the regional transportation plans, through stakeholder input, and through statewide ITS planning efforts.

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

Section V – 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 VI – Implementation Plan: This section identifies the projects needed to implement the ITS goals, agreements and standards needed, provides the sequence for funding and implementation, and provides a Financial Summary.

Section VII – Next Steps: This section describes the steps that will be established to ensure that there is an adequate process in place to continue a forum to discuss, monitor, evaluate and amend elements within the Plan.
II. Description of the Region

This Regional ITS Strategic Plan for Western Colorado covers the area including both CDOT Region 3 and CDOT Region 5. This area includes the entire Western Slope within these two Regions. It also includes the areas of North Park, the San Luis Valley and the Upper Arkansas Valley (see Figure 2). These areas were combined for ITS planning because of similar geographic, operational and institutional characteristics, and because ITS throughout the Project Area is primarily managed and operated from the Hanging Lake Tunnel TMC. This Project Area is described in more detail below.

II.A. Geography of the Region

Western Colorado, comprised of CDOT Regions 3 and 5, covers the entire Western Slope and also includes the areas of North Park, the San Luis Valley and the Upper Arkansas Valley. Colorado is divided into 15 Transportation Planning Regions (TPRs) that are responsible for transportation planning within their particular area. These TPR’s are defined and identified by geographic location (e.g., Southwest), and do not correspond exactly to CDOT’s Region boundaries. Western Colorado includes the TPRs of: Grand Junction/Mesa County, Gunnison Valley, Intermountain, Northwest, San Luis Valley, and Southwest.

The Project Area is predominantly mountainous, including several mountains over 14,000 in elevation and numerous mountain passes over 10,000 feet. With the exception of the Grand Junction area, the Project Area is rural with several small urban areas. Grand Junction is a major urbanized center experiencing rapid growth. The Project Area also contains the small urban communities of Aspen, Glenwood Springs, Craig, Steamboat Springs, Montrose, Durango, Alamosa, and Cortez.

Most of the counties in Western Colorado experienced double digit growth between 1990 and 2000 with the counties experiencing the highest growth representing primary tourist destinations — particularly ski resort towns.

The State Demographer projects that population and employment growth will continue to increase over the next twenty years for many of the communities in Region 3. However, the majority of people are projected to increasingly work in communities other than where they reside, thereby increasing the percentage of commuter trips using state highways.

Tourism is an important economic element for most of the communities in Western Colorado and presents several challenges. The seasonality of many attractions can make it difficult for businesses to remain viable and for their employees to maintain a consistent lifestyle. Local governments can likewise find it difficult to sustain the necessary infrastructure to accommodate large peaks in visitation during short seasons. Tourism-related service jobs have historically paid relatively low wages, which makes it difficult for service workers to afford living near their jobs. As a result many workers commute from outside the areas they work and turnover is often high.
Figure 2: Project Area (CDOT Regions 3 and 5)
II.B. Transportation

Most of the communities in Western Colorado are separated by several miles and connected by only a few roads. Due to the mountainous terrain, there are few parallel routes and most roads have steep grades, sharp turns and narrow cross sections in places.

Highways

The dominant travel corridor in the Project Area is the I-70 corridor. I-70 carries between 15,000 vehicles-per-day on the western end to more than 25,000 vehicles-per-day in Eagle County. This represents more than half of all east-west travel in Western Colorado and more than four times the volume that the two other major east-west routes (US 160 and US 40) carry combined. US 160, which runs through the southern portion of the Project Area, carries between 4,000 and 5,000 vehicles-per-day between communities, and carries as many as 15,000 vehicle-per-day through some of the built-up areas. Likewise, US 40 carries between 3,000 and 4,000 vehicles-per-day between Granby and Steamboat Springs. US 40 carries as many as 20,000 vehicles-per-day in the built-up areas of Steamboat Springs and the area between Winter Park and Granby.

US 50 from Salida to Montrose is another significant east-west highway. It carries between 2,000 and 3,000 vehicles-per-day on the rural segments with as many as 10,000 vehicles-per-day in the built-up areas of Salida, Montrose, and Gunnison. In Montrose, US 50 joins US 550 and continues north to Grand Junction, where traffic volumes increase substantially. The Average Vehicles-Per-Day for East – West Highways is illustrated in Table 2 below.

Table 2. Project Area Average Daily Traffic: East-West Highways (2003)

<table>
<thead>
<tr>
<th>East – West Corridors</th>
<th>Average Daily Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-70</td>
<td>15,000 – 25,000</td>
</tr>
<tr>
<td>US 160</td>
<td>4,000 – 5,000</td>
</tr>
<tr>
<td>US 40</td>
<td>3,000 – 4,000</td>
</tr>
<tr>
<td>US 50</td>
<td>3,000 – 10,000</td>
</tr>
</tbody>
</table>

North-south travel is considerably more complex in Western Colorado. There are no continuous corridors running from the southern portion to the northern portion of the Project Area. Essentially all north-south corridors terminate at I-70. In the southwest, US 550 runs from New Mexico, north through Durango to Montrose, where it joins US 50 and continues north to Grand Junction. US 550 carries between 3,000 and 5,000 vehicles-per-day between Durango and Montrose. US 50/550 carries about 9,000 vehicles-per-day between Montrose and Grand Junction. US 285 runs from New Mexico north through Alamosa to Buena Vista where it joins US 24 which continues north through Leadville and on to I-70 at Minturn or at Copper Mountain via SH 91. The Average Vehicle-Per-Day for North- South Highways is illustrated in Table 3 below.

Table 3. Project Area Average Daily Traffic: North-South Highways (2003)

<table>
<thead>
<tr>
<th>North – South Corridors</th>
<th>Average Daily Traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH 82</td>
<td>15,000 – 20,000</td>
</tr>
<tr>
<td>US 550</td>
<td>3,000 – 5,000</td>
</tr>
</tbody>
</table>
US 285 carries between 3,000 and 5,000 vehicles-per-day while US 24 carries about 4,000 vehicles-per-day. To the north, SH 131 runs from I-70 in Eagle County to Steamboat Springs, while SH 13 runs from I-70 in Rifle to the Wyoming border just north of Craig. SH 13 and SH 131 both carry between 1,000 and 2,000 vehicles-per-day except in the built-up areas where volumes are greater. SH 82 is another significant corridor running from Leadville, through Aspen, to I-70 in Glenwood Springs. While its length is not as great as the other corridors, it carries between 15,000 and 20,000 vehicles-per-day due to the number of communities it services.
Figure 3: Project Area Roadway Systems
Nearly every major highway in Western Colorado travels over one or more major mountain passes. I-70 crosses Vail Pass. US 550 crosses Coal Bank Pass, Molas Divide, and Red Mountain Pass. SH 145 crosses Lizard Head Pass. US 160 crosses La Veta Pass and Wolf Creek Pass. US 285 crosses Poncha Pass while US 24 crosses Tennessee Pass and SH 91 crosses Freemont Pass. US 50 crosses Monarch Pass, Cerro Summit and Blue Mesa Reservoir. US 40 crosses Muddy Pass and Rabbit Ears Pass. These passes have very steep grades, multiple sharp curves and reduced widths in many spots. In addition, due to their high elevation, they are frequently closed due to snowstorms or the need for avalanche control. I-70 also travels through Glenwood Canyon, which is sometimes closed for weather or other natural events.

As the population has grown, so has traffic. Not only have traffic volumes increased, but trip lengths have increased as well, due in part to increased commuting between communities. As a result many of the communities experience severe traffic congestion, especially the resort communities.

Transit

With increasing pressures from growth experienced throughout the state, increases in travel demand have led to congested traffic conditions in developed areas, activity centers, and resorts. Public transportation systems represent an important element in reducing the number of private vehicles on the roadway system, thereby helping to reduce the impacts of continued growth on the overall transportation system.

In addition to providing congestion relief, public transportation provides mobility to individuals who cannot travel without it. Such individuals are considered dependent upon public transportation for a variety of reasons. The four types of limitations that preclude persons from driving are physical limitations, financial limitations, legal limitations, and self-imposed limitations.

The regional transportation plans for Western Colorado identify more than 60 public and private transit providers spread throughout the Project Area. Most of these serve various special communities. Three major regional transit providers service the majority of the I-70 corridor:

**Eagle County Regional Transportation Authority (ECO)**
- ECO Transit was established in 1996 to provide regional connection between the communities of Avon, Beaver Creek, Dotsero, Eagle, Edwards, Gypsum, Leadville, Minturn, Red Cliff, and Vail

**Roaring Fork Transit Authority (RFTA)**
- RFTA operates year-round transportation services in Pitkin County, as well as parts of Garfield and Eagle counties. Services include free buses in Aspen, fare commuter buses (Down Valley Commuter Service) between Aspen, Glenwood Springs, and Rifle, and local service in Glenwood Springs. In addition, RFTA offers seasonal service both summer and winter, including transit to ski areas and special events.
- RFTA provided over 1,000,000 one-way trips on its regional commuter services between Rifle and Glenwood Springs to Aspen and Snowmass Village, and over
3,000,000 trips on their system, including the skier shuttle and Aspen local circulator services.

- Currently RFT operates its regional commuter services along the designated HOV lane between Basalt to Buttermilk, just south of Aspen Airport, and in mixed traffic between Basalt and Glenwood Springs. The regionally-endorsed vision for this system is to implement bus rapid transit along SH 82, which incorporated a new fleet of low-floor vehicles, improved transit stations and ITS elements such as automated fare collection, real-time information, and transit signal prioritization.

**Grand Valley Transit (GVT)**

- GVT operates a mix of fixed-route, dial-a-ride, and paratransit service. There are currently 11 fixed routes serving Grand Junction, Fruita, and Palisade. Dial-A-Ride stops are provided throughout the urban area and are charged a higher fare than fixed-route passengers. Complementary paratransit service is offered during the times that the fixed-route service is offered. Grand Valley Transit provided over 545,110 one-way trips in 2002. This included 530,600 trips serviced by the fixed-route system.

While almost every small urban area in Western Colorado has some transit service, four are particularly noteworthy:

- Steamboat Springs Transit, which provides daily service in and around the town of Steamboat Springs;
- The Link in Winter Park, which provides service to the town of Winter Park and the adjacent skiing and recreation areas;
- Mountain Valley Metropolitan District which provides service to the development next to Telluride, and;
- The Durango Lift, which provides service to the town of Durango and adjacent areas.

**Aviation**

Airports contribute to an 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, etc. Several General Aviation service facilities and commercial service facilities exist within this architectural region. Commercial services exist at or near the towns of Hayden, Grand Junction, Eagle, Aspen, Montrose, Gunnison, Telluride, Alamosa, Durango, and Cortez.

**Rail**

Railroads provide passenger and freight service throughout this the Project Area. AMTRAK provides passenger service (the California Zephyr) on the main line and runs one westbound train and one eastbound train per day connecting Grand Junction to Denver. This east/westbound train makes stops at Fraser/Winter Park, Granby, and Glenwood Springs before heading into Utah. During the ski season the Winter Park Ski Train, which utilizes the Union Pacific tracks, operates between Denver and Winter Park on Saturdays and Sundays.

The historic Grand Junction Railroad Station, listed on the National Register of Historic Places, was rehabilitated. Alternative uses were evaluated for the station and emphasis was given to the concept of relocating AMTRAK back into this station. In addition, Grand
Junction is a major rail freight center for the Union Pacific (UP) Railroad. The commodities shipped through Grand Junction include mixed freight, automobiles, produce and coal. The UP operates a major rail freight yard in Grand Junction, which sorts freight trains from the west (Salt Lake City, the Pacific Northwest, and California), from the east (Denver, Pueblo) and from the south (Paonia, Montrose, Delta).

II.C. Existing ITS Services and Infrastructure

ITS Services

The following section describes the ITS services and infrastructure that currently exist in the Project Area. The service areas identified are grouped by what is referred to in the ITS National Architecture as ITS User Service Areas. The ITS User Service Areas are as follows:

Traffic and Travel Management

Freeway Management – With a few exceptions, freeway management in Western Colorado focuses on information collection and dissemination. There are lane control signals approaching the Hanging Lake Tunnels and there is an active speed advisory sign westbound approaching Glenwood Canyon. Ramp metering has been discussed for Eagle County as traffic volumes and congestion increase, but no firm plans exist.

Incident Management - An extensive incident management plan was developed for I-70 from the west side of Denver to the Utah border. This system uses the network of CCTV cameras, variable message signs, call boxes, and advisory radio to respond to incidents in the corridor. The system identifies alternative routes, procedures and protocols and contact personnel and involves coordination between CDOT, the Colorado State Patrol, and local public works, police, fire and sheriff departments. This has proven to be a very effective system. Recently, CDOT updated the Plan based on lessons learned and experience gained in using the Plan. However, several additional devices have been identified for installation in the future.

Tunnel Management - Tunnels present a unique set of issues for traffic management. Due to their constrained nature, it is important to manage the environment inside the tunnel with ventilation fans and pumps. It is also important to quickly identify and respond to incidents inside the tunnels. Three tunnel systems are actively managed in Western Colorado, the Hanging Lake Tunnels on I-70 in Glenwood Canyon, the Beaver Tail tunnel on I-70, and the Wolf Creek Pass Tunnel on US 160 just east of the summit of Wolf Creek Pass. These tunnels have continuous surveillance along with lane use control signals, message boards, and traffic detectors. The Hanging Lake Tunnels also have an active incident detection system that alerts operators if there is a stoppage in the tunnels. The Beaver Tail Tunnel on I-70 in De Beque Canyon also has an incident detection system installed that will be monitored and controlled by the Hanging Lake Tunnels TMC.

Rural Highways - Rural highways present a unique challenge for ITS and providing call boxes on major routes. Typically, these facilities extend for long distances with relatively low traffic volumes compared to urban highways. Furthermore, there is frequently a scarcity of infrastructure including communications and power. This is certainly the case in Western Colorado. Despite these challenges CDOT has deployed
arterial scale variable message signs at most critical decision points and installed remote weather stations in key segments of major roadways. Region 5 also maintains a network of avalanche forecasters to supplement their data and to support maintenance operations.

- **Arterial Management** - CDOT Region 3 operates and maintains approximately 100 traffic signals while Region 5 operates and maintains about 50. These are spread throughout Western Colorado. Due to the large distance involved, both regions have installed telephone drops to all their signals for communication. In addition, Region 5 is hardwiring the signals together in each major grouping and providing on-street master controllers. These closed-loop systems are either installed or in progress in Alamosa, Pagosa Springs, Durango, and Cortez.

The City of Grand Junction operates 94 traffic signals. The City has had an ongoing project to connect their signals together on a fiber-optic system. These signals are operated on closed-loop systems. The City has also been installing closed-circuit television (CCTV) cameras at key locations to facilitate actively managing the arterial system.

**Traveler Information**

In addition to the statewide traveler information system operated by CDOT from the Colorado Transportation Management Center (CTMC), there are several other small-scale information systems operating in Western Colorado. Many of the communities provide information for local travelers via a City website. Steamboat Springs provides CDOT camera images and information from the local airport. Some of the transit agencies also provide information to their passengers as well as the public. The Roaring Fork Transit Authority (RFTA) provides CDOT images, images from the airport, and weather information on its website. However, they are hoping to be allowed to have direct access to the CDOT data and cameras if possible.

**Public Transportation Management**

There are several transit agencies throughout Western Colorado with varying degrees of sophistication and resources. Many of these agencies have deployed elements of transit management. Roaring Fork and Grand Valley transit have attempted route scheduling with mixed results. Roaring Fork and CDOT have implemented isolated cases of transit priority on the SH 82 corridor. Steamboat Springs and others are seriously pursuing automated vehicle locating and tracking technology. RFTA also has a robust set of transit management system tools planned associated with implementing bus-rapid-transit along SH 82 from Aspen to Glenwood Springs. Signal priority and a communications link with CDOT that will aid in the availability of real-time vehicle location information are key elements of the bus rapid transit system (the vision being implemented in coming years).

**Commercial Vehicle Operations**

Commercial vehicle systems are considered a statewide issue. These systems will be addressed in the Statewide Architecture effort.
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 either have already or are in the process of developing joint operation centers. Many of these agencies are also migrating, along with CDOT, to a statewide digital trunk radio system to facilitate on sight coordination of emergencies and incidents.

Vehicle Safety Systems

Vehicle safety systems are largely considered a private sector initiative in Colorado. These will be addressed in the Statewide Architecture instead of this effort since they have a much wider scope of application.

Data Management

- **Data Management** - Currently CDOT compiles databases of much of the data collected, especially that collected by the CTMC. However, there is also considerable data that is not complied by CTMC either because the communication links do not exist, or because the data is being managed locally, such as traffic signal data. As a result, there are several islands of data throughout the Project Area.

- **Communications** - Communications is a major weakness in Western Colorado. With the exception of the Glenwood Canyon area, CDOT has very little high-speed data communications. As a result, CDOT frequently has to rely on leased communications. Even then, there are major areas where high-speed communication is simply not available. Wireless communication can even be problematic. Large dead-zones in cell coverage exist throughout Western Colorado. Deployment of the digital trunk radio system is hampered due to lack of towers and limited range as a result of the mountainous terrain.

The City of Grand Junction is deploying an extensive fiber-optic system throughout town and the City of Glenwood Springs has deployed a citywide fiber-network, which connects all the stakeholders in town. CDOT also has fiber optics installed from the east end of Glenwood Canyon to Glenwood Springs connecting the CDOT Resident Office in Glenwood Springs to the Hanging Lake Tunnel TMC. RFTA is working on installing a wireless network along the SH 82 corridor to provide Internet access for bus passengers and to be used for automatic vehicle location service.

Maintenance and Construction Management

CDOT is currently in the process of implementing a statewide program for maintenance of ITS infrastructure. In addition, CDOT uses ITS extensively to predict winter maintenance needs and to determine avalanche control measures. Region 5 is contemplating instrumenting its maintenance vehicles to provide more real-time road condition data as the maintenance vehicles are performing their duties throughout the Project Area. CDOT is participating in a FHWA sponsored project, Maintenance Decision Support System, and has outfitted several maintenance vehicles with AVL and other detectors. CDOT is requiring large construction projects to include project incident management systems during construction.
ITS Infrastructure

Several ITS elements are either currently deployed in this Project Area, or are in the process of being implemented. This includes the Hanging Lake Tunnel (HLT) system, which includes a major Transportation Management Center. There are also a number of dynamic message signs, CCTV camera sites, call boxes, highway advisory radios, and remote weather stations. All of the major ports of entry (POE) have weigh-in-motion and Pre-Pass systems installed, which provides the capability for commercial vehicles to bypass the POE providing their credentials and vehicle weights are in compliance. Incident Management Plans have been developed for I-70. In addition, the City of Grand Junction is developing a Traffic Management System and many transit agencies are developing transit management systems. These are described in more depth below.

Since 1990, CDOT has invested more than $100 million into ITS infrastructure. While much of this has been in the Front Range, CDOT has made significant investments in Western Colorado as well. About 450 devices have been installed in Western Colorado, as shown below, and several more are being installed.

Table 4. Existing CDOT ITS Infrastructure

<table>
<thead>
<tr>
<th>ITS Device</th>
<th>Region 3</th>
<th>Region 5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATR</td>
<td>17</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>ATR Piezo</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Callbox</td>
<td>42</td>
<td>5</td>
<td>47</td>
</tr>
<tr>
<td>CCTV</td>
<td>15</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Highway Advisory Radio (HAR)</td>
<td>12</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Lane Control Sign</td>
<td>162</td>
<td>0</td>
<td>162</td>
</tr>
<tr>
<td>Over Height Detection</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Portable VMS</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>RTMS</td>
<td>21</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>Ramp Back Up/Wrong Way Detection</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Static HAR Beacon Sign</td>
<td>24</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Tunnel *</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>VMS</td>
<td>52</td>
<td>39</td>
<td>91</td>
</tr>
<tr>
<td>VMS Speed Control Radar</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Weather Station</td>
<td>21</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>Weigh In Motion (Load Cell)</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>384</strong></td>
<td><strong>72</strong></td>
<td><strong>456</strong></td>
</tr>
</tbody>
</table>

* The following ITS devices are used for tunnel operations: HLT: Air Velocity Sensors (4), Carbon Monoxide Sensors (18), CCTV – fixed (26), CCTV – PTZ (19) and Liner Heat Detectors (8). Wolf Creek, CCTV – PTZ (2), Beaver Tail: VMS and CCTV.

While many of these devices are concentrated along the I-70 corridor, they are also distributed throughout Western Colorado as shown on Figure 4.
Figure 4: Project Area ITS Infrastructure
(Western Slope)
Traffic Management Centers

Statewide ITS operations are managed through four major centers including the Hanging Lake Tunnels TMC in Glenwood Canyon between the towns of Glenwood Springs and Gypsum. The other three centers are located outside of the project area. The CDOT Regions, as well as other agencies, support and assist the centers with maintenance, coordination and other support services. The Colorado Transportation Management Center (CTMC) in the Denver Area is also important to ITS in Western Colorado.

The CTMC is responsible for coordinating and providing traveler information throughout the state, especially information dissemination. In Western Colorado, information collection requires a coordinated effort between HLT TMC and CTMC since HLT TMC actually operates and controls many of the devices. Weather data is gathered from the National Weather Service as well as CDOT weather stations. The Colorado State Patrol and CDOT maintenance crews collect information on road conditions. Traffic sensors, CCTV images, radar detectors, and other devices are monitored by HLT TMC and this data is forwarded to CTMC for dissemination. The CTMC aggregates and processes data before disseminating it through a variety of media. The primary sources for Pre-trip traveler information are the CDOT cotrip.org website, an automated telephone system and 511 service, broadcast fax, media reports, and wireless access to personal digital assistants (PDA’s)/ palm pilots and cell phones. En-route information is disseminated via dynamic message signs and highway advisory radio.

The HLT TMC primarily performs traffic management, incident management, and event management for CDOT Regions 3 and 5. The HLT manages several devices in the Glenwood Canyon as well as managing the Hanging Lake Tunnels and the Wolf Creek Pass Tunnel. HLT TMC also is designed to function as a backup to the CTMC although the lack of high-speed communications between the two facilities limits this capability.
III. Transportation Issues and Needs

The architecture process followed both a top-down approach and a bottom-up approach simultaneously. This portion describes the bottom-up approach. Before ITS services could be identified and prioritized, it was necessary to identify the transportation needs in the Project Area and the needs of the users, operators, and other stakeholders. This effort involved review of regional transportation plans, discussion with stakeholders, and examination of other transportation studies and projects in the Project Area. This process identified the following critical issues:

- Weather and crash related incidents on I-70
- Weather related closures on mountain passes
- Congestion in Grand Junction
- Congestion in mountain communities, esp. Durango, Steamboat, Vail/Avon and SH 82 corridor
- Special event impacts
- Wildlife crashes
- Natural or manmade emergencies
- Homeland security
- Maintenance of ITS
- Lack of transit
- Lack of communications/electrical infrastructure

The process of identifying these issues and discussion of the needs follows.

III.A. TPR Goals

There are six Transportation Planning Regions (TPRs) in Western Colorado. They are:

- Southwest TPR
- Gunnison Valley TPR
- Grand Junction/Mesa County TPR
- Intermountain TPR
- Northwest TPR

Each TPR was in the latter stages of developing their regional transportation plans during this project process. These regional transportation plans each contain an analysis of the transportation needs and goals in each TPR. Four of the six TPRs indicated their desire for economic growth, and all requested consideration for multi-modal facilities except for the Gunnison Valley TPR whose goal list was the shortest, focusing on quality of life, retaining western values, maintaining sense of community, and supporting economic growth. Both the SWTPR and Grand Junction/Mesa County TPR specifically mention the development or
enhancement of trail systems. The SWTPR went as far to make trails a standalone goal for their region.

Overall, the TPR’s in the Project Area appear to be similar in terms of what they desire for their transportation system. Recurring themes in goals for each TPR include:

- Promote economic growth
- Provide for multi-modal links
- Enhance quality of travel (quality of life)
- Increase and/or maintain safety, mobility and system quality
- Promote environmental preservation
- Maximize funds
- Obtain public support

### III.B. Stakeholder Issues and Needs

A broad overview of needs and issues identified by thorough stakeholder workshops is provided below.

#### Communication Coordination and Connectivity

Communication coordination and connectivity is the foundation of ITS. Without the links and interfaces much of the value of ITS is lost. In general throughout the Western Slope there is very little high-speed data communication especially fiber optics. In many cases the high-speed data communication that does exist is not in the areas where it is needed. Cellular telephone coverage on the Western Slope is also patchy; some areas have very good coverage while others have no coverage at all. The coverage also varies dramatically between different cellular telephone carriers. The mountainous terrain disrupts wireless communications in general. In addition, there are many locations where telephone and electricity are not available for several miles. These communication limitations restrict the types of ITS elements that can be deployed and where they can be effectively deployed.

Where communication and information does exist it is often not shared because the connections between different entities are not present. For example, there is extensive, CCTV coverage throughout the Glenwood Canyon area but Colorado State Patrol does not have direct access to this. These cameras recordings would be extremely useful to the Colorado State Patrol (CSP) in the event of an incident in the canyon, but CSP dispatch cannot get direct access to the images because the needed protocols have not been put in place. Hence, CSP can only get the images over the Internet and these are often not available during high demand periods.

Many localities have information that would be valuable to other jurisdictions but that information is not used due to lack of awareness, formatting, and other issues. For example, in southwestern Colorado the 911 dispatch uses latitude and longitude to dispatch emergency services while emergency calls frequently, are based on highway number and milepost. At the same time, CDOT has a database referencing all the state highways and mile markers to latitude and longitude. This information exists, but it was not readily available to the 911 dispatch center. Because of this project, the database is being made available to dispatch centers that request it.
### Communication Coordination and Connectivity

- Communication infrastructure is unreliable
- Need for better communication (especially fiber optics)
- Connectivity of systems
- Coordination communication with Amtrak
- GIS integration/coordination and sharing
- Inter jurisdiction coordination
- Request for more timely and accurate information disbursements
- Bi/multi-lingual information
- Establish better communication channels (e.g. maintenance calls CDP sites at Montrose)
- Coordination with multi-use net of the Dept. of Information Technology (DOIT)
- Web links (location specific information)
- Better cellular connections
- More fiber optics
- Mountain communications by radio
- Microwave
- Automated weather stations – beyond passes
- Need more call boxes

### Trip and Mode Options

The Western Slope is characterized by a sparse roadway network where there are limited options for travel when traffic incidents occur. This is only exacerbated for travelers unfamiliar with the area, who don’t know even the limited alternate routes available. There's very little information on alternative routes in the event of closures. In addition, for many trips, few options to the automobile exist. Where options to the automobile are available, such as regional bus service, it is not always obvious to travelers where and when to take those options.

The security of passengers on transit systems is also an issue, both the security of passengers themselves as well as the transit operators.

### Trip and Mode Options

- Increased transit ridership
- Increased alternative modes
- Increased BRT express service
- Transit traveler information/transit communications (mobile radio)
- Trip options (Steamboat related to Greyhound)
- “Next Bus” indicator system
- Traffic/transit data collection and dissemination
- Transit signal priority
- Better passenger transfer points – proposing station for all buses
- National Park Service transit options are under study
Traffic Congestion

Most rural routes, between communities, are not very congested. However, many of the mountain communities, especially the resort towns, experience severe traffic congestion on a recurring basis. This congestion is due to tourism and recreational travel as well as commuter travel. The cost of living in many western communities, especially the resort towns, forces much of the work force to live in other towns and commute. These communities are frequently located in narrow steep sided valleys making widening of roads or construction of parallel routes problematic. The result is extreme congestion with both primary and secondary accidents related to this congestion on narrow roads with few alternate routes. Furthermore, the congestion leads to increased emissions in air pollutants, which degrade many of the environmental qualities these communities rely on to attract visitors. In many of these communities, construction of additional capacity is cost prohibitive or has excessive negative impacts.

<table>
<thead>
<tr>
<th>Traffic Congestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Communication with traffic signals</td>
</tr>
<tr>
<td>• Congestion in urban areas</td>
</tr>
<tr>
<td>• ITS applications for Durango for traffic management of highways</td>
</tr>
</tbody>
</table>

Incidents/Special Events

Many of the mountain communities hold special events that attract large number of visitors from throughout the country and in some cases throughout world. Examples of this are the Telluride Bluegrass Festival, the Winter Park Music Festival, World Cup Skiing, and the X-Games. Also, there are many cycling races and other athletic events that attract competitors as well as spectators. These events frequently require road closures and detours that further complicate travel for visitors unfamiliar with the area as well as creating unwanted impacts within residential areas in the vicinity of the events.

Crashes, weather and other natural events can severely impact the transportation system throughout the Western Slope. These may require complete or partial closures of the road system several times throughout the year, adding considerable delay either due to congestion from the incident, or the need to detour many miles around a closure. An example of this is Red Mountain Pass on US 550, which is closed 20 to 30 times a year due to weather conditions or avalanche control measures. Each time it closes travelers must either wait for the road to reopen, or detour more than 50 miles out of the way. The nature of road closures, the resulting congestion, and other issues makes the provision of timely and accurate information to travelers especially important. Advising travelers well before they encounter congestion or closures allows them to avoid the incident altogether. It's also important to provide information to travelers before they depart so they can adjust their travel plans. Finally, there's a need to provide information to travelers traversing a detour route so that they know they are following the correct route.

<table>
<thead>
<tr>
<th>Incidents/Special Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Incident re-opening functional requirements</td>
</tr>
<tr>
<td>• Incident detection</td>
</tr>
<tr>
<td>• Need more extensive road/weather information systems</td>
</tr>
</tbody>
</table>
**Incidents/Special Events**

- Wildlife detection/number of accidents related to wildlife
- Seasonal/special events
- Adherence to incident management plans
- Joint incident management/emergency management planning
- Incident management plans – by sub region
- Coordination of stakeholders in the regions:
- Consider TPR priorities such as:
  - Traffic reliability and safety
  - Accidents
  - Mobility and congestion relief
  - ITS for problem areas
  - Includes 1/3 of money for intersection improvements

**Emergency Response**

The timeliness of emergency response is a critical issue. Emergency response planners often speak of a “golden hour”. If emergency responders can treat injuries within the first hour of a crash, the severity of the injuries declines dramatically. Due to the long distances between communities and a sparse roadway network, long response times are often a given. This makes it all the more important for timely and accurate identification of emergencies and determining the appropriate response.

**Emergency Response**

- Coordination between Emergency Management Service and ITS - interconnects
- Hazardous material information relay to emergency response
- 911 routing
- Make 511 Service more reliable
- 800 MHz Digital Trunk Radio (DTR) System
- Route guidance
- Emergency dispatch needs state highway milepost used versus rural addressing system Latitude/longitude - interconnecting

**Safety and Security**

Safety and security have become increasingly important element of transportation in general and ITS specifically. There is a need to provide security for the overall transportation system, protecting the vehicles and infrastructure from damage either intentional or unintentional. In addition, there's a significant investment in ITS elements, the computers electronics and sensors, mandating a need to provide security for these assets as well.

**Safety and Security**

- Passenger security/ Digital Video Recorders (DVR)
- Automated vehicle location
- Hazard Advisory Radio (HAR) traveler information on passes
### Safety and Security

- Virtual Port of Entry (POE) – Statewide
- Homeland Security/DTR enabling technology
- Wildlife detection/number of accidents related to wildlife
- Tie road surface temperature to Global Positioning Service for automobile reporting
- Priority mountain passes are Wolf Creek, Molas, Coal Bank, Red Mountain, La Veta, and Monarch (highest accident rate)
- Increased surveillance at critical locations (such as passes) on weather stations
- Need to plan for homeland security, emergency evacuation

### Maintenance and Construction

Managing maintenance and construction zones is also an increasingly important need. ITS can be a key tool for enhancing the safety of travelers as well as maintenance and construction workers. Maintenance of the ITS infrastructure is also a critical issue. These assets represent a considerable investment and must be maintained on an ongoing basis in order to sustain their effectiveness. In addition, more effective and timely use of deicing applications, particularly in mountain areas along with other routine maintenance activities, such as road-kill removal and weed control, would be made safer if real-time messaging is used to inform motorists of activities occurring along the roadway.

### Commercial and Freight Mobility

Commercial deliveries and freight are both important elements of transportation. This is especially true in Western Colorado where these represent a higher percentage of traffic than they would in a more urban setting. Also, because they are more isolated, many of the communities in Western Colorado are highly dependent on commercial traffic to keep these towns supplied. However, trucks often have more difficulty on mountain roadways than vehicular traffic. As a result, it is important to provide timely information on road and weather conditions to commercial traffic. Another critical issue is the safety aspect of truck traffic. Trucks are more likely to lose their braking ability on steep hills, resulting in crashes. Furthermore, truck crashes tend to be more disruptive to the roadway. Hence, commercial and freight traffic is important enough to specifically address with ITS.
<table>
<thead>
<tr>
<th>Commercial and Freight Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Virtual Port of Entry (POE) – Statewide</td>
</tr>
<tr>
<td>• Port-of-Entry/Weigh in Motion (WIM) Technology – Virtual Weigh Stations</td>
</tr>
<tr>
<td>• Truck information/warning systems</td>
</tr>
<tr>
<td>• Over height, overweight (tunnels too low, trucks to high, trucks too heavy)</td>
</tr>
<tr>
<td>• Truck speeds (speed warnings/advisories)</td>
</tr>
</tbody>
</table>
IV. 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 Architecture and are tailored to fit - separately or in combination - real world transportation problems and needs. Market packages identify physical ITS elements that are required to implement a particular transportation service.

Market packages for the study 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:

- **Advanced Traffic Management Systems (ATMS):** Manage operation of the roadway network.
- **Advanced Traveler Information Systems (ATIS):** Provide real-time information to travelers.
- **Advanced Public Transportation Systems (APTS):** Manage transit operations and make transit use more convenient and safe.
- **Emergency Management (EM):** Manage emergency response operations.
- **Maintenance and Construction Management (MCM):** Manage maintenance and construction activities and operations.
- ** Archived Data Management (AD):** Store and retrieve transportation system information for future analysis.

IV.A. Advanced Traffic Management Systems

Several ATMS market packages are already in operation in various portions of the region, either by CDOT of the City of Grand Junction. There are several automatic traffic recorders along I-70 and other major highways (Network Surveillance). CDOT and Grand Junction operate traffic signal systems (Surface Street Traffic Control) which include signalized railroad grade crossings (Standard Railroad Grade Crossing). Lane use control signs, variable message signs and cameras (Freeway Control) are controlled on I-70, especially through Glenwood Canyon. Variable message signs and highway advisory radio are used to provide traveler information (Traffic Information Dissemination) and to advise drivers of unsafe speeds (Speed Monitoring). CDOT and local jurisdictions provide incident management along I-70 through the regions (Incident Management System) Additional services are needed to close mountain passes (Roadway Closure Management). CDOT and Grand Junction are discussing coordinating traffic signals in the Grand Junction area between jurisdictions and sharing real-time data (Regional Traffic Control). Finally, while there are no specific plans,
SH-82 has an HOV lane so it may need special control in the future (HOV Lane Management). Table 5 lists the selected ATMS market packages for the study area.

**Table 5. Selected ATMS Market Packages**

<table>
<thead>
<tr>
<th>Market Package Name</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Surveillance (exist.)</td>
<td>Collects information from field devices (detectors, CCTV, etc.) for monitoring or roadway conditions.</td>
</tr>
<tr>
<td>Surface Street Control (exist.)</td>
<td>Provide traffic signal control.</td>
</tr>
<tr>
<td>Freeway Control (exist.)</td>
<td>Control of devices installed along freeways, including control of cameras and dynamic message signs.</td>
</tr>
<tr>
<td>HOV Lane Management (prop.)</td>
<td>Manages HOV lanes by coordinating freeway ramp meters and connector signals with HOV lane usage signals.</td>
</tr>
<tr>
<td>Traffic Information Dissemination (exist.)</td>
<td>Supports Dynamic Message Signs and Highway Advisory Radio</td>
</tr>
<tr>
<td>Regional Traffic Control (prop.)</td>
<td>Provides for the sharing of traffic information and control among traffic management centers to support a regional control strategy.</td>
</tr>
<tr>
<td>Incident Management System (exist.)</td>
<td>Detects incidents and provides links between transportation and emergency management centers to exchange information.</td>
</tr>
<tr>
<td>Standard Railroad Grade Crossing (exist.)</td>
<td>Manages highway traffic at highway-rail intersections where rail operational speeds are less than 80 miles per hour.</td>
</tr>
<tr>
<td>Reversible Lane Management (exist.)</td>
<td>Manage lane use controls and monitoring or reversible lanes. Currently used in Hanging Lakes Tunnels.</td>
</tr>
<tr>
<td>Speed Monitoring (exist.)</td>
<td>Monitors speeds of vehicles on roadways. DMS can then be used to post a safe speed reminder.</td>
</tr>
<tr>
<td>Roadway Closure Management (prop.)</td>
<td>Support for remotely controlled gates or barriers that close off roads in unsafe conditions, plus camera surveillance and traveler information.</td>
</tr>
</tbody>
</table>

**IV.B. 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, HAR, CDOT road conditions faxes, and future CDOT 511 phone system.

Table 6 lists the selected ATIS market packages for the study area.
### Table 6. Selected ATIS Market Packages

<table>
<thead>
<tr>
<th>Market Package Name</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast Traveler Information (exist.)</td>
<td>Dissemination of information over a wide area through existing infrastructures and low cost user equipment.</td>
</tr>
<tr>
<td>Interactive Traveler Information (exist.)</td>
<td>Provides tailored information in response to a traveler request. Includes dynamic web pages and 511-telephone information.</td>
</tr>
</tbody>
</table>

### IV.C. Advanced Public Transportation Systems

The three primary regional transit agencies in the study are have deployed various degrees of fixed-route operations demand response (Para-transit) and traveler information. All have expressed the need for Automatic Vehicle Location (AVL), Computer Aided Dispatch (CAD), electronic fare collection, and improved transit traveler information. In addition, transit security and automated maintenance are needed to improve rider and operator safety and reduce operating costs. Transit signal priority (Multi-modal Coordination) has also been specifically recommended for the SH-82 corridor.

Table 7 lists the selected APTS market packages for the study area.

### Table 7. Selected APTS Market Packages

<table>
<thead>
<tr>
<th>Market Package Name</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Vehicle Tracking (prop.)</td>
<td>Provide automatic vehicle location (AVL) to track transit vehicles.</td>
</tr>
<tr>
<td>Transit Fixed-Route Operations (exist.)</td>
<td>Performs automatic driver assignment and monitoring, as well as vehicle routing and scheduling for fixed-route services.</td>
</tr>
<tr>
<td>Demand Response Transit Operations (exist.)</td>
<td>Performs automatic driver assignment and monitoring as well as vehicle routing and scheduling for demand response transit services.</td>
</tr>
<tr>
<td>Transit Passenger and Fare Management (prop.)</td>
<td>Allows for the management of passenger loading and fare payments on-board vehicles using electronic means.</td>
</tr>
<tr>
<td>Transit Security (prop.)</td>
<td>Provides for the physical security of transit passengers.</td>
</tr>
<tr>
<td>Transit Maintenance (prop.)</td>
<td>Supports automatic maintenance scheduling and monitoring.</td>
</tr>
<tr>
<td>Multi-modal Coordination (prop.)</td>
<td>Establishes two-way communications between multiple transit and traffic agencies and transit signal priority.</td>
</tr>
<tr>
<td>Transit traveler Information (exist.)</td>
<td>Provides customized or real-time transit information.</td>
</tr>
</tbody>
</table>

### IV.D. 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 major challenge is integrating the emergency management centers with the traffic management centers where many of the devices are monitored and controlled.

Table 8 lists the selected EM market packages for the study area.

### Table 8. Selected EM Market Packages

<table>
<thead>
<tr>
<th>Market Package Name</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Response (exist.)</td>
<td>Provides computer-aided dispatch systems.</td>
</tr>
<tr>
<td>Emergency Routing (prop.)</td>
<td>Automatic Vehicle Location and dynamic routing for emergency vehicles.</td>
</tr>
<tr>
<td>Mayday Support (exist.)</td>
<td>Supports response to requests for help from in-vehicle or call box type systems.</td>
</tr>
<tr>
<td>Transportation Infrastructure Protection (prop.)</td>
<td>Uses surveillance cameras and sensors to monitor critical infrastructures such as bridges, tunnels, etc</td>
</tr>
<tr>
<td>Wide-Area Alert (exist.)</td>
<td>Facilitates the use of ITS driver information devices (such as DMS and HAR) to spread emergency alert messages – example would be Amber Alerts.</td>
</tr>
<tr>
<td>Early Warning System (exist.)</td>
<td>Uses various types of sensors and monitors to facilitate early detection and warning of emergencies, including weather emergencies and terrorist attacks.</td>
</tr>
<tr>
<td>Disaster Response and Recovery (exist.)</td>
<td>Supports the overall coordinated response to emergencies by transportation, emergency response, and maintenance personnel.</td>
</tr>
<tr>
<td>Evacuation and Re-entry Management (exist.)</td>
<td>Supports coordination of evacuation plans by transportation and safety agencies as well as the subsequent return to the evacuation area.</td>
</tr>
<tr>
<td>Disaster Traveler Information (exist.)</td>
<td>Augments existing traveler information systems to provide emergency traveler information, such as evacuation routes, etc., in the event of a disaster.</td>
</tr>
</tbody>
</table>

### IV.E. Maintenance and Construction Management

Market packages in this service area may be linked to problems concerning maintenance vehicles, work zones, and collecting/distributing weather and road conditions data. Currently, both 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. CDOT is further exploring instrumenting maintenance vehicles to collect more real-time road condition data and dispatch maintenance vehicles even sooner. CDOT is also trying to expand the locations where automatic deicing systems are employed.

Table 9 lists the selected MCM market packages for the study area.
### Table 9. Selected MCM Market Packages

<table>
<thead>
<tr>
<th>Market Package Name</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maintenance and Construction Vehicle and Equipment Tracking (prop.)</strong></td>
<td>Tracks the location of maintenance and construction vehicles and other equipment.</td>
</tr>
<tr>
<td><strong>Maintenance and Construction Vehicle Maintenance (prop.)</strong></td>
<td>On-board diagnostics that provide maintenance and repair information for snowplows, trucks, etc.</td>
</tr>
<tr>
<td><strong>Road Weather Data Collection (exist.)</strong></td>
<td>Collection of weather and road conditions data using sensors installed near the roadway.</td>
</tr>
<tr>
<td><strong>Weather Information Processing and Distribution (exist.)</strong></td>
<td>Processing and dissemination of road/weather conditions information to travelers, maintenance workers, etc.</td>
</tr>
<tr>
<td><strong>Roadway Automated Treatment (exist.)</strong></td>
<td>Automated anti-icing systems for bridges and roadways.</td>
</tr>
<tr>
<td><strong>Winter Maintenance (exist.)</strong></td>
<td>Supports winter road maintenance including snowplow operations, roadway treatments (i.e., salt spraying, etc.)</td>
</tr>
<tr>
<td><strong>Roadway Maintenance and Construction (exist.)</strong></td>
<td>Supports scheduled and unscheduled maintenance and construction of ITS and non-ITS equipment.</td>
</tr>
<tr>
<td><strong>Work Zone Management (prop.)</strong></td>
<td>Enables construction delay and routing information to be provided en-route to drivers, and also facilitates providing this information to other agencies.</td>
</tr>
<tr>
<td><strong>Work Zone Safety Monitoring (prop.)</strong></td>
<td>“Intrusion Alarms” and other devices that warn if a vehicle is approaching a work zone at a high rate of speed or has entered the work zone. May also monitor movements of workers.</td>
</tr>
<tr>
<td><strong>Maintenance and Construction Activity Coordination (prop.)</strong></td>
<td>Coordination of maintenance and construction activities between various agencies for improved operations.</td>
</tr>
</tbody>
</table>

### IV.F. 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 study area, existing ITS Data Marts include the CDOT ITS DMS logs and weather station data, as well as local traffic volume and speed monitoring data.

The ITS Virtual Data Warehouse enables a network arrangement where multiple agencies can access multiple data archives directly without data actually being uploaded to a central location.

Table 10 lists the Archived Data market packages.
Table 10. Selected Archived Data Market Packages

<table>
<thead>
<tr>
<th>Market Package Name</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITS Data Mart (prop.)</td>
<td>Collect data for future analysis for one agency only.</td>
</tr>
<tr>
<td>ITS Virtual Data Warehouse (prop.)</td>
<td>Supports networked access to data archives for multiple agencies.</td>
</tr>
</tbody>
</table>
V. Operational Concept

The previous section identified the ITS market packages that address the most critical transportation issues in Western Colorado. 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 using Turbo Architecture. Due to the large geographic area, the number of stakeholders, and the extensive list of roles and responsibilities, this list is not particularly insightful. However, in order to better illustrate the complex relationships of the stakeholders, a scenario-based approach is provided to illustrate the roles and responsibilities. This section provides an overview of these roles and responsibilities in the context of four specific operational scenarios. These operational scenarios are based on the strategic ITS objectives identified for Western Colorado.

V.A. Strategic Goals

The analysis of ITS Needs and Services identified five core services as well as necessary enabling infrastructure (communications and connectivity) to focus on in Western Colorado. These are:

- Incident Management
- Traveler Information
- Freeway and Arterial Traffic Management
- Transit Management and Multi-modal Coordination
- Safety Management

In order to further clarify ITS Goals, the region was divided into major sub-areas based on their unique characteristics. In each sub-area, key objectives were identified for implementing the core ITS services in that sub-area. The five sub-areas are:

- I-70 Corridor,
- Grand Junction Urban Area,
- Mountain Communities,
- Rural Northwest,
- Rural Southwest.

Each sub-area is described below and the strategic objectives for each are given.

I-70 Corridor

This is the major transportation corridor through Western Colorado, running from the Utah state line to the west side of Vail Pass. It is a significant truck and tourism route as well as a major commuting route for workers in the resort towns along the corridor. The strategic services are:

- Traveler Information
- Incident Management
- Emergency Response
Grand Junction

This is the only major urban center in Western Colorado. Traffic congestion is a growing problem. The strategic services are:

- Arterial Traffic Management
- Incident Management
- Multi-modal Coordination

Mountain Communities

This sub-area refers to the numerous small urban areas throughout the Project Area. Many of these are significant tourism and recreation destinations, experience recurring traffic congestion, and are home to major special events. Strategic objectives are:

- Arterial Traffic Management
- Congestion Management
- Special Event Management
- Multi-modal Coordination

Rural Northwest

This is the rural portion of the Project Area north of I-70. It is characterized by long distances between towns with limited services. Strategic services are:

- Pass Closure Management
- Traveler Information
- Emergency Response
- Incident Management
- Wildlife Crossing Protection

Rural Southwest

This is the rural portion of the Project Area south of I-70. It is characterized by large distances between towns, high mountain passes, and limited services. Strategic services are:

- Pass Closure Management
- Traveler Information
- Emergency Response
- Incident Management
- Wildlife Crossing Protection

V.B. Operational Scenarios

Four operational scenarios have been identified to illustrate the roles and responsibilities of the numerous stakeholders in Western Colorado. These four scenarios are:

- Incident Management on I-70
- Traffic and Transit Management on SH-82
- Regional Traffic Management in Grand Junction
These four scenarios were chosen as representative of the range of roles and responsibilities covered by the regional architecture. Each scenario represents key aspects of the overall ITS implementation in Western Colorado, highlighting key interfaces and information flows as well.

**V.C. Incident Management on I-70**

I-70 is the most important transportation corridor in Western Colorado. It carries more than half of all east-west travel and the majority of the population in Western Colorado is along or adjacent to the corridor. Furthermore, many of the important tourism destinations are served by I-70. Due to the mountainous terrain and high elevations, weather-related incidents occur often. Crashes are also more frequent due to the terrain and the geometry it imposes in the form of steep grades and sharp curves. In addition, for most of the corridor, there are few alternate routes and the require detours of up to 100 miles. Incidents occur regularly and they create major impacts due to the importance of the corridor for travel. For these reasons, stakeholders identified incident management on I-70 as one the most critical needs in the region.

**Market Packages Included**

Incident management on I-70 is based on the Incident Management System Market Package, but also includes elements of the following Market Packages as well:

- **Network Surveillance** – this package includes the control of traffic sensors and surveillance cameras along the corridor as well as the collection of data from those.
- **Freeway Control** – this package provides for control of the lane use controls, especially in the Hanging Lakes Tunnels.
- **Traffic Information Dissemination** – this package provides the posting of messages on dynamic message signs and highway-advisory radios along the corridor.
- **Roadway Closure Management** – provides control of automatic roadway closure gates on the corridor.
- **Broadcast Traveler Information** – while the Traffic Information Dissemination package provides HAR and DMS control, this package provides for dissemination of information to travelers outside the corridor through broadcast media such as radio and television.
- **Interactive Traveler Information** – this package supports corridor specific information to travelers through media such as the Internet and 511 service.
- **Emergency Response** – the package provides the support to receive emergency calls, identify the location, and initiate the proper response.
- **Mayday Support** – the package provides the support to automatic emergency notification services such as On Star.
- **Wide-Area Alert** – this package supports the dissemination of information throughout the statewide traveler information system where the magnitude of an incident warrants.
- **Archived Data Packages** – various elements of archived data management provide support for selecting detour routes, coordinating between agencies, converting between coordinate systems, and identifying resources for response.
Roles and Responsibilities

While there are numerous stakeholders, the critical ones for incident management on I-70 are the HLT TMC, the CTMC in Lakewood, Colorado, the county Emergency Operations Centers (EOCs), local emergency response agencies, the CSP, and the responsible CDOT Region 3 maintenance office. These critical stakeholders are described below along with their roles and responsibilities.

The **CDOT HLT TMC** functions as the traffic management center for I-70 and is responsible for control of all devices along the corridor. This includes collecting information from sensors and cameras along the corridor, controlling gates and lane use signs, and posting messages on DMS and HAR. HLT TMC also functions as the single point of contact for CDOT. This streamlines coordination between emergency response forces and CDOT resources.

The **CTMC** manages the statewide traveler information systems as well as functioning as a surrogate for Information Service providers. In the latter role, public information offices at CTMC provide all coordination with media. CTMC staff also update the CoTrip website, disseminate broadcast fax and email, update the 511 and telephone advisory system, and place messages on DMS and HAR outside the region as needed. CTMC also will provide secure video images to the EOC to support real-time decision-making at the EOC or incident command post. The current vision is that these images would be available over a secure Internet link, but this detail requires further study.

The **County EOC** functions as the Emergency Management Center as described in the architecture. The EOC is also considered to include the 911-Dispatch from a logical perspective. While this may not be physically accurate, from a functional perspective, it is generally true and the difference has little effect on the architecture. The EOC is responsible for receiving reports of an incident and dispatching the appropriate response. The EOC is also responsible for incident command and coordination of needed resources.

Emergency responders and CSP are primarily concerned with response to and clearing of the incident. They provide an initial assessment of the incident, take control of the scene, and initiate the appropriate incident management plans. They also determine any necessary lanes closures and when to reopen lanes to traffic. This includes determining the need to establish detours and alternate routes.

**CDOT Region 3 Maintenance** forces provide 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. 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.

**V.D. Pass Closure Management in Region 5**

While most of the highways in Western Colorado involve mountain passes to one degree or another, mountain passes are a dominant issue in CDOT Region 5. Every major highway in Region 5 crosses over one or more passes over 10,000 in elevation. Some, such as Red
Mountain Pass may be closed as much as 50 times in one year due to blizzards, avalanches, or other causes.

**Market Packages Included**
Pass Closure Management is based on the Roadway Closure Management market package, but also includes key elements of other packages as well:

- **Roadway Closure Management** – includes the key elements of gate operation and video surveillance to ensure that the gates have been closed and/or opened at the appropriate time.
- **Road Weather Data Collection** – provides the process to collect current road and weather conditions on the mountain passes.
- **Weather Information Processing and Distribution** – provides the data processing and information distribution. This also includes the current avalanche forecasting resources.
- **Broadcast Traveler Information** – collects information on pass closures and reopenings and disseminates it to travelers, the media, and other stakeholders.
- **Interactive Traveler Information** – provides tailored responses to information requests via the Internet, PDAs, 511 portals, and kiosks.
- **Winter Maintenance** – supports the maintenance operations required to reopen a pass once it has been closed.

**Roles and Responsibilities**

While there are numerous stakeholders, the critical ones for pass closure management are HLT TMC, the CTMC in Lakewood, Colorado, the CSP, and the responsible CDOT Region 5 maintenance office. These critical stakeholders are described below along with their roles and responsibilities.

The CDOT HLT TMC functions as the traffic management center for western Colorado and is responsible for control of all ITS devices in the region. This includes collecting information for sensors and cameras along the corridor, controlling gates and lane use signs, and posting messages on DMS and HAR. HLT TMC also functions as the single point of contact for CDOT. This streamlines coordination between emergency response forces and CDOT resources.

The CTMC manages the statewide traveler information systems as well as functioning as a surrogate for Information Service providers. In the latter role, public information offices at CTMC provide all coordination with media. CTMC staff also update the CoTrip website, disseminate broadcast fax and email, update the 511 and telephone advisory system, and place messages on DMS and HAR outside the region as needed.

Colorado State Patrol is primarily responsible, in cooperation with CDOT, for determining when to close and subsequently open state highways.

CDOT Region 5 Maintenance forces verify road closures, provide on-site observation of weather and other environmental conditions, and work to reopen passes after they have been closed.
V.E.  Traffic and Transit Management on SH-82

After I-70, State Highway 82 is the busiest corridor in western Colorado. Due to the extreme volumes and congestion, transit usage is a critical component of travel in the corridor. Major sections of SH-82 have dedicated high-occupancy-vehicle (HOV) lanes. Coordination between RFTA and CDOT is essential to efficient management of the corridor. This scenario identifies the key elements of multi-modal coordination in a congested corridor.

Market Packages Included

While the previous scenarios primarily focused on CDOT operated market packages, many of the market packages in the SH-82 corridor are the responsibility of RFTA. The market packages include:

- **Surface Street Control** – this package provides the control and monitoring of the traffic signals in the corridor.
- **HOV Lane Management** – this package provides for future facilities to regulate and enforce HOV lane usage.
- **Transit Vehicle Tracking** – this package provides the hardware and data management to determine the real-time location of transit vehicles.
- **Transit Fixed-Route Operations** – this package performs the vehicle routing and scheduling functions.
- **Multi-modal Coordination** – this market package provides the interface between RFTA and CDOT to improve services, especially through transit signal priority.
- **Transit Traveler Information** – this package provides users at stops and on-board transit vehicles with access to transit arrival and departure times.

There are several other transit related market packages that RFTA is likely to implement in the SH-82 corridor. However these additional packages do not require significant cooperation with or interface to the other major stakeholders hence they do not add to this scenario.

Roles and Responsibilities

While there are numerous stakeholders, the critical ones for the SH-82 corridor are HLT TMC, RFTA, the CSP, and CDOT Region 3 Traffic. These critical stakeholders are described below along with their roles and responsibilities.

The CDOT HLT TMC functions as the traffic management center for western Colorado and is responsible for control of all ITS devices in the corridor with the exception of traffic signals which are controlled by the signal maintenance shop and CDOT traffic engineering. HLT TMC provides camera images and real-time travel information data to RFTA.

The RFTA manages the transit system in the SH-82 corridor. RFTA provides transit traveler information via a website and telephone. The vision for the corridor also includes transit traveler information at stops and on vehicles, which would be operated by RFTA. RFTA will also be responsible for communicating transit vehicle location to the transit signal priority system. RFTA acquires camera images and real-time travel information from HLT TMC to use for estimating transit arrival times. In addition, transit vehicles may be used as probes to provide travel data to HLT TMC.
Colorado State Patrol is primarily responsible for enforcement of the HOV lanes along SH-82 as well as responding to transit security issues along with local law enforcement.

CDOT Region 3 Traffic is responsible for operation and maintenance of the traffic signals along the corridor, including the signal side of the transit signal priority system. For simplicity sake, this stakeholder is assumed to include the traffic signal maintenance forces as well.

V.F. Regional Traffic Management in Grand Junction

Grand Junction is the only city in Western Colorado that manages it’s own ITS infrastructure. In addition, Grand Junction has its own fiber optics communication network. The City also operates traffic signal on the state highway system within town. This scenario focuses on the inter-jurisdiction coordination aspects of shared control between CDOT and the City.

Market Packages Included

While Grand Junction has a transit system and multi-modal coordination the previous is an aspect, this scenarios focuses on the shared management and control of traffic management. The market packages include:

- **Surface Street Control** – this package provides the control and monitoring of the traffic signals in the corridor.
- **Freeway Control** – this package provides the communication and control for ramp control, especially wrong way entrance, and for freeway monitoring and surveillance, especially related to incident management.
- **Regional Traffic Control** – this package provides for the sharing of information and control among the city’s traffic control center, CDOT Region 3 traffic, and the HLT TMC.

Roles and Responsibilities

The key stakeholders in this scenario and the HLT TMC, Grand Junction Traffic Engineering, and CDOT Region 3 Traffic. These critical stakeholders are described below along with their roles and responsibilities.

The CDOT HLT TMC functions as the traffic management center for western Colorado and monitors and control traffic along I-70 from the Utah state line to Vail Pass. HLT TMC will gather local road conditions form Grand Junction and CDOT Region 3 Traffic and forward them to the statewide traveler information system as well as use them for more localized management.

The City of Grand Junction Traffic manages the city’s traffic signal system as well as the Riverside Parkway traffic management system, which includes cameras and traffic volume and speed detectors. Grand Junction also manages several signals on the state highway system. The City makes provides access to its fiber optic network to CDOT as well as providing camera images and traffic data.

CDOT Region 3 Traffic is responsible for operation and maintenance of the traffic signals on state highways outside city limits. Region 3 will coordinate operation of key signals with the
City. Region 3 also shares camera images and traffic data with the City where communication facilities facilitate this sharing.

V.G. Functional Requirements

Functional requirements are one of the mandatory components 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 design. At the regional architecture level these 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, implementable groupings of processes within a given subsystem.

The major physical entities in the regional architecture, the equipment packages and high-level functional requirements are described below.

CDOT ITS Branch

Government Reporting Systems Support - select and format data residing in an ITS archive to facilitate local, state, and federal government data reporting requirements.

ITS Data Repository - collect 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.

Traffic and Roadside Data Archival - collect and archive 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.

Virtual Data Warehouse Services - provide capabilities to access "in-place" data from geographically dispersed archives and coordinate information exchange with a local data warehouse. While many of the functions performed by this equipment package are similar to the functions inherent in other archived data management subsystem equipment packages (e.g. data management, fusion, analysis) this equipment package also provides the specialized publishing, directory services, and transaction management functions associated with coordinating remote archives.

Hanging Lake Tunnel TMC

Traffic Data Collection - collect 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 - remotely monitor and controls traffic sensors and surveillance (e.g., CCTV) equipment, and collects, processes and stores the collected traffic data.
The collected information is provided to traffic operations personnel and made available to other centers.

**Traffic Maintenance** - monitor the operational status of field equipment and detect failures. Field equipment status is presented to Traffic Operations Personnel and failures are reported to the Maintenance and Construction Management Subsystem.

**TMC Freeway Management** - provide center monitoring and control of freeway traffic control systems including overhead lane control signals, freeway mainline metering, and variable speed control systems.

**TMC HOV Lane Management** - provide center monitoring and control of HOV lanes.

**TMC Traffic Information Dissemination** - disseminate 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 and monitor and control driver information system field equipment including dynamic message signs and highway advisory radio, managing dissemination of driver information through these systems.

**TMC Incident Detection** - identify and report incidents to Traffic Operations Personnel by remotely monitoring and controlling traffic sensor and surveillance systems that support incident detection and verification.

**TMC Incident Dispatch Coordination/Communication** - formulate and manage an incident response taking 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 Reversible Lane Management** - remotely monitor and control reversible lanes through an interface to reversible lane field equipment (traffic sensors, surveillance equipment, lane control signals, physical lane access controls, etc.) and to traffic operations personnel to support central monitoring and control of these facilities.

**TMC Speed Monitoring** - remotely monitor and control speed monitoring and speed warning systems. This equipment package can also notify an enforcement agency if excessive speeds are identified.

**Barrier System Management** - remotely monitor and control 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.

**Safeguard System Management** - remotely monitor and control 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.
TMC Evacuation Support - support 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.

TMC Environmental Monitoring - assimilate 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.

CDOT Region 3 and Region 5 Traffic
Traffic Maintenance - monitor the operational status of field equipment (esp. traffic signals) and detect failures.

TMC Signal Control - provide the capability for traffic managers to monitor and manage the traffic flow at signalized intersections including analyzing and reducing the collected data from traffic surveillance equipment and developing and implementing control plans for signalized intersections.

TMC Regional Traffic Control - support 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 - support center-to-center coordination between the Traffic Management and Transit Management Subsystems, monitor transit operations, and provides traffic signal priority for transit vehicles on request from the Transit Management Subsystem.

TMC Work Zone Traffic Management - coordinate 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.

Colorado Transportation Management Center
The CTMC functions as both an ISP and as a backup traffic management center. As backup traffic management center it requires all the functionality that the HLT TMC requires as well as the following:

ISP Data Collection - collect and store 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.
Basic Information Broadcast - collect, process, store, and disseminate traveler information including traffic and road conditions, incident information, maintenance and construction information, event information, transit information, parking information, and weather information. The same information is broadcast to all equipped traveler interface systems and vehicles.

ISP Traveler Data Collection - collect traveler-related data from other centers, consolidate, verify, and refine the collected data, and make this data available in a consistent format to applications that deliver traveler information.

Traveler Telephone Information - service voice-based traveler requests for information that supports traveler telephone information systems such as 511. 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 - collect and provide emergency information to the public, including wide-area alerts and evacuation information; provide 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.

CDOT Region 3 and Region 5 Maintenance

MCM Data Collection - collect and store 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 - support 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 - 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 - 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 - 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. It also collects current and forecast environmental conditions information that is made available by other systems.
MCM Environmental Information Processing - processes current and forecast weather data, road condition information, local environmental data, and uses internal models to develop specialized detailed forecasts of local weather and surface conditions. The processed environmental information products are presented to center personnel and disseminated to other centers.

MCM Automated Treatment System Control - 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 - 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 - 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 - 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 - 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 - monitor traffic conditions using fixed equipment such as loop detectors and CCTV cameras.

Roadway Equipment Coordination - support 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 - 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. 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.

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

Roadway HOV Control - monitors and controls high occupancy vehicle (HOV) and high occupancy toll (HOT) lanes. It includes traffic sensors that monitor HOV lane usage and display equipment such as lane control signals that provide lane status to drivers.

Roadway Traffic Information Dissemination - includes field elements that provide information to drivers, including dynamic message signs and highway advisory radio.

Roadway Reversible Lanes - includes field elements that monitor and control reversible lane facilities. It includes the traffic sensors, surveillance equipment, lane control signals, physical lane access controls, and other field elements that manage traffic on these facilities. It provides current reversible lane facility status information and accepts requests and control commands from the controlling center.

Roadway Speed Monitoring - 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** - 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.

**Grand Junction Traffic**

**Traffic Maintenance** - monitor the operational status of field equipment (esp. traffic signals) and detect failures.

**TMC Signal Control** - provide the capability for traffic managers to monitor and manage the traffic flow at signalized intersections including analyzing and reducing the collected data from traffic surveillance equipment and developing and implementing control plans for signalized intersections.

**TMC Regional Traffic Control** - support 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** - support center-to-center coordination between the Traffic Management and Transit Management Subsystems, monitor transit operations, and provides traffic signal priority for transit vehicles on request from the Transit Management Subsystem.

**CSP and County EOCs**

**Emergency Data Collection** - collect and store 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** - provide 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.

**Incident Command** - provide 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. 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.
Emergency Call-Taking - support 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 911, 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 - track the location and status of emergency vehicles and dispatch 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 - monitor 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 - coordinate evacuation plans among allied agencies and manage 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.

Transit Management (GVT, RFTA, ECO)

Each transit agency is somewhat different in the range ITS User Services it plans on deploying. Many of these services do not require any external coordination. Functional requirements derived from services requiring external coordination include:

Transit Data Collection - collect and store 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 - monitor 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.

Transit Center Fixed-Route Operations - manage fixed route transit operations supporting planning and scheduling of fixed and flexible route transit services. The package allows fixed-route and flexible-route transit services to develop and disseminate
schedules and automatically updates customer service operator systems with the most current schedule information.

**Transit Center Multi-Modal Coordination** - determine the need for transit priority on routes and at certain intersections and request transit vehicle priority at these locations.

**On-board Transit Signal Priority** - provide the capability for transit vehicles to request signal priority at signalized intersections through short-range communication directly with traffic control equipment at the roadside.

**Transit Center Information Services** - collect the latest available information for a transit service and make 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 en-route.

**Transit Evacuation Support** - manage 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 Environmental Monitoring** - assimilate current and forecast road conditions and surface weather information from a variety of sources, including both weather service providers and vehicle probes.
VI. Implementation Plan

Ultimately, the realization of the strategic goals for intelligent transportation systems in Western Colorado will be dependent on developing projects that deploy the enabling infrastructure and create the connections and interfaces that do not exist today. While all implementations that lead to the strategic goals are important, some are more critical than others. This may be because they implement critical supporting infrastructure, like fiber-optic backbone, because they fill an essential role such as managing pass closures, or because they require extensive cooperation and coordination between agencies such as a transit signal priority system.

Furthermore, an ITS project can be significant on different levels, just as transportation facilities can. Some projects are significant on a state or national level, such as incident management on a heavily traveled interstate highway. Other projects are significant on a regional level because they implement strategic objectives across a large portion of the Project Area. Finally, some projects implement strategic objectives, but on a more localized basis.

VI.A. Recommended ITS Projects

With the aforementioned framework in mind, the following ITS strategic projects are recommended to address the ITS strategic objectives in Western Colorado (see Figure 5):

Projects of Statewide Significance
1. Install fiber-optic cable along I-70 from Frisco to Glenwood Canyon including all equipment, connections with lateral devices and C2C connectively with CSP and local jurisdictions (the segment from Frisco to Vail is physically in Region 1, but is needed for Region 3).
2. Install fiber-optic cable along I-70 from Glenwood Springs to Grand Junction including all equipment, connections with lateral devices and C2C connectively with CSP and local jurisdictions.
3. Completion of the I-70 Incident Management Plan improvements from Vail to Grand Junction, including automated road closure for Glenwood Canyon.
4. Providing a secure interface so that participating agencies, such as transit providers or local governments, can access camera images and other data directly.
5. Developing a communications master plan for the rural areas of Western Colorado where existing communication infrastructure is inadequate.
6. Instrumenting maintenance vehicles to provide road and weather condition data.

Projects of Regional Significance
7. Installation of Automated Pass Maintenance and Management Systems on the major highway routes, including:
   7.1 US 550 between Durango and Ouray (Coal Bank Pass, Molas Divide, Red Mountain Pass),
   7.2 US 160 over Wolf Creek Pass,
Figure 5: Recommended ITS Strategic Projects

These projects are discussed in more detail in the following sections.
7.3 US 40 between Kremmling and Steamboat Springs (Muddy Pass and Rabbit Ears Pass),
7.4 US 50 over Monarch Pass,
7.5 SH 145 over Lizard Head Pass,
7.6 US 24 over Tennessee Pass,
7.7 US 50 over Cerro Summit,
7.8 SH 91 over Fremont Pass,
7.9 US 160 over La Veta Pass, and
7.10 US 50 in the Blue Mesa Reservoir area.

8. Implementation of a Transit Signal Priority System on State Highway 82 from Glenwood Springs to Aspen (this is separate from the arterial management system for SH 82).


10. Implementation of arterial management systems on:
   10.1 SH 82 from Glenwood Springs to Aspen,
   10.2 US 40 through Steamboat Springs,
   10.3 US 40 through Winter Park,
   10.4 US 550 and US 160 through Durango,
   10.5 US 160/US 285 through Alamosa,
   10.6 US 550 and US 50 through Montrose, and
   10.7 US 50 through Gunnison.


12. Developing communication links between the HLT TMC and major Emergency Operations Centers and other transportation providers.

13. Enhancing transit management systems for local transit operators, to include automatic vehicle location, automatic fare collection, and real-time transit passenger information.

**VI.B. Projects of Statewide Significance**

As discussed above, some projects are important to the achievement of state and national strategic objectives as well as regional strategic objectives. This is particularly the case for projects focused along the I-70 corridor. This corridor is a critical part of the interstate transportation system connecting Denver and other cities to the east, with cities in Utah, Nevada and California. Disruption of this roadway affects other roadways throughout the western United States. This level of significance also implies that statewide ITS funding could be made available for these projects. Three projects are critical to achieving the strategic objective for the I-70 corridor:
Fiber optic cable installation along I-70

While numerous ITS devices have been deployed along the I-70 corridor and incident management plans have been in place for several years, there is still a pressing need to gather greater real-time information along the corridor and to manage the numerous devices needed for efficient management of the corridor. In particular, there is a growing demand for real-time video images both for incident and emergency responders and for the traveling public at large. However, further deployment of surveillance cameras and other devices is constrained by the lack of supporting communications infrastructure to transmit the video images and control data between the field and the control centers at Hanging Lake Tunnel and the CTMC now in Golden. With the exception of about 20 miles in Glenwood Canyon, there is no direct communication along I-70.

Recently, CDOT completed installation of fiber optic lines from the Denver Metro area to Frisco. Extending this system from Frisco to Glenwood Canyon and from Glenwood Springs to Grand Junction provides a critical piece of supporting infrastructure, which will support the deployment of more extensive incident and emergency management systems along I-70, as well as significantly improve the quality of traveler information along the I-70 corridor. Given that I-70 is the most important corridor in the project area and that the fiber-optic communications is a critical piece of supporting infrastructure for other strategic goals, these two fiber optic projects are the highest priority in the Project Area, and are presented in more detail below.

1. Install fiber-optic cable along I-70 from Frisco to Glenwood Canyon

CDOT has designated a fiber-optic backbone system connecting the major regional Transportation Management Centers as a critical piece of enabling infrastructure. Recently, CDOT installed fiber-optic cable from the CTMC to the town of Frisco in Summit County. Fiber-optic cable also runs from HLT TMC, east to the end of the Glenwood Canyon near the town of Dotsero. This project will extend the fiber-optic line from Frisco to Glenwood Canyon, a distance of about 70 miles. The segment from Frisco to Vail is physically in Region 1, but is needed for Region 3. This project also installs the network communication hardware necessary to manage a high-speed network and provide center-to-center connectivity. Equipment and lateral connection are included in the incident management system.

Estimated Construction Cost: $10,500,000
Design Costs (8%): $840,000
Annual Maintenance and Repair (10%): $1,050,000

2. Install fiber-optic cable along I-70 from Glenwood Springs to Grand Junction

Fiber-optic cable has been extended from HLT TMC to the CDOT Resident Offices in Glenwood Springs; however, there is no high-speed communication available to CDOT between Glenwood Springs and Grand Junction. This project also installs the network communication hardware necessary to manage a high-speed network and provide center-to-center connectivity. Equipment and lateral connection are included in the incident management system.

Estimated Construction Cost: $10,500,000
Design Costs (8%): $840,000
Regional ITS Architecture for Western Colorado

CDOT Region 3 and Region 5

Annual Maintenance and Repair (10%): $1,050,000

I-70 Incident Management Plan Improvements

Due to the volume of traffic it carries and the inter-regional and interstate nature of trips along it, I-70 has a unique strategic importance in the project area. For this reason, incident management and traveler information along I-70 are important to the Project Area, and to the state as a whole. CDOT Regions 1 and 3 have jointly developed an Incident Management Plan for I-70 from the Utah State Line to the Denver metro region. From an operational standpoint, this management plan has been highly successful. At the same time, the plan recommended several additional devices, particularly variable message signs, surveillance cameras, and highway advisory radios.

Due to limited funding and the lack of communication infrastructure, many of these recommendations have not been implemented. While numerous devices such as surveillance cameras, variable message signs and highway advisory radios have been deployed at several locations along the corridor, these deployments have been limited in the western slope. Several locations have been identified as part of the incident management plan development, but the lack of high-speed communications has limited these deployments. Once a fiber optic network is installed along I-70, completion of the identified devices should be the next priority. Along with this, automatic road closure systems are needed to assist with incident management, especially at the westbound entrance to Glenwood Canyon.

3. Completion of the I-70 Incident Management Plan improvements from Vail to Grand Junction, including automated road closure for Glenwood Canyon

Recently, CDOT updated the Incident Management Plan for I-70. Based on the plan, I-70 will require the following: 9 VMS, 10 CCTV, 21 Call Boxes, and HAR. This estimate also includes the communication equipment and lateral cables.

Estimated Construction Cost: $2,900,000
Design Costs (8%): $232,000
Annual Maintenance and Repair (15%): $435,000

4. Providing a secure interface so that participating agencies, such as transit providers or local governments, can access camera images and other data directly

While CDOT has several cameras and other sensors along the highway system many other agencies do not have direct access to these devices. Direct access to camera images and other sensors would greatly benefit many other stakeholders such as emergency management centers and transit agencies. A secure access would provide resource sharing similar to that which some Front Range communities have, albeit at slower speeds. This work would most likely be completed by CTMC hence no cost is associated with it.

5. Developing a communications master plan for Western Colorado

Several areas of Western Colorado have limited or no communications infrastructure. Long distances make fiber optics not cost effective and the mountains and rugged terrain interfere
with many wireless communications methods. Many areas have no, or very limited, cellular telephone coverage. Since ITS is dependent on communications this condition limits the ability to deploy ITS is the more remote areas, which are some of the most critical areas as well. A communications master plan will identify public and private options for communications as well as exploring numerous wireless communications options throughout the regions.

Estimated Cost: $150,000

6. Instrumenting maintenance vehicles to provide road and weather condition data

CDOT maintenance vehicles are constantly on the road network and drivers frequently call in reports of road conditions, accidents, and other data. However, at times the drivers are too busy driving to provide complete information and the information they do provide is generally qualitative. Instrumented vehicles would significantly increase the amount of weather and road condition data available. These systems could also be combined with vehicle safety systems such as edge of pavement detection to greatly improve road maintenance.

Cost Estimate: Not quantified.

VI.C. Projects of Regional Significance

Automated Pass Management

One of the major issues in Western Colorado, from both a traveler information perspective and from a maintenance management perspective, is the closure of mountain passes on major highways. These passes may be closed, either fully or partially, due to rockslides, avalanche control, excessive snowfall, or maintenance needs. Due to the sparse roadway network, pass closures can entail long delays or detours of up to 100 miles. This package of improvements closes roadways to vehicular traffic over mountain passes when driving conditions are unsafe, maintenance must be performed, and for other scenarios when access to the roadway must be prohibited. Roadway Closure Management, the Market Package for this ITS applications includes automatic or remotely controlled gates that manage access to roadway segments. Remote control systems allow the gates to be operated from a central location, improving system efficiency and reducing personnel exposure to unsafe conditions during severe weather events and other situations that necessitate road closure. Surveillance systems allow operating personnel to visually verify the safe activation of the closure system and driver information systems (e.g., VMS and HAR) provide closure information to motorists in advance of the closure.

Roadways requiring automated pass management systems include:

1. US 550 between Durango and Ouray (Coal Bank Pass, Molas Divide, Red Mountain Pass),
2. US 160 over Wolf Creek Pass,
3. US 40 between Kremmling and Steamboat Springs (Muddy Pass and Rabbit Ears Pass),
4. US 50 over Monarch Pass,
5. SH 145 over Lizard Head Pass,
6. US 24 over Tennessee Pass,
7. US 50 over Cerro Summit,
8. SH 91 over Fremont Pass,
9. US 160 over LaVeta Pass, and
10. US 50 in the Blue Mesa Reservoir area.

7. Automated Pass Maintenance and Management

These systems provide the sensors to monitor road and weather conditions, the devices to automatically close roadways and post warning signs, and the devices to disseminate condition information to travelers. They consist of shoulder delineation for snow removal, automatic gates, advanced warning signs, arterial scale variable message signs, highway advisory radio, and road and weather information systems. A fully automated system is estimated to cost approximately $250,000, exclusive of communications. Communication costs could vary widely, but are expected to average $50,000 per location. An incremental deployment could consist of manual gates and warning signs and would cost about $150,000. However, several of the required devices are already deployed throughout the Project Area and devices can be shared between adjacent passes such as Coal Bank and Molas Divide (i.e. closing both passes simultaneously).

Estimated Construction Cost (full system): $2,650,000
Design Costs (8%): $212,000
Annual Maintenance and Repair (15%): $397,500
Estimated Construction Cost for Manual System = $1,650,000

8. Transit Signal Priority System on State Highway 82 from Glenwood Springs to Aspen

SH 82 from Glenwood Springs to Aspen is the most heavily traveled corridor in the Project Area with the exception of I-70. Much of the traffic is daily commuter travel combined with tourism and recreation travel. A rapid transit corridor has been designated parallel to the highway. However, funding for the ultimate transit solution is several years away. Currently RFTA operates its regional commuter services along the designated HOV lane between Basalt to Buttermilk, just south of Aspen Airport and in mixed traffic between Basalt and Glenwood Springs. The regionally-endorsed vision for this system is to implement bus rapid transit along SGH 82, which incorporates a new fleet of low-floor vehicles, improved transit stations and ITS elements such as automated fare collection, real time information, and transit signal prioritization. Currently, delays at signalized intersections reduce the operational efficiency of transit as a mode choice and disrupt bus scheduling. A transit signal priority system will improve the on-time performance and increase the attractiveness of transit as a trip choice in this corridor. In addition, the necessary communications infrastructure will facilitate improvements in the signal operations for general-purpose traffic as well. This project could entail installing transponders on each bus that uses the system, receivers at each signalized intersection, and communications between the signal controllers and a master controller. This
infrastructure also uses the arterial management system through the built up areas of the corridor.

Estimated Construction Cost: $1,000,000  
Design Costs (12%): $120,000  
Annual Maintenance and Repair (15%): $150,000

9. **Regional Traffic Management System in Grand Junction**

Grand Junction is currently in the process of extending fiber-optic cable to most of the arterial intersections in the urban area and placing the traffic signals under closed-loop control. This is a critical first step in improving active management of the traffic signals and increasing the efficiency of the transportation network. Bringing all the signals in the Grand Junction area, including CDOT and Mesa County, under control of a single multi-jurisdictional control system is the next step in improving traffic operations in this sub-region. This would allow each jurisdiction to maintain autonomous control of its own signals while ensuring that signals remain coordinated. It also provides the mechanisms for more advanced traffic control strategies.

Estimated Construction Cost: $1,500,000  
Design Costs (8%): $120,000  
Annual Maintenance and Repair (15%): $225,000

10. **Arterial Management Systems**

Congestion management is an essential strategy for preserving mobility in the western communities. This entails providing closed-loop signal control along the state highways, coordinating adjacent signals not on the state highway, and providing traffic sensors and video cameras for real-time monitoring of traffic. These systems are required on the following:

1. SH 82 from Glenwood Springs to Aspen,
2. US 40 in Steamboat Springs,
3. US 40 in Winter Park,
4. US 550 and US 160 in Durango,
5. US 160 and US 285 in Alamosa,
6. US 550 and US 50 in Montrose, and
7. US 50 in Gunnison.

Each of these systems is estimated to cost $500,000.

Estimated Construction Cost: $3,500,000  
Design Costs (8%): $280,000  
Annual Maintenance and Repair (15%): $525,000

11. **Automated Wildlife Detection Systems**
Wildlife crashes are a significant safety problem in Western Colorado. CDOT is testing several different wildlife detection systems to alert drivers of wildlife on the road and to scare wildlife away from concentrated crossing areas. However, none of these have been selected as the preferred treatment at this time. Once CDOT determines which technology is the most appropriate for deployment, formal cost estimates, budgets, and locations will be determined. For the time being, an aggregate cost of $2,000,000 has been assigned as a placeholder for a pool of funds to address potential wildlife detection areas in the Project Area.

Estimated Construction Cost: $2,000,000  
Design Costs (8%): $160,000  
Annual Maintenance and Repair (20%): $400,000

12. **Communications links between HLT and EOCs.**

Local emergency management centers are responsible for coordinating police, fire, and other emergency responders for incidents and for evacuations. These activities are greatly enhanced by access to real-time information, especially video images, as well as access to advisory radio and message signs. However, most emergency management centers do not have access to cameras or other sensors. Communications links would provide access to existing CCTV installations and facilitate coordination with the HLT TMC for disseminating information to travelers. Due to the number of emergency operations centers, their varying requirements, and other parallel efforts, this action has not been quantified.

13. **Transit Management Systems**

Enhancing transit systems and increasing ridership is a key tool for managing congestion in communities in Western Colorado. Advanced transit management systems have been shown to reduce cost per passenger mile as well as increasing ridership. These transit management systems could include automatic vehicle location, automatic fare collection, and real-time transit passenger information. Since each transit system differs in the amount of automation and the extent of transit system they want to manage, this item has not been quantified.

**VI.D. Relating Projects to Goals**

shows each of the Strategic ITS Projects and identifies the goals that are implemented by that project. This table indicates that every one of the project implements one or more of the Strategic Goals.

**VI.E. Agreements**

The operational concepts presented previously define the overall relationships between stakeholders in the region. In order to fully implement the operational concept, additional agreements may be necessary to define the roles and responsibilities of the agencies involved. These agreements may have technological and operational impacts on the development of some of the systems. This section discusses existing, planned and potential agreements.
### Table 11. Project Goals

<table>
<thead>
<tr>
<th>Strategic ITS Projects</th>
<th>Implemented Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>Install fiber-optic cable along I-70 from Glenwood to Vail</td>
</tr>
<tr>
<td></td>
<td>- I-70: Connect HLT and EJT</td>
</tr>
<tr>
<td></td>
<td>- I-70: Traveler Information</td>
</tr>
<tr>
<td></td>
<td>- I-70: Incident Management</td>
</tr>
<tr>
<td></td>
<td>- I-70: Emergency Response</td>
</tr>
<tr>
<td></td>
<td>- I-70: Road Closure Management</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Install fiber-optic cable along I-70 from Grand Junction to Glenwood</td>
</tr>
<tr>
<td></td>
<td>- I-70: Traveler Information</td>
</tr>
<tr>
<td></td>
<td>- I-70: Incident Management</td>
</tr>
<tr>
<td></td>
<td>- I-70: Emergency Response</td>
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<tr>
<td></td>
<td>- I-70: Road Closure Management</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Complete I-70 Incident Management and Traveler Information System</td>
</tr>
<tr>
<td></td>
<td>- I-70: Traveler Information</td>
</tr>
<tr>
<td></td>
<td>- I-70: Incident Management</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Provide a secure web interface to camera images</td>
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<tr>
<td></td>
<td>Traveler Information (Region Wide)</td>
</tr>
<tr>
<td></td>
<td>Incident Management (Region Wide)</td>
</tr>
<tr>
<td></td>
<td>Emergency Response (Region Wide)</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>Develop a communications master plan</td>
</tr>
<tr>
<td></td>
<td>Traveler Information (Region Wide)</td>
</tr>
<tr>
<td></td>
<td>Incident Management (Region Wide)</td>
</tr>
<tr>
<td><strong>6</strong></td>
<td>Instrument maintenance vehicle for road and weather information</td>
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<tr>
<td></td>
<td>Traveler Information (Region Wide)</td>
</tr>
<tr>
<td></td>
<td>Incident Management (Region Wide)</td>
</tr>
<tr>
<td><strong>7.1</strong></td>
<td>Install pass maintenance and management system on Molas Divide, Red Mountain and Coal Bank passes</td>
</tr>
<tr>
<td></td>
<td>Southwest: Pass Closure Management</td>
</tr>
<tr>
<td><strong>7.2</strong></td>
<td>Install pass maintenance and management system on Wolf Creek Pass</td>
</tr>
<tr>
<td></td>
<td>Southwest: Pass Closure Management</td>
</tr>
<tr>
<td><strong>7.3</strong></td>
<td>Install pass maintenance and management system on Muddy Pass and Rabbit Ears Pass</td>
</tr>
<tr>
<td></td>
<td>Northwest: Pass Closure Management</td>
</tr>
<tr>
<td><strong>7.4</strong></td>
<td>Install pass maintenance and management system on Monarch Pass</td>
</tr>
<tr>
<td></td>
<td>Southwest: Pass Closure Management</td>
</tr>
<tr>
<td><strong>7.5</strong></td>
<td>Install pass maintenance and management system on Lizard Head Pass</td>
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<tr>
<td></td>
<td>Southwest: Pass Closure Management</td>
</tr>
<tr>
<td><strong>7.6</strong></td>
<td>Install pass maintenance and management system on Tennessee Pass</td>
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<tr>
<td></td>
<td>Southwest: Pass Closure Management</td>
</tr>
<tr>
<td><strong>7.7</strong></td>
<td>Install pass maintenance and management system on Cerro Summit</td>
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<td></td>
<td>Southwest: Pass Closure Management</td>
</tr>
<tr>
<td><strong>7.8</strong></td>
<td>Install pass maintenance and management system on Fremont Pass</td>
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<td></td>
<td>Southwest: Pass Closure Management</td>
</tr>
<tr>
<td><strong>7.9</strong></td>
<td>Install pass maintenance and management system on La Veta Pass</td>
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<td></td>
<td>Southwest: Pass Closure Management</td>
</tr>
<tr>
<td><strong>7.10</strong></td>
<td>Install pass maintenance and management system in the Blue Mesa Reservoir area</td>
</tr>
<tr>
<td></td>
<td>Southwest: Pass Closure Management</td>
</tr>
<tr>
<td><strong>8</strong></td>
<td>Implement Transit Signal Priority on SH 82 from Glenwood to Aspen</td>
</tr>
<tr>
<td></td>
<td>Mountain Communities: Multi-modal Coordination</td>
</tr>
<tr>
<td></td>
<td>Mountain Communities: Special Event Management</td>
</tr>
<tr>
<td><strong>9</strong></td>
<td>Complete the Regional Traffic Management System in Grand Junction</td>
</tr>
<tr>
<td></td>
<td>Grand Jct.: Arterial Traffic Management</td>
</tr>
<tr>
<td></td>
<td>Grand Jct.: Incident Management</td>
</tr>
<tr>
<td></td>
<td>Grand Jct.: Multi-modal Coordination</td>
</tr>
<tr>
<td><strong>10.1</strong></td>
<td>Implement arterial traffic management system on SH 82 from Glenwood to Aspen</td>
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<tr>
<td></td>
<td>Mountain Communities: Arterial Traffic Management</td>
</tr>
<tr>
<td></td>
<td>Mountain Communities: Congestion Management</td>
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<tr>
<td></td>
<td>Mountain Communities: Special Event Management</td>
</tr>
<tr>
<td><strong>10.2</strong></td>
<td>Implement arterial traffic management system on US 40 in Steamboat Springs</td>
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<td></td>
<td>Mountain Communities: Arterial Traffic Management</td>
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<td></td>
<td>Mountain Communities: Congestion Management</td>
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<tr>
<td></td>
<td>Mountain Communities: Special Event Management</td>
</tr>
<tr>
<td><strong>10.3</strong></td>
<td>Implement arterial traffic management system on US 40 in Winter Park</td>
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<tr>
<td></td>
<td>Mountain Communities: Arterial Traffic Management</td>
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<td></td>
<td>Mountain Communities: Congestion Management</td>
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<tr>
<td></td>
<td>Mountain Communities: Special Event Management</td>
</tr>
<tr>
<td><strong>10.4</strong></td>
<td>Implement arterial traffic management system on US 550 and US 160 in Durango</td>
</tr>
<tr>
<td></td>
<td>Mountain Communities: Arterial Traffic Management</td>
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<tr>
<td></td>
<td>Mountain Communities: Congestion Management</td>
</tr>
<tr>
<td></td>
<td>Mountain Communities: Special Event Management</td>
</tr>
<tr>
<td><strong>10.5</strong></td>
<td>Implement arterial traffic management system on US 160 and US 285 in Alamosa</td>
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<td></td>
<td>Mountain Communities: Arterial Traffic Management</td>
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<td></td>
<td>Mountain Communities: Congestion Management</td>
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<tr>
<td></td>
<td>Mountain Communities: Special Event Management</td>
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<tr>
<td><strong>10.6</strong></td>
<td>Implement arterial traffic management system on US 550 and US 50 in Montrose</td>
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<tr>
<td></td>
<td>Mountain Communities: Arterial Traffic Management</td>
</tr>
<tr>
<td></td>
<td>Mountain Communities: Congestion Management</td>
</tr>
</tbody>
</table>
The following are projects and implementations that require establishment of formal agreements:

- **Regional Traffic Control**: there are some informal agreements currently in place. For example, CDOT Region 2 maintenance currently coordinates with the HLT TMC to have DMS messages posted on the freeway. As the network of ITS implementations grow along each of the corridors and regionally, many agencies will be responsible for operation and maintenance of ITS devices such as traffic signals, vehicle detectors, CCTV cameras, DMS and RWIS stations. Agreements that detail the authority, priorities for shared operation, and liability will be necessary to share the 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 control and to use existing ITS systems to their full effectiveness should be the primary set of agreements.

- **Incident Management**: There is an existing incident management plan for the I-70 Mountain Corridor. This plan defines the roles of key agencies in responding to incidents along the freeway based on the incident location and severity. There is interest in expanding the coverage of incident management plans to consider other major highways within the study area. In addition, there is a desire to develop responses that include the use of existing and future ITS deployments (i.e. signal timing plans and DMS messaging). The sharing of ITS devices becomes critical as maintenance and device reliability will be an issue for all agencies involved. These agreements must be sure to address device availability as well as the means by which control conflicts (i.e. competing messages on a DMS) can be resolved.

- **Communications**: As the communication networks in the study area grow, there will be opportunities for sharing of communications infrastructure. In fact, it is expected that the communications planning will embody that concept in order to leverage a communications network that best serves the needs of the agencies within the study area. The purpose of the agreement is to define the ownership and subsequently responsibilities for maintenance and repair of the network. Provision in these agreements should accommodate new participants as the infrastructure network grows.

### VI.F. ITS Standards

ITS Standards facilitate interoperability and integration of ITS devices and systems. From the US DOT ITS Standards Program web site. ([http://standards.its.dot.gov/standards.htm](http://standards.its.dot.gov/standards.htm)).

<table>
<thead>
<tr>
<th>Strategic ITS Projects</th>
<th>Implemented Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement arterial traffic management system on US 50 in Gunnison</td>
<td>Mountain Communities: Special Event Management</td>
</tr>
<tr>
<td>Implement Automated Wildlife Detection systems on critical roadway sections</td>
<td>Emergency Response (Region Wide)</td>
</tr>
<tr>
<td>Develop communications links between HLT and EOCs</td>
<td>Incident Management (Region Wide)</td>
</tr>
<tr>
<td>Implement transit management systems for local transit operators</td>
<td>Mountain Communities: Multi-modal Coordination</td>
</tr>
</tbody>
</table>
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.”

The ITS standards govern communications between the following interfaces between various ITS subsystems as defined in the National ITS Architecture:

- Center to Center (Example: Traffic Management Center (TMC) to Emergency Dispatch Center)
- Center to Roadside (Field) (Example: TMC to DMS)
- Center to Vehicle/Traveler (Example – Information service provider to kiosk, Emergency Dispatch Center to emergency response vehicle)
- Roadside to Roadside (Example – traffic signal controller to railroad crossing equipment)
- Roadside to Vehicle (Example – transit signal priority or electronic toll collection)

The physical architecture flows between these subsystems from the National ITS Architecture are linked 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”. This use of the standard enables one software driver to communicate with NTCIP-compliant DMS signs from different vendors.

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

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

- **National Location Referencing Information Report**: A basis for location referencing standardization activities by various application communities and SDOs.

- **Standard for Common Incident Management Message Sets (IMMS) for use by Emergency Management Centers (EMC)**: Standards describing the form and content of the incident management message sets for emergency management systems to traffic management systems and from emergency management systems to the emergency telephone system for E911.

- **Standard for Data Dictionaries for Intelligent Transportation Systems**: A set of meta-entities and meta-attributes for ITS data dictionaries, as well as associated conventions and schemes, that enable describing, standardizing, and managing all ITS data.

- **Standard for Functional Level Traffic Management Data Dictionary (TMDD)**: This document includes data elements for traffic control, ramp metering, traffic modeling, video camera control traffic, parking management and weather forecasting, as well as data elements related to detectors, actuated signal controllers, vehicle probes, and dynamic message signs. It also contains data elements for roadway links, for incidents and traffic-disruptive roadway events.

- **Standard for Traffic Incident Management Message Sets for Use by EMCS**: Enables consistent standardized communications among incident management centers, fleet and freight management centers, information service providers, emergency management centers, planning subsystems, traffic management centers and transit management centers.

- **The National Transportation Communications for ITS Protocol Family (NTCIP)**: The National Transportation Communications for ITS Protocol (NTCIP) standards committee is a specialized SDO focus group comprised of AASHTO, ITE and national Electrical Manufacturers Association (NEMA) delegates. This joint committee provides for the development of a family of ITS standards that apply to the majority of interfaces between traffic and transit management systems and devices. These standards are referred to in shorthand as the NTCIP for traffic systems, and the Transit Communications Interface Protocols (TCIP) for transit systems.

These key baseline standards are critical for the deployment of a wide range of market packages because they establish the common vocabulary of data elements and message structures that allow regional ITS applications to exchange data and information with each other. The adoption of this common vocabulary is of particular importance for the exchange of information between CDOT CTMC, HLT TMC and the various transit and traffic signal systems deployed or planned in the region.

**VI.G. Financial Summary**

Based on the project priorities identified in the previous section, a financial summary was prepared to balance project funding through the program time frame. The costs, which are in 2005 dollars, to implement the recommended projects are summarized in Table 17 below. Pass maintenance and
management systems are assumed to be implemented in two stages, with a manual system implemented initially followed by an upgrade to a fully automated system.
Table 12. Financial Summary (Cost are in 2005 dollars)

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Project Name</th>
<th>Near Term (1 – 3 years)</th>
<th>Mid-Term (4 – 7 years)</th>
<th>Long Term (8 – 10 years)</th>
<th>Project Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fiber-optic cable along I-70 from Glenwood to Vail</td>
<td>840,000</td>
<td>5,000,000</td>
<td>500,000</td>
<td>840,000</td>
</tr>
<tr>
<td>2</td>
<td>Fiber-optic cable along I-70 from Grand Junction to Glenwood Springs</td>
<td>840,000</td>
<td>5,000,000</td>
<td>550,000</td>
<td>5,000,000</td>
</tr>
<tr>
<td>3</td>
<td>I-70 Incident Management and Traveler Information System</td>
<td>232,000</td>
<td>2,900,000</td>
<td>435,000</td>
<td>232,000</td>
</tr>
<tr>
<td>4</td>
<td>Provide a secure web interface to camera images</td>
<td>150,000</td>
<td></td>
<td></td>
<td>150,000</td>
</tr>
<tr>
<td>5</td>
<td>Develop a communications master plan</td>
<td>150,000</td>
<td></td>
<td></td>
<td>150,000</td>
</tr>
<tr>
<td>6</td>
<td>Instrument maintenance vehicle for road and weather information</td>
<td>20,000</td>
<td>150,000</td>
<td>22,500</td>
<td>8,000</td>
</tr>
<tr>
<td>7.1</td>
<td>Pass maintenance and management system on Molas Divide, Red Mountain</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.2</td>
<td>Pass maintenance and management system on Wolf Creek Pass</td>
<td>18,000</td>
<td>150,000</td>
<td>22,500</td>
<td>6,000</td>
</tr>
<tr>
<td>7.3</td>
<td>Pass maintenance and management system on Muddy Pass and Rabbit Ears Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.4</td>
<td>Pass maintenance and management system on Monarch Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.5</td>
<td>Pass maintenance and management system on Lizard Head Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.6</td>
<td>Pass maintenance and management system on Tennessee Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.7</td>
<td>Pass maintenance and management system on Cerro Summit</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.8</td>
<td>Pass maintenance and management system on Fremont Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.9</td>
<td>Pass maintenance and management system on La Veta Pass</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>7.10</td>
<td>Pass maintenance and management system in the Blue Mesa Reservoir area</td>
<td>16,000</td>
<td>150,000</td>
<td>22,500</td>
<td>4,000</td>
</tr>
<tr>
<td>8</td>
<td>Transit Signal Priority on SH 82 from Glenwood to Aspen</td>
<td>60,000</td>
<td>500,000</td>
<td>75,000</td>
<td>40,000</td>
</tr>
<tr>
<td>9</td>
<td>Regional Traffic Management System in Grand Junction</td>
<td>40,000</td>
<td>500,000</td>
<td>75,000</td>
<td>40,000</td>
</tr>
<tr>
<td>10.1</td>
<td>Arterial traffic management system on SH 82 from Glenwood to Aspen</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.2</td>
<td>Arterial traffic management system on US 40 in Steamboat Springs</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.3</td>
<td>Arterial traffic management system on US 40 in Winter Park</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.4</td>
<td>Arterial traffic management system on US 550 and US 160 in Durango</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.5</td>
<td>Arterial traffic management system on US 160 and US 285 in Alamosa</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.6</td>
<td>Arterial traffic management system on US 50 and US 550 in Montrose</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>10.7</td>
<td>Arterial traffic management system on US 50 in Gunnison</td>
<td>28,000</td>
<td>200,000</td>
<td>30,000</td>
<td>12,000</td>
</tr>
<tr>
<td>11</td>
<td>Automated Wildlife Detection Systems on critical roadways sections</td>
<td>40,000</td>
<td>500,000</td>
<td>100,000</td>
<td>40,000</td>
</tr>
<tr>
<td>12</td>
<td>Develop communications links between HLT and EOCs</td>
<td>40,000</td>
<td>500,000</td>
<td>100,000</td>
<td>40,000</td>
</tr>
<tr>
<td></td>
<td>Transit management systems for local transit operators</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------</td>
<td>---</td>
<td>---</td>
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</tr>
<tr>
<td>Total</td>
<td>1,448,000</td>
<td>10,150,000</td>
<td>1,297,500</td>
<td>1,282,000</td>
<td>15,300,000</td>
</tr>
</tbody>
</table>
VII. Next Steps

The ITS Strategic Plan is intended to guide the deployment of ITS elements within the study area. It is intended that this document be maintained as an input to the formal planning process in the study area.

1. In order to satisfy federal requirements, a Regional ITS Architecture, consistent with the ITS Strategic Plan, will be completed by the ITS Working Group.

2. The ITS Branch should continue to actively work with the regions utilizing the ITS Strategic Plan Steering Committee, and involve other interested stakeholders, to promote the projects and ensure that they remain visible and receive support at all necessary levels in order to secure implementation. The ITS Committee should meet at least every six months to evaluate and discuss plan status and determine whether updates to the ITS Strategic Plan are necessary.

3. Sponsoring agencies should develop high priority projects further for inclusion in the upcoming cycle of updates to the Statewide Transportation Improvement Program. Projects identified in this ITS Strategic Plan should be submitted by sponsoring agencies for inclusion in that document as part of mainstreaming ITS.

4. Incident management planning should continue for other major corridors, such as SH-82, and also for the rural areas. These require coordination with local sheriffs and rural emergency responders as well as the regional emergency management forums.

5. The CTMC should move forward with developing secure interfaces for agencies outside CDOT, which do not have direct communications lines with CDOT.

6. The ITS Branch should proceed with communication master planning for Western Colorado since this forms the foundation for management and control of ITS devices throughout the region.

7. CDOT and the ITS Steering Committee will conduct regular updates and maintenance of the architecture.