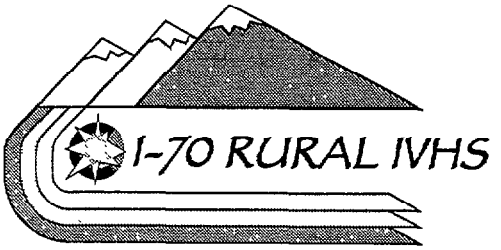
CORRIDOR PLANNING AND FEASIBILITY ANALYSIS

CORRIDOR MASTER PLAN

NOTE TO READER:

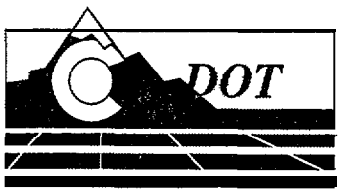
THIS IS A LARGE DOCUMENT

Due to its large size, this document has been segmented into multiple files. All files separate from this main document file are accessible from links (blue type) in the table of contents or the body of the document.



CORRIDOR PLANNING AND FEASIBILITY ANALYSIS

CORRIDOR MASTER PLAN



Colorado Department of Transportation

DE LEUW, CATHER & COMPANY

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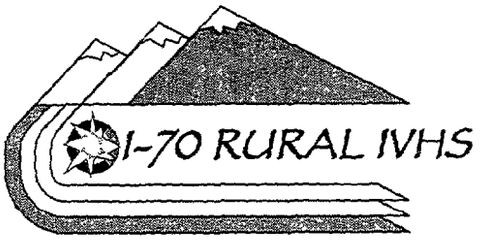


CORRIDOR

MASTER PLAN

EXECUTIVE OVERVIEW

EXECUTIVE OVERVIEW

OBJECTIVES

- *Recommend Corridor-Related ITS Strategies/ Actions*
- *Establish Comprehensive ITS Benefits to Leverage Institutional/Fiscal Support*
- *Create and Escalate ITS Program Advocacies*
- *Facilitate Integrated National, State- Wide and Corridor- Wide ITS Deployment*

PROCESS

- *Compile and Summarize Current Knowledge/ Activities*
- *Establish User Service Plan Founded in Transportation Needs/ Requirements*
- *Develop a Consistent Conceptual ITS Architecture*
- *Define Functional Requirements for Integrated Deployment of Systems and Subsystems*
- *Generate and Recommend Actions, Strategies. and Implementation Scenarios*

Scope: Develop evaluation criteria to assess which strategies are most appropriate in the study corridor. Identify communication links needed along the corridor and with the Denver metro traffic operations center [now the interim Traffic Operations Center (iTOC) and the Colorado Transportation Management Center (C-TMC)]. Prepare an implementation plan of IVHS technologies for this corridor with a focus on short-range and long-range options...that willprovide CDOT with a framework for completing the overall goals outlined in the plan. This plan will be the Corridor Master Plan and will constitute the final reportfor this phase of the project.

Deliverable: *Corridor Master Plan*

The I-70 Rural IVHS Corridor Master Plan is the guidance document for deployment of the Intelligent Transportation System (ITS) for the Interstate-70 Corridor from Denver to Glenwood Springs, Colorado. As a working document, the Plan recommends strategies and actions to implement corridor-wide and project-specific applications to meet the ITS goals and objectives of the responsible Colorado Department of Transportation (CDOT) ITS Program Office and Engineering Regions (1,3, and 6) through joint efforts with other affected agencies.

The I-70 Rural IVHS Corridor Master Plan is developed by and for the responsible agencies and their respective constituencies to characterize feasible, credible, and doable ITS actions that address mobility, safety, environmental, social, and economic necessities with respect to transportation.

The I-70 Rural IVHS Corridor Master Plan reflects the vision, mission, goals, and objectives of the responsible CDOT ITS Program Office and Engineering Regions with respect to systematic and integrated implementation of advanced technology applications. The approach and actions to accomplish the ITS program for the I-70 West Corridor must necessarily coordinate ITS initiatives:

- along the entire length of the I-70 West Corridor;
- throughout each responsible Engineering Region;
- across Engineering Region jurisdictional boundaries;

- between all internal and external transportation systems planning, design, and start-up organizations;

- in conjunction with other local, regional, and state transportation-related operating and service agencies;

- for the constituency represented by travelers, residential and business communities, town and county governments, and economic development and tourism trades; and

- with federally-supported ITS program plans for eventual evolution into nationwide compatibility and interoperability.

EXPECTED ITS BENEFITS

It is difficult, at best, to sell a new transportation-related idea and/or program to all the potential stakeholders unless each can recognize and understand some associative gain or improvement for themselves or their constituents. Transportation of people and goods, as an economic and social necessity in this country, has become a "hotbed" of personal and emotional discord.

Most want and need unrestricted mobility, but not to the detriment of some perceived personal, environmental, economic, or social impact. For a variety of reasons, many are convinced that the transport of people and goods in this country destroys the environment, causes economic losses, negatively impacts quality of life, and/or improperly invests dollars at taxpayer expense. There is an outcry for different solutions than those that have been carried out in the past and present.

Near term (early action) ITS applications for the I-70 West Corridor are founded on collecting, processing, and disseminating real-time information for decision-making. The benefits of automating information can:

- connect state, regional, and local jurisdictions so that transportation-related conditions, activities, and actions are known and understood;
- deliver real-time data to transportation facility maintenance crews so that predetermined actions for forthcoming adverse travel conditions can be prevented or circumscribed and routine maintenance activities can be preplanned and prescheduled;
- expedite emergency service provider knowledge of and dispatch and response to incident sites and travelers in trouble;
- provide accurate, reliable, and timely advance condition and advisory data to the traveling public about downstream road, weather, and travel conditions so that informed decisions about whether, when, and how to travel quickly and safely can be made before a trip is undertaken or what to do and where to go when a trip is in progress;
- allow access to and use of a variety of travel alternatives so that individual users have additional opportunities on how they perform their trip-making;
- facilitate efficient and safe movement of large goods-moving vehicles so that they can maintain their schedules and avoid en-route hazards;

- maintain local economic expectations regarding the delivery of customers and goods by informing the "deliverers" in advance so that safe and efficient travel is planned and programmed; and
- monitor and track air and noise pollutants that encourage violators to conform to prescribed standards or "get off the road."

It could be argued that these benefits are subjective, unsubstantiated, and not technically quantified. Because ITS is in its infancy, applications must be deployed to substantiate and quantify benefits. Where advanced technologies have been applied throughout the country, data is being collected and compiled so that short- and long-term evaluations can quantify costs and resulting benefits. For the I-70 West Corridor, benefits cannot be analyzed until the Intelligent Transportation Infrastructure (ITI) is deployed, used, tested, and measured for its performance in corridor-specific applications.

Cost, and financial support, is really the implementation barrier. Equipping the I-70 West Corridor with a complete ITI from ground zero would, in 1996 dollars, cost approximately $200-$250 million. Funding such an initiative would compete with other necessary transportation facility improvement and maintenance needs, meaning one or portions thereof would be neglected at the expense of the other, and/or other financial resources would need to be contributed.

That cost, if it satisfies most stakeholder concerns, is money well-spent when compared to understanding that the same amount of money ($250 million) may "6-lane" I-70 (potentially excluding new tunnel bores) or provide a light rail system within the I-70 median (capital costs only--additional funds would be needed to operate the system; it will be costly to electrify the entire length; and it may be technically infeasible to bore a third tunnel between the existing tunnel pair).

There is no one "be all and end all" comprehensive solution. A program that satisfies one special interest may impact another. Intelligent Transportation Systems concepts offer new and innovative methods that, while not the only solution, can be integrated into any transportation program to modify travel and transport management, operations, and behavior.

Theoretically, ITS applications can improve the transportation system. Benefits have been realized by Colorado and other states and organizations that have implemented ITS technologies. Policy, legislation, and decision-makers (at the state, regional, and local levels) and their constituents (special interest groups and the general public) need to make a concerted effort to act together to initiate ITS applications with the I-70 West Corridor and throughout the state.

All past actions and transportation system improvements have compounded the aforementioned strife. Unless each individual and/or group, denouncing others for the current problems, can suggest another program that is in the best interest of all stakeholders, all should work together to implement ITS projects and programs (recommended in this Corridor Master Plan) so that positive corridor-specific results can be accomplished. ITS is a beneficial solution with good, cost-effective potential to satisfy the majority of all stakeholders.

To establish a basis for ITS action, goals and objectives, at program and project levels, have been introduced to address the multitude and magnitude of transportation issues. The I-70 West Corridor- Wide Program Goals seek to:

- improve safety for all users traveling along or impacted by travel along I-70;
- reduce congestion:
  - created by extreme weather, road surface, and traffic conditions
  - by encouraging alternate mode usage
- ✓ offer accurate travel information to users to:
  - make better, more informed decisions regarding their trip-making along the I-70 West Corridor
  - secure peace of mind during their travels that trips can be made safely;
- ✓ overcome institutional barriers that may affect the deployment and/or success of advanced technology applications; and
- build a proactive constituency in support of ITS initiatives so that all physical, travel, and environmental elements, influenced by transportation needs, can be adequately addressed and positively resolved.

Supplemental to the I-70 West Corridor- Wide ITS Program Goals, I-70 Rural IVHS Study Goals were established and are reflected as the primary component of this Corridor Master Plan:

- to identify and deploy successful short-term (early action) projects that result in beneficial solutions to mobility, safety, and environmental concerns; and
- to leverage federal and private dollars so that projects can be implemented, evaluated, operated, and maintained to continue positive and reliable value.

COMPANION DOCUMENT SUMMARIES

As a stand-alone guidance document, the Corridor Master Plan provides summaries of companion documents, which should be referenced where more detail is required. Those documents include:

- Information Search Memorandum--identification of current and emerging ITS technologies and applications and background data (traffic; safety; transportation services; physical, environmental, and institutional characteristics; infrastructure);
- Needs Assessment Report--identification and assessment to validate technological and institutional needs of the agencies and organizations that operate, maintain support, and use surface transportation systems within the I-70 West Corridor;
- Early Action Projects Executive Summary and Appendix--detailed summaries for 15 specific projects recommended for design and deployment in the I-70 West Corridor and preview of future ITS actions for medium- and long-term implementation; and
- Business Plan/Marketing Strategy--recommended institutional actions to implement ITS initiatives and execute a system-wide ITS program that offers direction to organize and manage I-70 West Corridor ITS operations; to develop and make policy and funding decisions; and to finance project-specific and corridor-wide actions. It also recommends actions to build community and agency support; identify, educate, and engage stakeholders;

"market" (public relations, advertising, promotional campaigns) ITS; and enlist public and private sector, organization, and community sponsorship.

USER SERVICE PLAN

The User Service Plan, contained within this Corridor Master Plan, maps the transportation-related needs of the I-70 West Corridor system "users" (local and regional travelers, commercial vehicle operators, transit providers, owners, operators, service providers, local governments, businesses) into User Service functional categories. By applying potential advanced technology applications to the various user needs, the I-70 Rural IVHS Corridor Master Plan design is driven by local necessity to meet the goals and objectives of the Corridor, Regional, State, and National ITS Programs.

A comprehensive review of the 5 national IVHS User Services and 7 IVHS Functional Areas, developed in 1992 as part of the national IVHS program (reference Working Paper on IVHS User Services and Functions. The Mitre Corporation, November 1992) resulted in the expansion of those services and areas into 12 functional areas (listed alphabetically, not by order of importance or magnitude) for the I-70 West Corridor:

- Commercial Vehicle Operations
- Data Collection/Aggregation
- Emergency Response
- Institutional Issues
- Public Transportation/Alternative Modes
- Traffic Management/Operations
- Communication Systems
- Education/Training
- Environmental/Economic Impact
- Public/Private Partnerships
- Safety/Warning
- Traveler Information

As the national IVHS program matured and evolved into the ITS National Program Plan (NPP), the I-70 Rural IVHS study also evolved as system-wide user problems and needs were identified. The development of a I-70 West Corridor-specific User Service Plan took into account the recommendations of the NPP with the expansion of User Services therein related to the transportation problems and needs within the corridor. Problem and needs were synthesized from surveys, conversations, and follow-up contacts with a variety of corridor users into 17 statements for consideration:

- limited financial resources;
- congestion;
- road closures;
- no alternate routes;
- recurring incidents at known locations;
- inadequate communications systems;
- inefficient management of goods movements;
- limited confidence in state government services;
- lack of coordination/cooperation;
- ineffective information dissemination;
- commercial vehicle use of the corridor;
- shortage of transit services;
- environmental impacts;

- poorly delineated/maintained travel ways;
- lack of personal travel security;
- vehicular/animal conflicts; and
- driving inexperience/excessive speeds.

The defined functional areas, identified user needs, and analyzed NPP was used to formulate specific ITS goals and objectives to support development of the User Service Plan for the I-70 West Corridor. These ITS goals and objectives are extremely important to the decision-making process. The benefactors of advanced technology applications (all transportation system users) must recognize that their respective investments meet their specific needs. Each User Service must establish an ability to meet user needs by addressing one or more of the following Corridor-Wide ITS Implementation Goals:

– enhancing traveler mobility;
- increasing safety;
– improving environmental quality;
- augmenting communications and/or user interface;
- encouraging high public and policy-level acceptance and positive perceptions;
- promoting transit usage and improving transit services;
- stimulating public and private investments;
- using existing advanced technologies in innovative ways; and/or
- reinforcing economic benefits of transportation.

The User Service Objectives, identified by the affected transportation system users, have been established to include:

- improvements to operational capacity;
-reductions in traveler delays;
-reductions in peak period vehicular demand;
-reductions in accident frequency and severity;
-reductions in emergency response times;
-development of better access;
-augmentation of transit/bicycle/pedestrian facilities, services, and accessibility;
-strengthened management and oversight of commercial vehicle operations;
-development of incident and congestion management strategies;
-funding source leverage;
-identification and commitment of investment partners;
-capture of economic benefits;
-development of multi-modal opportunities;
-creation of “competitive” travel times/modes;
-reduction in vehicular emissions;
-provision of reliable of weather/road/traffic condition data;
-management of hazardous materials transport and overheight/overweight vehicles;
-advancement of traffic operations management/control;
-evaluation and improvement of current processes and regulations;
-creation and support of a cooperative working environment;

-education of all stakeholders;
-reductions in unnecessary trip-making; and
-development of staff capabilities.

Transportation Problems and Needs were mapped to the Corridor- Wide ITS Goals and related User Service Objectives to identify ITS Candidate Actions. Candidate actions were assessed for early action, medium, and longer-term priority, based on prioritization of problems and needs that require immediate action. Finally, the problems and needs were mapped to the NPP User Services/Bundles to define specific I-70 West Corridor User Services. These are aggregated as the User Service Plan Summary in Table EO-1.

PROGRAM DEVELOPMENT AND EVALUATION

I-70 West Corridor ITS Program Development and Evaluation has resulted in the development of a Conceptual System Architecture and related Functional Requirements as a framework for furthering the maturation of ITS projects and programs for the I-70 West Corridor. It recommends a hybrid organization-based architecture for the I-70 West Corridor, strongly considering the existing centralized (ITS Program Office and interim TOC functions) and decentralized (Engineering Region functions) operating structures within CDOT.

The key element of the recommended architecture is its ability to interface with the distributed ITI Network statewide ITS vision comprised of the statewide C-TMC, regional traffic operations center (TOC) hubs, the Colorado State Patrol Computer-Aided Dispatch (CAD) system, and other local and regional traffic emergency, transit, and commercial vehicle management systems to provide redundancy to each other if and as needed. This allows back-up operations for ITS subsystem functions within the I-70 West Corridor, while maintaining autonomous management and control within the Engineering Regions.

Additionally, the hybrid architecture provides for local operation and expansion within the entire I-70 West Corridor ITS, Local subsystems that will require autonomy but need support functions can be accommodated. For example, the Summit Stage GPS/AVL transit subsystem can be operated and controlled from a local operations center that is "connected" to the CDOT Region 1 region TOC at Eisenhower Tunnel. Region 1 would control and operate vehicular probe and traveler information systems that interface with the Summit Stage APTS so that all data is compiled together for dissemination to travelers. If the Summit Stage APTS operations center cannot be initially staffed full-time during operating hours, system controls can be transferred back and forth to the regional TOC. Similarly, if a subsystem failure occurs at the Summit Stage operations center, the regional TOC can take

TABLE EO-1
USER SERVICE PLAN SUMMARY

PROBLEM/NEED	CANDIDATE ACTION	BUNDLE: USER SERVICES
- ineffective information dissemination	- highway advisory radio (I-TAR) and variable message sign (VMS) systems to disseminate information to traveling public - real-time traveler information kiosks and broadcasts at public and private facilities (non-transportation) - intelligent rest stops - real-time weather/road/traffic information distribution via the media	- Travel and Transportation Management: En-Route Driver Information; Traveler Services Information - Travel Demand Management: Pre-Trip Travel Information - Public Transportation Operations: En-Route Transit Information - Emergency Management: Emergency Notification and Personal Security
- shortage of transit services	- multi-modal transfer centers with traveler information kiosks and links to TOCs and other public facilities - automated tracking of public transportation vehicles to improve scheduling and management of services - communication links and vehicle sensors for private transit shuttles to serve as probes throughout corridor - intelligent bicycle system - automated transit referral service for public and private service providers	- Travel and Transportation Management: En-Route Driver Information; Traveler Services Information - Travel Demand Management: Pre-Trip Travel Information - Public Transportation Operations: Public Transportation Management; En-Route Transit Information; Ride Matching and Reservation
- environmental impacts	- mobile emissions testing stations and advisory signage at high-pollution sites - voluntary retrofit of vehicles to alternative fuel systems by government agencies and private organizations - coalition of governments and businesses for exchange of economic development strategies	- Travel and Transportation Management: Emissions Testing and Mitigation - Travel Demand Management - Public Transportation Operations
- recurring incidents at known locations - poorly delineated/maintained travel ways - lack of personal travel - security vehicular/animal conflicts - driving inexperience/excessive speeds	- courtesy patrols for high-incident segments within the corridor - alternative service roads for emergency access - automated answering/dispatch system for coordinated regional response - accident investigation pull-outs at know high incident locations - retrofit lighting/reflective coatings in tunnel bores; lighted guidance systems - golor-wade 'L-way emergency call - sensor/detector actuated warning and predictive systems for pavement surface and weather conditions - automatic avalanche/rock slide detection/warning systems at high-hazard locations - personal in-vehicle MAYDAY systems - sanding/storm water runoff sensor - systems excessive speed warning systems - animal alert warning system	- Emergency Management: Emergency Notification and Personal Security; Emergency Vehicle Management - Travel and Transportation Management: Incident Management - Travel Demand Management: Demand Management and Operations - Advanced Vehicle Control and Safety Systems: Longitudinal and Lateral Collision Avoidance; Vision Enhancement for Crash Avoidance; Safety Readiness

over operations seamlessly (without loss of continuing data collection, processing, and dissemination functions) until the local system is back on-line.

Infrastructure and functional requirements are identified for C-TMC, regional TOC, and other local operations centers. This includes generic hardware and communications requirements for data collection, processing, and dissemination. General infrastructure and functional requirements for roadside and in-vehicle equipment and communications are broadly defined.

The communications links and data requirements for agency-to-agency and statewide-to-regional-to-local inter-ties are identified, along with several recommended communications protocols for consistent connectivity between subsystem components.

IMPLEMENTATION PLAN

The Implementation Plan recommends actions that must take place at the statewide, regional, and corridor-wide levels for an integrated ITS to occur and succeed. Currently, each Engineering Region has deployed advanced technology applications (such as variable message signs, emergency call boxes, tunnel control centers, truck speed warning systems) independently of other subsystems within a region and between the regions. Equipment, devices, communications protocols and link media, proprietary software, and operating requirements are vastly different and quite possibly incompatible.

If this type of deployment continues, operating, maintenance, and replacement costs will escalate (separate technical staff to operate and maintain different systems; inventories for non-transferrable components and parts; inability to exchange data between subsystems) to an unmanageable level where systems will eventually be taken off-line because they cannot financially be maintained or they have to be replaced, at additional cost, to interoperate with other subsystems. Such a scenario will justify any outrage by system users at having to pay more for less.

At the system-wide level institutional and technical programs and projects are recommeded before any further subsystem deployment occurs. This includes:

- retrofit, dismantling, and/or replacement of existing proprietary subsystems that do not have connectivity with future subsystem implementation;
- designing a corridor-wide open, integrated, inter-operable (state, regional, corridor) communications system;
- establishing statewide and corridor-wide oversight and technical teams to manage current and future ITS actions and activities;
- starting the education and marketing processes so that all stakeholders are familiar with the function and use of advanced technology applications;
- cross-training existing staff in operations and maintenance of ITS subsystems and/or hiring experienced electronic, electrical, and systems engineers and technicians;

- reviewing and modifying regulatory barriers for procuring and deploying ITS statewide;
- bringing all responsible agency, policy, and decision-making personnel to the table to coordinate actions and activities in a positive, agreeable atmosphere so that a cooperative environment is established within each organization from the top down;
  developing a Corridor-Wide Operations Plan that identifies unanimously agreed to roles, responsibilities, and relationships between operating organizations and functionality and communications between devices and operations/management centers;
- drafting and executing inter- and intra- agency agreements that define who plans, designs, operates, and maintains individual subsystems;
- developing statewide ITS standards and protocols and equipment/device specifications; and
- developing a prioritization process that enables decision-makers to compare ITS project benefits and costs to conventional highway construction project benefits and costs so that project selection for funding and implementation is fair and most appropriate (rather than arbitrary).

The Implementation Plan outlines the processes that must be developed to create a Corridor- Wide Operations Plan. The production of this document must be a cooperative effort between the CDOT ITS Program Office and the 3 Engineering Regions with jurisdiction over I-70. The Plan includes the following elements to identify how each project and subsystem should be integrated into a corridor-wide system:

-detailed system architecture definition;
-lines of responsibility and procedures for inter-jurisdictional:
  + cooperation,
  + operations,
  + maintenance,
  + financing,
  + staffing and training, and
  + program follow-through; and

✓ program controls for:
  + implementation budgets,
  + implementation schedules,
  + procurement,
  + public and private sector partners, and
  + system integration.

Within the I-70 West Corridor-Wide Operations Plan, alternative technologies need to be further refined to provide guidelines for recommending specific technologies in the Project Development Plans. The following considerations have been initially assessed during the identification and screening of alternative technologies (highlighted in the Information Search and Needs Assessment companion documents) and during the development of the corridor-wide system architecture concept (documented in Section VI, Program Development and Evaluation):

- performance and reliability;
- cost;
- standards;
- integration of existing components;
- procurement opportunities;
- operations and maintenance resources and capabilities;
- environmental impacts; and
- consistency with state-wide and national plans.

A list of existing communications, computer, and electronic technologies has been developed, each item having appropriate applicability for implementation of ITS Candidate Actions within the I-70 West Corridor. These include:

✢ vehicle probes	-weather sensors	-infrared sensors
✢ microwave sensors	-radar sensors	-closed-circuit television
✢ aerial surveillance	- computer-aided dispatch	-weigh-in-motion devices
✢ automatic vehicle location	-fiber optics	-highway advisory radio
✢ auto vehicle identification	-roadside beacons	-transponders
✢ two-way radio	-cellular radio	-cellular telephone
✢ cable television	-satellite	-landlines
✢ spread-spectrum microwave	digital am/fin subcarrier	-pager-based radio
✢ lighted guidance delineation	-automatic lane controls	- road use pricing
✢ incentive programs	-commuter/passenger rail	- light rail transit
✢ high speed rail	-dead reckoning	- route selection algorithms
✢ automatic movable barriers	-data fusion	- real-time traffic prediction
✢ electronic parking controls	-ramp metering	-incident detection algorithms
✢ central computer systems	-local area networks	- adaptive signal control
✢ wide area networks	-HOV lanes	-signpost odometer
✢ global positioning systems	-map matching	-video monitoring
✢ video surveillance	-video broadcasting	- variable message signs
✢ variable speed signs	-2-way call boxes	-solar power
✢ ramp metering	-information kiosks	-loop detectors

At the project-specific level, additional recommendations are defined that must be implemented as each ITS subsystem is planned, designed, and deployed. Project Development Guidelines, a Project Operations Plan, and a Project Evaluation Plan must be developed for each project before it is designed and deployed. Each of these plans must be designed to support the overall I-70 West Corridor ITS goals and objectives and must reflect the operating processes and procedures defined in the Corridor-Wide Operations Plan.

Every project needs a solid plan of action to guide its development and implementation. Similar to CDOT's Work and Management Plan for traditional transportation projects, the Project

Development Guidelines should provide detailed information on how each project will be managed, administered, plauned, and designed. An important component of the Project Development Guidelines documents appropriate measures of effectiveness by which overall system-wide and project-specific performance can be compared and evaluated between the "before and after" condition. These parameters are used in the development of the Project Evaluation Plan so that the project can be appropriately evaluated. An initial set of system-wide measures include:

Quantifiable Appraisals:

- travel time	- fuel consumption	– energy usage
- vehicle occupancy rates	- emission rates	– accident rates
- ransit usage rates	- transit service reliability	- economic stimuli
- public investment	- private investment	- capital costs
– operating costs	- maintenance costs	– traffic counts

-Qualitative Appraisals:

- user attitude	- public reaction	– political will

Project-specific measures of effectiveness must be tailored to each individual project. They should address the noted User Service Goals and Objectives for the User Service they are intended to address and include quantitative and qualitative criteria that can be evaluated.

Functional Requirements for the corridor-wide system and sub-systems within each project must also be established in the Corridor-Wide Operations Plan and individual Project Development Plans. Functional requirements that should be considered include:

- monitoring and surveillance (and roadway/roadside data collection sources);
- system/sub-system communications (data distribution);
- infrastructure/vehicle/traveler interface;
- control strategies;
- navigation and guidance;
- data processing; and
- in-vehicle sensors.

System and sub-system attributes and functions support the functional requirements. These must also be reflected in the Corridor-Wide Operations Plan and individual Project Development Plans. How, when, where, why, and what information is transmitted and processed must be defined so that the corridor-wide and project-specific sub-systems are compatible and interoperable with each other as well as with other regional systems that will be necessarily linked to the state-wide and national systems.

The communications and information flow and processing functions must be supported by capable operations and maintenance personnel. The CDOT Engineering Regions, in some cases, do not have sufficient resources and technical capability to support existing system functions. Additional professional and technical staff will be required as ITS projects are implemented. CDOT has developed other successful cross-training programs to use as models to support ITS operations and maintenance requirements. Other transportation agencies and organizations will look to CDOT for staffing and training support to implement their respective responsibilities on specific projects (in which they are partnered) as they are deployed.

The Project Evaluation Plan must be developed for each ITS subsystem. It is vital to ensure that envisioned benefits meet or exceed the actual capital, operating, and maintenance costs. The operating agencies must know that their expenditures of taxpayer dollars satisfy public expectations so that continued investment in a project can be justified. The Project Evaluation Plan establishes the process by which the responsible Region or Division will measure before and after conditions associated with the project. It identifies what measures are to be used for comparison; who will collect, tabulate, and evaluate the data; how long the evaluation period should continue; what thresholds would be considered acceptable; and contingency requirements should the project not perform to expectation.

The Implementation Plan identifies a process to include ITS Projects in the Transportation Improvement Plan (Regional TIP) and Statewide Transportation Improvement Program (STIP). The steps to that process include:

- submitting applicable projects to the responsible Metropolitan Planning Organization (MPO) where appropriate for inclusion in the Regional TIP;
- working with the 15 Regional Planning Commissions as they develop and update their respective Regional Transportation Plans (RTPs); and
- developing an Intelligent Transportation Management System, similar to the 6 management systems identified in the ISTEA legislation, so that effective statewide database and management procedures can be accessed and used by all affected organizations.

The Implementation Plan recommends annual updates so that it retains consistency with all other programs and projects (that are initiated within the I-70 West Corridor and its linkages to the rest of the northwest region and the state), as well as national ITS initiatives and programs.

The Implementation Plan further details the Early Action (Wear-Term) Project recommendations, defining a draft Project Development Plan for ITS projects that CDOT and its project partners make a concerted effort to initiate, design, and/or deploy within the next 5 years. These projects represent site-specific solutions to user needs that will provide beneficial outcomes to critical problems while gaining positive public support.

The *Early Action Projects* have been identified by the CDOT Engineering Regions as having the highest priority to effectively solve current transportation problems within their respective jurisdictions along the I-70 West Corridor. Projects recommended as high priority on a corridor-wide basis are noted as such. High priority projects having statewide significance would be initiated by the CDOT ITS Program Office. Early action (short-term) projects include:

- ✓ Road/Weather/Traffic Condition Information System:
  - + Voice/Data Communications Upgrades (EAP CS-4/Corridor-Wide)
  - + Call Box System (EAP ER-3/Corridor Wide; State-Wide)
  - + Summit Stage Transfer Center APTS/ATIS Operational Test (EAP PTAM-1/Region 1)
  - + Georgetown Area Gusty Wind Sensor/Variable Message Sign System (EAP TIS-1/ Region 1)
  - + Vail Super-HAR/VMS Program (EAP TIS-5/Region 3)
- ✓ Interstate Traffic Management System (State-Wide):
  - + Automated Reversible Lane Program (EAP TMO-3/Region 1)
  - + Hanging Lake Tunnel Control Center Upgrades (EAP CS-9/Region 3)
- ✓ Interstate/National Highway System Fiber Optic Backbone (State-Wide):
  - + High-Capacity Data Transmission Links (EAP CS-2)
- ✓ Incident Management Programs:
  - + Hot Spot Courtesy Patrols (EAP ER-1/Corridor-Wide)
  - + Incident Investigation Sites (EAP SW-1/Corridor-Wide)
  - + Emergency Response Information System (EAP SW-8/Region 3)
- ✓ Dumont/Downieville Automated Port of Entry (EAP CVO-2/CVO Division; Region 1)
- ✓ Advanced Technology Roadway Delineation (EAP SW-4/Corridor-Wide)
- ✓ Advanced Ice Detection/Warning System (EAP DCA-7/Region 3; Corridor-Wide)
- ✓ Mobile Emissions Testing Stations (EAP EEI-5/Corridor-Wide)

Medium-Term ITS Projects are those that should be given strong consideration for initiation, design, and/or deployment within the next 10 years. These have been designated by the Statewide ITS Implementation Team, the ITS Program Office, and the Engineering Regions as second priority projects. Additional projects are recommended for consideration.

Medium-term projects are less detailed because of the potential for change. Project overviews have been developed that briefly describe the project. These identify which current transportation problems can be resolved and/or which user needs can be addressed; denote potential benefits and approximate capital, operating, and maintenance costs; and recognize potential participating partners.

Since there are numerous medium-term projects that can be implemented, the Regions should carefully review and evaluate each project, at least annually, to decide if they are still applicable to current and future needs and changing circumstances. This could include other projects identified in the *Early Action Projects Appendix* and new subsystems as they develop over time, as well as those recommended in this *Corridor Master Plan.*

CDOT Engineering Regions, the ITS Program Office, and the Statewide ITS Implementation Team need to stay abreast of national ITS initiatives and private sector advancements. New technologies are continually emerging--new projects can be formulated where old ones become obsolete. Medium-term ITS project recommendations for the I-70 West Corridor, include, to date:

- Data Collection/Processing/Dissemination:
  - Advanced Sensor Technology Applications (State-Wide),
  - Tenmile Canyon/Vail Pass Icy Road Sensor/VMS System (Region l),
  - Avalanche Detection and Warning System (Regions 1 & 3), and
  -Glenwood Canyon Excessive Speed Warning System (Region 3);
- Traveler Services Information:
  - Traveler Information Systems Expansion:
    - Idaho Springs Intelligent Rest Area (Region l),
    - Other Rest Stop/Information Center Traveler Service Systems (Region 3),
    - Eisenhower Tunnel Motorist Information System (Region l),
    - Vail Pass Rest Area ATIS Upgrades (Region l),
    - Glenwood Canyon Rest Areas (Grizzly Creek, Hanging Lake, No Name) ATIS Upgrades (Region 3),
    - Denver West Intelligent Rest Area/Transit Center (Region 6), and
    - POE Traveler Information Centers (Region 3);
  -Internet/World Wide Web Traveler Information Page (Corridor-Wide);
  - CCTV Exchange Partnerships (Statewide ITS Implementation);
  - Resort Area Real-Time Condition Broadcasts (Regions 1 & 3);
  - Front Range Trailblazer System (Region 6);
- -Electronic Payment Services:
  - One-Stop Shopping Commercial Vehicle Automated Credential Processing (State-Wide); and
- -Safety and Warning Systems:
  - In-Vehicle Cellular/GPS Mayday System (State-Wide).

Long-term ITS projects, applicable to the I-70 West Corridor, are those that can be considered beyond a 10 year horizon. Known potential applications are listed that span the realm of opportunities that could develop in the next ten years. These represent the kinds of ITS and multi-modal transportation system initiatives that CDOT Regions and the Statewide ITS Program Office should monitor annually. As new ideas and technologies emerge, they should be examined for their ability to satisfy current and future transportation needs within the Corridor. Long-term suggestions within the Implementation Plan are visionary and require more detailed assessment as time goes on and paradigms shift. Long-term ITSprojects can include:

- -in-vehicle sensor, navigation, and guidance systems:
  - on-vehicle/roadside beacon edge-of-lane delimiters,
  -route navigation and guidance devices,

-infra-red vision enhancement devices,
-private vehicles as automated probes, and
- congestion prediction;

- automated highway system elements (automated vehicle control systems):
  -in-vehicle position sensor (following, lane changes) warnings,
  automated collision avoidance (braking and/or steering), and
  - adaptive cruise control;
- universal traveler information programs:
  -personal/portable traveler information devices,
  -in-vehicle radio data systems, and
  -real-time dissemination of airline and transit service data to information centers, in-vehicle devices, and personal portable devices;
- road use controls:
  -ramp and/or mainline toll plazas (full-time or peak period),
  -peak period use restrictions (commercial and/or private vehicles), and
  -automated special use lanes (HOV, trucks, transit);
- comprehensive roadway instrumentation (detectors, CCTV, VIDS throughout the I-70 west Corridor and along state highways connecting to I-70);
- advanced public transportation systems:
  -coordinated gps/avl of all transit operators (public and private),
  -corridor-wide integrated fare systems (smart cards), and
  -real-time/interactive ride matching/car pooling connections;
- integration of its technologies with other major transportation investment strategies:
  -multi-modal transfer centers (commuter/passenger/high-speed rail, light rail transit, bus, bicycle, pedestrian information/electronic fare collection interfaces),
  -automated intermodal centers (freight transfer for truck/rail/air modes), and
  -intelligent bicycle/pedestrian systems;
- safety/emergency response systems:
  -comprehensive 2-way mayday emergency and stranded motorist assistance,
  -electronic flare call for help,
  -automated at-grade railroad crossing warning system (in-vehicle),
  -driver impairment detection and warning (ii-vehicle), and
  -animal/vehicular warning system; and
- road maintenance and management systems:
  -in-vehicle weather/pavement condition sensors.

FITTING IT ALL TOGETHER

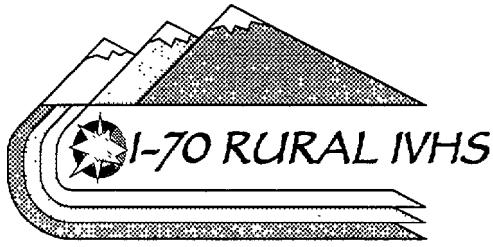
The I-70 Rural IVHS Corridor Planning and Feasibility Analysis ***Corridor Master Plan*** defines a distinct ITS strategic deployment plan that integrates the elements and components of:

-the existing institutional and organization structures;
-the existing advanced technology applications;
-the current and planned ITS initiatives (national, state, and local);
-the recommended management structure; and
-the recommended short-, medium-, and long-term projects and programs

into an system-wide strategy that accomplishes the study's goals and objectives to develop a system that can help improve safety, increase operational capacity, disseminate real-time information to travelers, enhance incident management functions, promote the use of alternative transportation modes, and protect the surrounding environment.

AFTERWARD

Intelligent Transportation Systems (ITS) and Intelligent Vehicle Highway Systems (IVHS) are used interchangeably throughout this document. The creators and implementors retained this Study's name, ***I-70 Rural IYHS Corridor Planning and Feasibility Analysis***, because of its familiarity to all stakeholders. The evolution of the program name from IVHS to ITS occurred naturally since all surface transportation system modes (motorized and non-motorized personal vehicles, commercial vehicles, freight and passenger trains, buses, transit vehicles, and pedestrians) were always considered a part of incorporating "intelligence" into the transport of people and goods.



CORRIDOR MASTER PLAN

SECTION I
INTRODUCTION

SECTION I INTRODUCTION

The *Corridor Master Plan for the I-70 Rural IVHS Corridor Planning and Feasibility Analysis* project presents the overall Intelligent Transportation Systems (ITS) strategic deployment plan for the I-70 West Corridor from Denver to Glenwood Springs, Colorado. The intelligence and recommendations were derived from extensive information gathering and evaluation through outreach, coalition-building, existing and planned systems inventory, needs development and assessment, and business plan and marketing strategy creation. Some of the information contained herein is repetitive of the other materials documented in companion documents prepared for this study. This conscious and deliberate amassing of redundancy is intentional, since this Corridor Master Plan is meant to serve as a stand-alone guidance and reference document.

Companion documents to this Corridor Master Plan provide additional detailed data that support the development and recommended actions contained herein. The *Early Action Projects Executive Summary*, the *Early Action Projects Appendix*, the *Information Search Memorandum*, the *Needs Assessment*, and the *Business Plan and Marketing Strategy* contain a compilation and evaluation of local, regional, statewide, and national perspectives and directions for ITS that has been applied to the I-70 West Corridor as a foundation for the development of this *Corridor Master Plan*. Those documents are briefly summarized in subsequent sections of this Plan. The users of this Plan are encouraged to reference the companion reports if further background is desired.

PURPOSE AND NEED

The I-70 West Corridor from Denver to Glenwood Springs is the most heavily traversed intercity (rural) and interstate (regional) travel way in the State of Colorado, serving a variety of users from the local populace to the business traveler and from the recreationalist to the commercial vehicle operator. All users rely on this one facility to provide a safe and quick passage to and from their respective destinations and originations.

Because environmental, physical, financial, policy, and social constraints limit how the I-70 facility can be expanded or enhanced to serve the rapidly growing traveler "population," the Colorado Department of Transportation envisioned, in 1990, that Intelligent Transportation Systems (then called Intelligent Vehicle-Highway Systems) applications could have tremendous benefit for improving mobility and increasing safety within this heavily traveled corridor.

What is the purpose of this study? Why is it needed? These two questions are interrelated. The rationale behind this study, and any follow-on activity and recommendations described herein, is to set the stage for deploying an integrated set of ITS-related programs and actions that will benefit the majority of users while remaining sensitive to the environmental, physical, financial, policy, and social impacts that affect the corridor and its users. The overall ITS program envisioned for the I-70 West Corridor is divided into three phases:

The *Planning Analysis Phase* (for which this *Corridor Master Plan* and its companion documents are the result) is intended to *"focus on developing a comprehensive implementation program of IVHS technologies aimed at a multi-phase effort which clearly identifies the most feasible options,*

gains public support, enlists cooperation and participation of private sector interests, and provides funding recommendations for short-term and long-term solutions. "

A Detailed *Planning* and Design Phase, concurrent and subsequent to the release of this documentation, will include the development, engineering, and preparation of plans and specifications to support the candidate actions recommended during the Planning Analysis Phase that this and companion reports document. *"It may also include a detailed financing plan providing for private sector support. "*

A third *Financing Phase* will provide support to the implementors of the recommended actions *"in obtaining funds from the multiple sources needed to implement IVHS technologies in the the I-70 West Corridor. There will be a heavy emphasis on soliciting for public/private partnership agreements to implement and operate IVHS technologies in this corridor. "*

The initiators of this project were successful in obtaining federal funding to support the costs for the research, evaluation, and preparation of documents that deliver the message of the Planning Analysis Phase of this study. The federal "financier's" expect that this Corridor Master Plan and its companion documents address each element defmed in the study scope and that each "deliverable" (study product) is produced.

Much urban ITS planning, design, and deployment activity has been accomplished for many of the large metropolitan areas throughout the country. Federal and state proponents of ITS implementations recognize the importance of linking these metropolitan activity centers through the rural transportation network. These documents and the contents therein will serve, not only as a guide for implementation of ITS technologies in the I-70 West Corridor, but as au example for other rural ITS initiatives, throughout the country, in developing and implementing similar programs along those rural transportation corridors.

The I-70 Rural IVHS study is one of the first to address rural ITS applications in a specific transportation corridor that has significant and increasing travel use and demand. This particular corridor cannot be improved or enhanced by traditional "demand-responsive" construction activities (like adding more lanes to carry the vehicular traffic because of the aforementioned environmental, physical, financial, policy, and social constraints.

Other innovative programs and projects need to be envisioned and developed that address the transportation-related problems and needs within this corridor. Intelligent Transportation System applications, although not the only solution, have high probability of success to resolve, in conjunction with other social, economic, and environmental programs, many of the conflicting concerns and perceptions about the need for improvements and use of the I-70 facility from Denver to Glenwood Springs.

When the *I-70 Rural IVHS Corridor Planning and Feasibility* Analysis project was conceived and as the project was developed, the visionaries within the research and planning divisions and the responsible engineering regions of the Colorado Department of Transportation identified 25 specific areas/functions where ITS applications might resolve specific mobility and safety problems within

the I-70 West Corridor. These areas and/or functions have received the primary focus and attention in the planning and analysis of ITS initiatives during the study process:

1. additional variable message signs on westbound in advance of the Loveland Pass exit, eastbound in advance of Floyd Hill exit, Dowd Junction, Vail Pass, and other needed locations;

2. upgrades of computer equipment to provide better automatic message handling of the new and existing message signs along the corridor;

3. sensor-actuated environmental warning and predictive systems for ice, snow, and high winds at numerous locations along the corridor including, but not limited to, Dowd Junction, Vail Pass, Floyd Hill, and Glenwood Canyon;

4. automatic avalanche and rock slide warning systems for road maintenance crews and travelers at high-hazard locations;

5. an initial cellular reporting program, to be expanded as coverage of the corridor becomes complete;

6. public cellular-based roadside telephones in remote locations;

7. corridor courtesy patrols;

8. Glenwood Canyon and Eisenhower Tunnel-based control centers for ITS along the corridor;

9. real-time traveler information lii to facilities provided by the Colorado Tourism Board [now defunct];

10. "intelligent" rest areas;

11. a transit/rideshare site adjacent to the Morrison interchange with real-time road information, transit schedules, and weather information;

12. other intermodal [multi-modal] ties to public transportation systems (including recreation-specific buses) along the corridor;

13. the inclusion of HOV lanes/ramps at locations where future congestion levels may warrant widening;

14. the placement of portable message signs and highway advisory radio units at strategic locations throughout the corridor for use in incident management;

15. road and weather information distribution via privately supported information kiosks at airports, various ski areas, via cable TV, and other media;

16. retrofit of lighting and reflective coatings of both bores of the Twin Tunnels to reduce accidents and improve capacity;

17. remote controlled bi-directional lane controls for the Twin Tunnels to provide increased capacity through a 3:1 [lane] split;

18. remote video surveillance of the Twin Tunnels and approaches, Genesee to Morrison exit, Dowd Junction, Vail Pass and Floyd Hill for faster accident detection and response;

19. model the benefits of automatic median barrier relocation equipment creating a 3:2 [3:1] lane split near Idaho Springs with a filled median;

20. traveler information links with the CSP [Colorado State Patrol] and commercial traffic reporting agencies;

21. digital AM, FM, or pager-based radio sub-carrier traffic message channels;

22. data and communications links to the CDOT-sponsored traffic operations center;

23. data and communications links with the CSP;

24. satellite or earth-based personal radio mayday systems; and

25. other potential ITS features identified during the needs assessment.

Several of these ITS features have been initiated as deployment projects through other federal ITS program grants (cellular/GPS-based mayday and digital AM radio sub-carrier traffic messaging channels) and are currently in the developmental and implementation phases. Others have been initiated as a result of early action recommendations coming out of this study (cellular call boxes, variable message sign additions and upgrades).

A I-70 communications study is being commissioned to design data and communications links between CDOT-sponsored traffic operations and management centers and the Colorado State Patrol computer-aided dispatch systems. During the process of this study, these initiatives have been tracked and coordinated with to ensure compatibility and correlation between this and other plans and actions so that an integrated ITS for the I-70 West Corridor transpires now and into the future.

The I-70 Rural IVHS Corridor Planning and Feasibility Analysis study process involved the investigation and evaluation of ITS applications for each of the referenced features and identification of related and emerging technologies, programs, and plans that can address these and other cataloged transportation problems and needs related to the I-70 West Corridor. The additional need to coordinate, correlate, and cooperate with the numerous transportation and ITS planning entities and activities throughout the state and the nation has been a significant portion of the work during this study process.

Finally, and perhaps most important, the study and its documentation was formalized to help policy and decision-makers recognize and understand the importance and ability of ITS to resolve the ever-increasing demands on the I-70 West Corridor transportation system to respond to the societal and economic needs within the State of Colorado. It is increasingly important, too, for all users (the stakeholders) to acknowledge and grasp that the I-70 West Corridor serves a multitude of apparently opposing needs. For all, the system-wide ITS approach to solving the dilemma is paramount so that financial investments in the corridor are wisely spent to benefit the majority of the stakeholders.

BACKGROUND

As a guiding document and reference manual for the implementation of integrated ITS strategies, projects, and programs for the I-70 West Corridor, a synopsis of background ITS activity and the make-up of the I-70 corridor is necessary to bring newly involved parties to the same level of understanding as those who have developed this and other Colorado ITS plans of action.

Founded in 1988, Mobility 2000 was an informal assembly of industry, university, and government representatives created to promote the use of advanced technologies to improve highway safety and efficiency. The initiative was formalized in 1991, when the Intermodal Surface Transportation Efficiency Act (ISTEA) was enacted, and the national Intelligent Vehicle Highway System (IVHS) program was established. A growing sense soon developed in the IVHS community, especially in the public transit arena, that the term "intelligent vehicle highway systems" did not embrace all the transportation modes addressed in the national IVHS program. In 1994, the national IVHS program was re-designated as the Intelligent Transportation System (ITS), to clarify the multi-modal intent.

The I-70 Rural IVHS Corridor Planning and Feasibility Analysis was initiated and funded when the national program was known as IVHS. Due to the familiarity with the term IVHS among the involved stakeholders, and the time and expense that would be required to change the study's name in the contract documents, the original title was retained. References within the Corridor Master Plan, and other documents, will use IVHS and ITS interchangeably. Most references will be made to ITS unless a specific project or document carries the IVHS designation in its formal title.

Physical Characteristics. The I-70 West Corridor, from Denver to Glenwood Springs (Figure I-l, Study Area), provides east/west vehicular access across the State of Colorado and to numerous communities and recreational areas throughout the northwest region. This heavily traveled transportation corridor is classified as a rural, mountainous freeway facility, characterized by steep grades and sharp curves.

Many governmental jurisdictions and special interest groups are stakeholders in the ability of the I-70 West facility to carry large volumes of traffic with minimal negative impact to the surrounding areas. From the C-470/I-70 interchange west of Denver in Jefferson County, at an elevation of 6000 feet, I-70 enters Mount Vernon Canyon as a six-lane facility, traversing 6 to 8 percent grades as it heads west into the Rocky Mountains. The Hogback, a geologic formation along the Front Range, establishes the demarcation of the foothills from the Denver metropolitan area valley. Residential communities, scenic overlooks, historical, paleontological, and archaeological sites, and business/commercial activities attract commuters and travelers to this 12.5 mile segment of the

corridor. Access to the towns of Golden, Evergreen, Morrison, Black Hawk, and Central City, and other northern Front Range communities intersect I-70 in this area via US 6, SH 40, SH 26, andC-470.

Entering Clear Creek County at 7500 feet, I-70 narrows to a four-lane facility, dropping into the bottom of the canyon between Smith and Floyd Hills and Santa Fe and Saddleback Mountains in the Arapaho National Forest. At the bottom of the grade, US 6 interchanges with I-70, providing alternate access to Black Hawk and Central City via SH 119. Idaho Springs, an historic mining town nestled within the Flirtation Peak canyon, lies approximately 8 miles from the Clear Creek/Jefferson County line. I-70 winds through the canyon approach and cuts through the mountainside via the 1/4 mile long Twin Tunnels.

Climbing out of the Idaho Springs canyon, I-70 begins a steep and twisting 15 mile ascent toward Georgetown and Silver Plume, passing the towns of DUMONT Downieville, and Lawson, reaching 8500 feet at the US 40 interchange. US 40 continues west to Empire and into its climb to Berthoud Pass on the Continental Divide, providing access to Winter Park, Steamboat Springs, and other recreational areas in northwest Colorado. I-70 turns south through Empire Pass toward Georgetown, at 9000 feet. At Georgetown, I-70 turns east, climbing toward a 10,000 foot elevation and the historic mining town called Silver Plume.

From Silver Plume, I-70 continues a 12 mile westward climb toward the Continental Divide at 11,000 feet, serving the towns of Graymont and Bakerville before intersecting with US 6. US 6 heads south, then west, over Loveland Pass, providing an alternate route crossing the Divide for over-height and hazardous cargo-carrying commercial vehicles that are restricted from passing through the Eisenhower/Johnson Memorial tunnels.

I-70 travels through the Eisenhower/Johnson Memorial Tunnels, an approximate 2 mile directionally-divided passage through the Continental Divide, delineating the Clear Creek County/Summit County boundary. Exiting the westbound tunnel portal and turning southwest, a six-lane I-70 bends and descends for 10 miles, along 6 to 8 percent grades, into the Dillon Reservoir valley, serving the towns of Dillon, Silverthorne, and Frisco in Summit County. The valley flourishes with summer and winter recreational activities. Access to Keystone and the ski slopes via US 6; south to Breckenridge and Leadville via SH 9; and north to Kremmling and Steamboat Springs via SH 9 make this activity center an important travel hub.

I-70, a four-lane divided freeway, begins another 11.5 mile ascent into the White River National Forest and the Eagles Nest Wilderness, continuing south through Officer's Gulch, before turning west at the junction of SH 91, leading to Fremont Pass. I-70 veers west then north to Vail Pass at 10,666 feet as it enters Eagle County. West of Vail Pass, I-70 continues a 13 mile up and down, winding travel path, generally northwest, then west into the Vail Valley at 8200 feet.

About 3 miles southwest of Vail, I-70 intersects with US 24 (heading southeast to Leadville) at Dowd Junction, where it turns easterly and parallel to the Eagle River and the Southern Pacific (formerly Denver & Rio Grande Western)/AMTRAK passenger train route. The I-70 descent into the Eagle River Valley, at approximately 7500 feet, serves the towns of Avon, Edwards, Wilmor, and Wolcott.

Local routes intersect this 15 mile stretch of I-70, providing access north to Steamboat Springs via SH 131 and south along county roads into the White River National Forest. West of Wolcott, I-70 enters the Red Canyon, a generally straight and flat 15 mile passage through the town of Eagle to Gypsum. US 6 parallels I-70 throughout this stretch. I-70 continues west for 9 miles, at an approximate elevation of 6200 feet, toward Dotsero and the confluence of the Eagle and Colorado Rivers before entering Garfield County and Glenwood Canyon.

Entering Glenwood Canyon and Garfield County, I-70 winds sharply along a new four-lane elevated and cantilevered structure for 13 miles. It passes through the Hanging Lake tunnels and provides access to numerous recreational and rest area facilities along the Colorado River. Exiting the Canyon to the west, I-70 enters the City of Glenwood Springs area, at about 6000 feet, famous for many summer recreational activities. The interchange into the City of Glenwood Springs provides access to SH 82, which leads to the towns and recreational areas of Carbondale, Basalt, Snowmass, and Aspen.

Environmental Characteristics. The I-70 Corridor, from west Denver to Glenwood Springs traverses mountains and forest lands. From the Hogback at the foothills of the Rocky Mountains, I-70 passes through Mount Vernon Canyon along the north fork of Bear Creek, surrounded by woodland on the north and south. It crosses Soda Creek and Beaver Brook before leaving Jefferson county.

I-70 crosses rugged, mountainous terrain throughout Clear Creek County between the Roosevelt National Forest on the north and the Arapaho National Forest on the south. It enters the Arapaho National Forest at Graymont, west of Georgetown and Silver Plume. I-70 parallels Clear Creek from the US 6 junction, 3 miles inside the eastern county border, to the Eisenhower tunnel east portal (Johnson tunnel east portal for eastbound traffic). Numerous creeks and streams feed into Clear Creek from their headwaters on the north and south. Fishing in these waterways is a popular summer recreation activity.

The towns along I-70 are the surviving vestiges of the gold and silver mining days of the late 1800s. Many mine portals are still evident, with tailings scarring the hillsides. Some of the mines are still operating. Gold-panning in Clear Creek survives the history of the area as a thriving summer past-time.

I-70 descends into the Dillon Reservoir Valley in Summit County, within the Arapaho National Forest and skirts the southern tip of the Eagles Nest Wilderness. I-70 parallels Straight Creek upon its exit from the west portal of the Eisenhower tunnel (Johnson tunnel west portal entrance for eastbound travel) in Summit County until the creek converges with the Blue River at Silverthome. I-70 then parallels Tenmile Creek from Frisco to Vail Pass. Again, numerous streams feed into Straight and Tenmile Creeks from their headwaters in the surrounding mountains.

Summit County is a popular year round vacation and recreational get-a-way, offering: fishing, camping, hiking, biking, and special events during the spring, summer, and fall; and downhill and cross country skiing, ice fishing, and special events during the winter.

I-70 enters Eagle County at Vail Pass, crossing the Gore Range as it traverses the Arapaho and White River National Forests. It parallels Gore Creek and is surrounded by woodlands until its juncture with US 24 at Dowd Junction. Here, I-70 enters the Eagle valley, paralleling the Eagle River until its confluence with the Colorado River near the western county line. I-70 traverses the White River National Forest to Wilmor, where it follows the southern boundary of BLM Public Lands.

Western Eagle County is nationally known for its winter recreational activities at the Vail and Beaver Creek ski resorts. Much of the County is a haven for summer hiking, biking, fishing, and off-road vehicle activities. Many of the Colorado mountain resort area workers live in Eagle County.

I-70 re-enters the White River National Forest in Glenwood Canyon in Garfield County. It parallels the Colorado River through Glenwood Springs. Designated as a scenic byway throughout the Canyon, I-70 passes through wild vegetation and steep, craggy rock walls. The Canyon offers numerous mild weather outdoor recreation activities, including hiking, biking, river rafting, and picnicking.

Deer, elk, and Big-Horn sheep are common throughout the I-70 Corridor. These animals cross and graze within the I-70 rights-of-way during the spring and fall months. Animal/vehicular conflicts can be frequent, causing personal property damage and injury. "Roadkill" requires additional CDOT resources to remove and dispose of carcasses.

Generally, the climate throughout the I-70 Corridor, from west Denver to Glenwood Springs, is characterized by 18 to 43 annual temperature days above 90 degrees Fahrenheit and 196 to 237 annual temperature days below freezing. High temperatures, from 99 to 104 degrees Fahrenheit, are usually recorded in June and July. Lows, around 3 to 10 degrees Fahrenheit, usually occur in January.

Pressure altitude variations range from a low in December between 5300 and 6300 to highs between 5600 and 6600 in June. Annual precipitation is approximately 11 inches per year. Thunderstorms occur about 34 days per year, peaking in July. Average snowfall is about 52 inches per year. About 11 days out of every year, record snowfall is greater than 1.5 inches. Winds peak in April with 4.7 percent of the gusts stronger than 60 miles per hour.

Weather extremes exacerbate travel along I-70. Preferential roadway icing, blizzards, avalanche, and high winds are characteristic during the winter months, creating visibility, traction, and stop/start driving hazards. Rock and mud slides, gusty winds, and rain storms are common during the spring thaw. The summer months are generally mild, however, snowstorms and their associated travel hazards do occur. The fall season inaugurates the onset of winter with sporadic snowstorms and gusty winds.

Travel Characteristics. The I-70 Corridor supports east/west interstate, regional, and local vehicular travel. It serves as a major interstate trucking route between Denver and Salt Lake City. Commercial vehicle use of the corridor makes up approximately 20 percent of the year round vehicular traffic. Commercial vehicles also provide the necessary goods to support the communities along I-70.

I-70 serves as the primary access to the numerous winter and summer recreational areas in the northwest region of Colorado. In the winter, destination-oriented trips, from the Denver metropolitan area to ski resorts in Summit, Eagle, Garfield, and Routt Counties, comprise over 50 percent of the weekend vehicular travel. Peak westbound travel usually occurs on Friday evenings and Saturday mornings; peak eastbound travel results from return ski-related trips on Sunday evenings. These trips, particularly when adverse weather creates driving hazards, cause urban-like traffic congestion, travel delays, and accidents.

Spring, summer, and fall recreational trips can be destination-oriented, however, many are not associated with a particular destination, but for sight-seeing and "Sunday drives." These tourist trips, again make up more than 50 percent of the seasonal trips, with the same peak day and hour travel patterns and resulting effects.

Limited-stakes gambling in Gilpin County has created an additional demand on I-70 between Denver and Idaho Springs. Although gaming trips do not normally peak at the same time as recreational trips, safety and mobility become large issues on the US 6 and SH 119 routes to Black Hawk and Central City that access I-70.

I-70 serves many communities and is often the only thoroughfare for those towns adjacent to it. It is therefore the major facility for local citizens to make their daily home-based work and non-work trips. Many recreational area workers live in the smaller communities within a 50 mile radius of the resort towns to take advantage of more affordable living. Approximately 70 percent of the work trips are made using private automobiles that occur on weekdays between 7:00 and 9:00 am and 4:00 and 6:00 pm daily. Much of the work related travel uses segments of I-70, creating traffic operational problems at interchanges with state highway and county route access points.

There are numerous public and private transit service providers that operate within the I-70 Corridor. RTD provides public fixed route and demand responsive services for the Denver metropolitan area, including those communities in Jefferson County west of C-470 served by I-70. Private transit operators provide fixed shuttle service, for tourists and commuters, from the Denver area, along I-70, to the recreational areas.

Summit County operates the Summit Stage, a "free" fixed route hub-and-spoke transfer system serving the communities of Copper Mountain, Frisco, Breckenridge, Keystone, Dillon, and Silverthome. The Stage also offers demand-responsive special services and a Winter Service Express. The Breckenridge In-Town Shuttle and Trolley and the Keystone Express provide local service for their respective resort areas. Summit County School District RE-1 provides transportation for students residing in the County.

Eagle County supports two public transit providers: the Avon/Beaver Creek Transit Service and the Vail Transit System. Eagle County School District RE-50 serves Eagle County students as well as those in southern Routt County and eastern portions of Garfield County.

Garfield County relies on the Pitkin County Roaring Fork Transit Agency (RAFTA) to provide public transit service to Carbondale and Glenwood Springs. Students residing in these communities are provided school transportation through the Roaring Fork RE-1 district.

Aviation facilities, in addition to Denver International Airport, that serve as commercial air travel centers include the Eagle County Regional Airport and Aspen/Pitkin County Airport (Sardy Field). Other airports, providing commercial air service to areas north of I-70, include the Yampa Valley Regional Airport (Hayden) and Bob Adams Field (Steamboat Springs--currently not in operation).

The Southern Pacific (SP) railroad offers commodity transport in the Denver metropolitan area and through portions of Eagle, Garfield, and Pitkin Counties. AMTRAK provides passenger rail service on the Southern Pacific Railroad tracks between Denver and Salt Lake City. The Leadville Colorado and Southern Railroad Company operates summertime daily passenger rail service in Lake and Eagle Counties, which has high tourist demand. There is no rail service in Summit and Clear Creek Counties.

The State Trails Program, established in 1971 by the Colorado Division of Parks and Outdoor Recreation, has funded the development of numerous bicycle and recreational trails. The Colorado Greenway Project, funded by Colorado Lottery proceeds, also provides trail funding. The United States Forest Service and the Bureau of Land Management maintain numerous hiking, biking, and off-road vehicle trails throughout their respective jurisdictions.

Summit County has 44 miles of asphalt-surfaced bicycle/pedestrian trails, including the Blue River Bikeway, the Tenmile Canyon Trail (Vail Pass), the Dillon-Frisco Trail, and the Dillon-Keystone Trail. The Colorado Trail, an unpaved path from Denver to Durango, passes through Summit County, benefitting hikers, horseback riders, and cross-country skiers.

Most of the bicycle/pedestrian trails in Eagle County are located in the Vail area. The Vail Bike Trails system provides paved facilities from East Vail to West Vail along Gore Creek. On- and off-street feeders and the extensive Vail Mountain hiking and biking trail network connect to the Vail Bike Paths.

The Horseshoe Bend Trail, Scout Trail, and Red Mountain Trail begin in Glenwood Springs in Garfield County. The Horseshoe Bend Trail is a paved bicycle/pedestrian path running into Glenwood Canyon and connecting to the I-70 trail system in the canyon along the Colorado River. Scout Trail is an unpaved mountain bike path leading to Lookout Mountain. Red Mountain Trail climbs south along the Roaring Fork River and serves mountain bike and horseback riders, hikers, and cross-country skiers.

IVHS/ITS GOALS AND OBJECTIVES

The relationship between national, state, and regional goals and objectives for ITS provide the framework for meeting the transportation needs within the I-70 West Corridor with respect to advanced technology applications. The *I-70 Rural IVHS* study Program Goals were defined to respond to the challenges and opportunities of the complex transportation problems that confront the agencies responsible for, communities within, and the travelers using the I-70 West Corridor.

National ITS Program Goals. The *National ITS Program* has been designed to help meet goals outlined in the ***Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA)***: *"...to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy and will move people and goods in an energy efficient manner."* Initial goals for ITS in the United States included:

- ✓ improving mobility and transportation productivity;
- ✓ maximizing use of existing transportation facilities;
- ✓ conserving energy resources;
- ✓ enhancing safety; and
- ✓ reducing adverse environmental impacts.

Certain societal, economic, and legislative factors have influenced, and continue to influence the evolution of the National ITS Program as it changes to meet the needs of its constituents:

- + accessibility and mobility;
- + dependence on the single occupant vehicle;
- + land use and demographics;
- + economics and productivity;
- + international competitiveness;
- + changes in the defense industry;
- + the National Information Infrastructure (NII) [Information Superhighway and telecommunications industry];
- + fiscal pressures;
- + ISTEA legislation; and
- + Clean Air Act Amendments (CAAA).

These and other factors have lead to the development of the *National ITS Program Plan* and a ***redefinition of the National ITS Program Goals***:

- ✓ improve the safety of the Nation's surface transportation system;
- ✓ increase the operational efficiency and capacity of the surface transportation system;
- ✓ reduce energy and environmental costs associated with traffic congestion;
- ✓ enhance present and future productivity;
- ✓ enhance the personal mobility and the convenience and comfort of the surface transportation system; and
- ✓ create an environment in which the development and deployment of ITS can flourish.

Colorado ITS Program Goals. In the future, through the comprehensive implementation of ITS technologies nationally, Colorado has the potential to realize a more balanced and better integrated transportation system. To specifically envision Colorado's future highway system, ultimate goals of the *C-Star Program*, paralleling the national ITS vision, were established. The *C-Star* vision stated goals to:

- ✓ improve efficiency for movement of people and goods;
- ✓ increase safety;

- improve coordination of transportation systems;
- develop public/private partnership;
- enhance intrastate and interstate commerce; and
- reduce environmental impacts.

In August 1993, a collection of ITS proponents from each of the CDOT Engineering Regions, CDOT Headquarters, the Colorado State Patrol, and this study's project team convened in Glenwood Springs to establish the Statewide ITS Implementation Team. The continued cooperation and coordination of that group has lead to the evolution of the C-Star Program into Smart Path, a statewide, systematic vision for the ITS in Colorado.

Smart Path Program Objectives. Colorado's heavily traveled rural, suburban, and tourist roadways are strong candidates for early ITS deployment. Investment in specific ITS implementations is the right choice for providing a cost-effective, long-term solution to Colorado's current and anticipated transportation needs. Smart Path is a statewide program of projects and implementation activities that will lead to the deployment of an integrated ITS in Colorado. Smart Path program primary goals are:

-to identify specific transportation system needs and requirements that exist in either rural or urban parts of the state;

-to identify those ITS activities which show the greatest potential for meeting those identified needs and which will have the most beneficial impacts on transportation in Colorado; and

-to develop an approach that will support decision-making in respect of future ITS activities.

These broad goals have been further subdivided into a series of objectives that relate to two specific categories:

-Objectives for ITS Application:

- to satisfy transportation system needs that are regional or statewide priorities;
- to focus on ITS implementation activities that respond to critical needs;
- to implement ITS solutions that enhance intermodal coordination and recognize interactions among various components of all statewide transportation systems;
- to integrate ITS applications with other transportation-related operations and management functions;
- to encourage near-term ITS implementation that is highly-visible and low risk, with a high probability of success;
- to implement ITS solutions that encourage effective public and private partnerships and resource-sharing; and
- to encourage private sector participation in developing and implementation ITS solutions,

-Objectives of the Smart Path Program Approach:

-to demonstrate that selection of ITS solutions are needs driven;

to demonstrate that ITS applications are compatible with and complementary to traditional approaches;
- to identify the benefits of ITS implementations and support comparison of those with other investments;
- to explore opportunities to enhance andfor supplement current transportation system commitments;
- to develop a balanced program between research, operational testing, and deployment that pushes the state-of-the-art;
to establish realistic cost estimating processes as a means to present overall implications of ITS investments;
- to create an environment of cooperation and trust among responsible agencies;
- to inform and educate stakeholders of ITS potential and their respective roles; and
- to educate and encourage buy-in by policy and decision-makers.

I-70 West Corridor ITS Program Goals. Federal, state, and local agencies, service providers, environmental and civic groups, commercial vehicle and public transportation operations, and recreational areas, that rely on the I-70 West Corridor, each have a stake in the ability of the transportation system to move people and goods effectively and efficiently. Encompassing goals set by the national and Colorado ITS programs, ITS objectives for the I-70 West Corridor are established as:

- improve safety;
- reduce congestion:
-decrease disruptions due to weather/road conditions
-encourage alternative mode usage;
- disseminate traveler information:
-traveler peace of mind
-good driver decisions;
- overcome institutional barriers; and
– build a constituency.

I-70 West Corridor Study Goals.Because of the physical, environmental, and travel characteristics of I-70 from Denver to Glenwood Springs, the Colorado Department of Transportation (CDOT) identified it as a prime corridor for implementing ITS technologies. The I-70 Rural IVHS Corridor Planning and Feasibility Analysis study was initiated to address the multi-jurisdictional problems and needs associated with the facility and to develop near- and long-term strategies, beyond traditional capacity improvements, to enhance mobility, improve safety, protect the environment., stimulate economic development, increase efficiency, and encourage multi-modal transportation alternatives.

To identify all problems associated with travel along the I-70 West Corridor, as well as issues and concerns voiced by local, regional, and state-wide interests in transportation in Colorado, the following goals were established:

-to identify and set-up implementation for successful short-term (early action) projects; and

-to create leverages for federal and private dollars to fund recommended ITS programs and projects.

RELATED PLANS, PROGRAMS AND ORGANIZATIONS

To ensure interoperability of technology and existing systems, and area-wide ITS compatibility, the 1-70 Rural IVHS study has been performed, and documentation developed, in coordination with other CDOT ITS plans, programs, and organizations, and with ongoing national ITS efforts. As a reference manual, this Corridor Master Plan is intended to provide a comprehensive compilation of candidate ITS actions for implementation in the I-70 West Corridor. To assist in that effort, brief descriptions of related plans, programs, and organizations are compiled in Appendix A of this document so that implementors have a base from which to coordinate, gather information, and correlate activities as each program and project is initiated.

Further, Appendix B provides a listing of stakeholders who were contacted and participated in the development of study and resulting recommendations. These individuals (and the groups they represent) must be brought into the development and initiation of each ITS program and project recommended in this Corridor Master Plan to ensure stakeholder buy-in and program/project success.

The ITS program is full of acronyms to shorten the written and spoken forms that describe the complexities of systems, programs, and technologies. Many of these acronyms are used throughout this and companion documents. To assist the new and emerging ITS champions of the programs and projects contained herein, acronyms are spelled out in an alphabetical listing contained in Appendix C. Users of this document are encouraged to reference companion documents to gain more thorough knowledge and understanding of ITS technologies and applications.

The technical details of ITS development, design, and deployment are relatively simple to resolve compared to the organizational and institutional elements that need to be addressed. It is extremely critical that the relationships, roles, and responsibilities between the involved agencies are defmed and coordinated so that implementation of ITS applications within the I-70 West Corridor are integrated with state-wide ITS as well as respect the jurisdictional philosophies of the operators and maintainers of the proposed system and sub-systems.

The responsible state, federal, and regional organizations and agencies that have a major stake in the 1-70 Rural NHS program must be coordinated with and apprised of all activities during the development and evolution of each ITS program and project for the I-70 West Corridor. The success of each project and program will be highly dependent on the comprehensive coordination with, involvement by, and knowledge of these primary stakeholders. Briefly, the major participants in eveq initiative and their respective roles and responsibilities are:

CDOT Headquarters: Coordination of all modes of transportation throughout the State of Colorado and management and supervision of the state's interstate and state highway system. Current Contacts: Pete Mire&, Chair, Transportation Commission of Colorado, (303) 757-9207;

Bill Vidal, CDOT Executive Director, (303) 757-9201; and Dan Hopkins, Director of Public and Inter-Governmental Relations, (303) 757-9469.

CDOT Division of Highway Operations and Maintenance: Development and implementation of uniform transportation systems operation and maintenance planning, training, inspection, and program development and implementation, including ITS. Current Contact: Bill Reisbeck, (303) 757-9203.

CDOT ITS Program Office: Oversight, coordination, and facilitation of all statewide ITS activities and initiatives, including I-70 West Corridor strategies. Current Contacts: John Kiljan, ITS Program Director, (303) 757-9508 ; Joni Brookes, Statewide ITS Engineer, (303) 239-5805; Neil Lacey, ITS Research Engineer, (303) 757-9974; Dick Mango, CVO Engineer.

CDOT interim Traffic Operations Center (ITOC): Development, deployment, operations, and maintenance of systems and subsystems for statewide advanced traffic management, including any interconnect to I-70 West Corridor traffic operations/management centers. Current Contacts: Larry Corcoran, Manager, (303) 239-5807; John Nelson, ITS Communications Engineer, (303) 239-5806.

CDOT Transportation (Engineering) Region 1: Administration of operations and maintenance activities for transportation systems within the I-70 West Corridor region comprising Jefferson (excluding the Denver metropolitan area), Clear Creek, Summit, Grand, and Gilpin Counties. Current Contacts: John Unbewust, Region Transportation Director, (303) 757-9371; Pam Hutton, Region Traffic Engineer, (303) 757-9122; Ed Fink, Region Maintenance Supervisor, (303) 757-9649.

CDOT Transportation (Engineering) Region 3: Administration of operations and maintenance activities for transportation systems within the I-70 West Corridor region comprising Eagle, Garfield, Pitkin, Routt, Moffat, Rio Blanco, Jackson, Mesa, Delta, Gunnison and Park Counties. Current Contacts: Bob Moston, Region Transportation Director, (970) 830-7201; Jim Nall, Region Traffic Engineer, (970) 830-7213; John Smith, Region Maintenance Supervisor, (970) 830-6976.

CDOT Transportation (Engineering) Region 6: Administration of operations and maintenance activities for transportation systems within the I-70 West Corridor region comprising the Denver metropolitan area in Jefferson County. Current Contacts: Larry Warner, Region Transportation Director, (303) 757-9251; Lou Lipp, Region Traffic Engineer, (303) 757-9511; Al Kline, Region Maintenance Supervisor, (303) 757-9514.'

CDOT Division of Engineering, Design, and Construction: Development statewide roadway systems, and in particular relationship to ITS, statewide traffic engineering development. Current Contacts: Jim Siebels, Director, (303) 757-9202; Matt Reay, Staff Traffic Engineer, (303) 757-9271.

CDOT Division of Transportation Development:Administration of statewide transportation planning activities for highways, rail, mass transit, and bicycle and pedestrian modes, including data collection and research. Current Contact: Jennifer Finch, Director, (303) 757-9211.

Colorado Department of Public Safety, Colorado State Patrol (CSP): Enforcement of all state laws relating to motor vehicles and highway safety including stolen and abandoned vehicles, motorist assist, highway regulations, vehicular and motor carrier safety, incident response, and hazardous materials transport. Current Contact: Linda Sumpter Smith, Communications Division Director, (303) 239-4534.

Federal Highway Administration--Colorado Division: Oversight and approval of statewide transportation initiatives involving the Interstate highway system and all federal financing of state and local highway-related projects. Current Contacts: George Osborne, Division Transportation Manager, (303) 969-6703; Charmaine Farrar, ITS Programs Manager, (303) 969-6703 x374; Scott Sands, Traffic Operations Engineer, (303) 969-6703 x362.

Federal Highway Administration--Region 8: Federal oversight, coordination, and advisory representation to FHWA-Colorado Division and CDOT for the development and implementation of statewide transportation system initiatives involving allocation and disbursement of federal funds to the state. Current Contact: Jeff Kolb, Transportation (ITS) Specialist, (303) 969-6744.

Denver Regional Council of Governments (DRCOG) Denver metropolitan area oversight and. approval of transportation projects to be included in regional Transportation Improvement Plan (TIP) to allocate funding for I-70 West Corridor area initiatives in Jefferson, Clear Creek, and Gilpin Counties. Also, review and approval of any travel demand forecasting, paratransit services, travel demand and congestion management strategies, other social services related to people mobility within its jurisdiction. Current Contacts: George Scheuernstuhl, Transportation Director, (303) 480-6743; Steve Rudy, Congestion Management Engineer, (303) 480-6747.

Northwest Colorado Council of Governments (NWCCOG): Oversight of transportation planning, travel demand forecasting, and social services related to people mobility in the northwest region of Colorado including I-70 West Corridor area initiatives in Summit, Eagle, Pitkin, Routt, Grand, and Jackson Counties. Current Contact: Linda Venturoni, Director, (970) 468-0295.

Associated Governments of Northwest Colorado (AGNWC). Oversight of transportation planning, travel demand forecasting, and social services related to people mobility in the northwest region of Colorado including I-70 West Corridor area initiatives in Garfield, Mesa., Rio Blanc, and Moffat Counties. Current Contact: Jim Evans, Director, (970) 625-1723.

Northwest Transportation Planning Region (NWTPR). Established by Colorado State legislation following the passage of ISTEA in 1991, this TPR develops the region's transportation plan for submission to CDOT. All 15 TPR plans are incorporated into Colorado 's 20 Year Transportation Plan. The Northwest TPR encompasses Moffat, Rio Blanco, Grand, Jackson, and Routt Counties. Current Contact: Bob Carlstrom, (970) 723-8470.

Intermountain Transportation Planning Region (IMTPR). Established by Colorado State legislation following the passage of ISTEA in 1991, this TPR develops the region's transportation plan for submission to CDOT. All 15 TPR plans are incorporated into Colorado's 20 Year Transportation Plan. The Intermountain TPR encompasses Summit, Eagle, Pitkin, Garfield, and Lake Counties. Current Contact: Lou Trapani, (800) 285-0409.

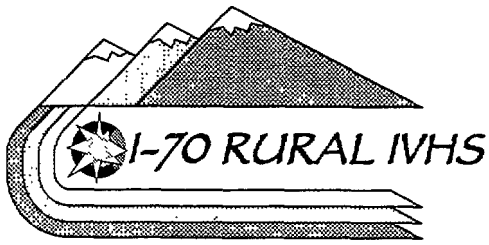
Regional Transportation District (RTD): Development, operations, and maintenance of Denver metropolitan region transit services including I-70 West Corridor areas in Jefferson, Clear Creek, and Gilpin Counties. Current Contact: Dave Shelley, Senior Planner, Systems Planning Division, (303) 299-2408.

Colorado Association of Transit Agencies (CASTA): Leadership, resources, support, and technical assistance to locally-based transit agencies in Colorado, whose membership includes all transit organizations operating in the I-70 West Corridor. Current Contact: Jeanne Erickson, Executive Director, (303) 839-5197.

Colorado Ski Country USA. Umbrella organization representing and serving the interests of all ski resorts in Colorado, including those in the I-70 West Corridor areas of Clear Creek, Summit, Grand, Eagle, Garfield, Routt, and Pitkin Counties providing advocacy and informational actions. Current Contact: Renetta Lueckenhoff, Director of Governmental Affairs, (303) 837-0793.

Colorado Municipal League (CML). Umbrella organization representing and serving 99 percent of Colorado cities and towns, including those in the I-70 West Corridor areas of Summit, Eagle, Garfield, Pitkin, Lake, Routt, Rio Blanco, Grand, Jackson, Gunnison, Clear Creek, Jefferson, Adams, and Denver Counties providing advocacy and informational actions. Current Contact: Ken Bueche, Executive Director, (303) 831-6411.

Colorado Motor Carriers Association (CMCA): Umbrella organization representing and serving the freight transport industry in the efficient and productive movement of goods throughout Colorado, including trucking along the I-70 West Corridor and state highways within the northwest region and rail transport along Union Pacific, Southern Pacific, and local railroad trackage traversing the northwest region. Current Contact: Greg Fulton, (303) 433-3375.



CORRIDOR

MASTER PLAN

SECTION II
INFORMATION SEARCH SUMMARY

SECTION II INFORMATION SEARCH SUMMARY

OBJECTIVES

- *Define the Existing System*
- *Outline the Institutional Framework*
- *Identify the Perceptions and Realities*
- *Inventory the Candidate Technologies*
- *Document the Findings*

PROCESS

- *Experience the Corridor*
- *Survey the Stakeholders*
- *Investigate the Environment*
- *Search the Literature*
- *Research the Technology*
- *Consolidate the Findings*

SOURCES

- *C-Star Strategic Plan and Smart Path Vision and Business Plans*
- *Other CDOT Plans and Programs*
- *FHWA/FTA Guidelines*
- *Project Stakeholder Coalition*
- *Other Domestic and Foreign Agencies and Private Sector Businesses*
- *System Operators and Integrators*

Scope: Survey existing andpotential IVHS technologies and identify the range of IVHS applications that are candidates for implementation in the corridor for each of the major organizational areas of IVHS:

advanced traffic management systems (ATMS);
advanced traveler information systems (ATIS);
commercial vehicle operations (CVO);
advancedpublic transportation systems (APTS); and
automatic vehicle control systems,

with particular emphasis on the first two categories. The range of applications will be summarized in a non-technical memorandum format. The memorandum will provide references and examples of existing programs in other states, provinces, and countries for each candidate application. For innovative applications for which no examples exist or are planned the rationale for inclusion will be included. Drawing upon the C-Star Strategic Plan for this work is acceptable.

Deliverable: Information Search Memorandum

The Information Search task for the I- 70 Rural IVHS Corridor Planning and Feasibility Analysis involved an investigation of ITS technologies and applications, with emphasis on advanced transportation management and advanced traveler information systems, that have high potential for implementation within the I-70 West Corridor from Denver to Glenwood Springs. Collection of background information (physical, social, environmental, organizational, and event-related) was necessary to associate and evaluate the proficiency of a technology and/or application to serve a problem or need within the I-70 West Corridor.

While a large part of the Information Search activities concentrated on gathering data about advanced technologies and their respective applications, the research had an equally strong focus on the institutional framework supporting the transportation system. Many opportunities for improving the effectiveness of a transportation system can be achieved through management and operational efficiencies.

Based on information collected through field investigation, a

literature search, and via stakeholder surveys, the Information Search provides a broad overview of the corridor-wide transportation system characteristics, detailing the physical geometry, technological infrastructure, and operating environment of the Corridor. The system metrics provide valuable information that can be used to reveal the limitations of certain technologies and applications under existing conditions.

The transportation system characteristics described in this Information Search provide the framework for directly relating particular organizational, operational, and technological elements to the evaluation and assessment of transportation problems and needs within the I-70 West Corridor. The base elements are cross-referenced in the Needs Assessment documentation to describe how advanced technological and institutional systems can address the problems and needs within the Corridor. System characteristics include transportation facilities and services(traffic volumes, accident data, service interruptions); user definitions (recreation, communities, surface and air transportation services); the physical environment (woodlands, waterways, wildlife, mineral resources); and the technological infrastructure (sensors, detectors, operations centers, communications).

Users of the I-70 West Corridor additionally have opinions and perspectives about travel throughout the Corridor and operation of the transportation elements within the Corridor. The Information Search defines those transportation system users in terms of:

- general travelers;
- commercial vehicles operators;
- communities/businesses;
- owners/maintainers; and
- transportation service providers.

As further background, the Information Search presents a discussion of the characteristics of the various organizations within the I-70 West Corridor study area. Information pertaining to the organizational characteristics is useful in translating the intra-agency and inter-agency relationships into meaningful institutional needs. Generally, organizations pertinent to the I-70 ITS implementation program encompass:

- operating agencies
- policy makers
- social-economic organizations
- financial partners
- local agency authorities
- special interest groups

During the early stages of wide-area planning studies and implementation programs, the FHWA ITS Planning Process calls for the establishment of a multi-organizational coalition. That coalition-building process facilitates ITS outreach and agency buy-in. The necessary cooperation and coordination between jurisdictions was initiated as one of the Information Search activities to set the stage for continued support through ITS program implementation and operation.

The Information Search describes the project coalition that has been established for the I-70 Rural IVHS study within the I-70 West Corridor. It depicts the agendas, priorities, and policies of the I-70 Rural IVHS Study Steering Committee and Action Teams, as well as other stakeholders. This is intended to fulfill the coalition member objectives during the planning process, and ensure that the final system meets the needs and expectations of the involved stakeholders.

The Information Search presents the results of a comprehensive industry survey that considers proven technology, field-tested technology, and new technology emerging into the market for application to the corridor needs, in support of each of the functional areas of ITS:

- Advanced Traffic Management Systems (ATMS);
- Advanced Traveler Information Systems (ATIS);
- Commercial Vehicle Operations (CVO);
- Advanced Public Transportation Systems (APTS);
- Advanced Safety and Warning Systems (ASWS); and
- Advanced Vehicle Control Systems (AVCS).

To ensure a comprehensive survey of the full range of technologies available, the following information sources were explored:

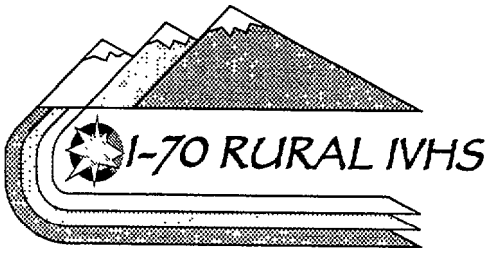
- C-Star Strategic Plan, Smart Path Visionary/Business Plans, other CDOT plans and programs;
- Federal Highway Administration (FHWA), Federal Transit Administration (PTA), and other federal agency documentation;
- Coalition member agency/organization policies and plans;
- Other domestic and foreign agency actions;
- System operators and system integrators; and
- Domestic and foreign private sector research, development, and implementation programs.

The Information Search identifies, and thoroughly explains, available technologies associated with the following ITS applications:

- variable message signs
- cellular telephone
- corridor courtesy patrols
- real-time traveler information
- other intermodal ties
- incident management
- lane controls
- sensor-actuated environment
- call boxes
- regional traffic operations centers
- mass transportation
- high occupancy vehicle infrastructure
- roadway delineation
- video surveillance

The various technologies, functionalities, and system options are specified for each application, citing typical uses and actual deployments wherever possible. These features categorize the 25 areas for investigation identified in the CDOT scope of work for this study.

The Information Search features a Literature Search, presenting an overview of the various documents, articles, and thinking regarding ITS (then IVHS) through 1993.



CORRIDOR MASTER PLAN

SECTION III
NEEDS ASSESSMENT SUMMARY

SECTION III NEEDS ASSESSMENT SUMMARY

OBJECTIVES

- ✓ *Assess Technological and Institutional Needs*
- ✓ *Apply Technologies to User Needs*
- ✓ *Define Institutional Barriers*
- ✓ *Document the Analysis*

PROCESS

- ✓ *Analyze Transportation System Characteristics*
- ✓ *Assess Mobility, Safety, Information, and Communications Resources*
- ✓ *Apply Advanced Technology Solutions*
- ✓ *Establish User Service Objectives*
- ✓ *Report the Results*

SOURCES

- ✓ *CDOT ITS Program Office; Regions 1,3,6*
- ✓ *Colorado State Patrol*
- ✓ *Local Governments*
- ✓ *FHWA Colorado Division; Region 8*
- ✓ *Transportation Service Providers*
- ✓ *Local Communities and Organizations*
- ✓ *Recreation/Tourism Interests*
- ✓ *Emergency Response/ Enforcement Organizations*
- ✓ *Commercial Vehicle Operators*

Scope: Identify and assess the needs of those who operate and maintain and support the surface transportation systems on the corridor. Contacts should include, but not be limited to, maintenance and traffic personnel in CDOT Regions 1 and 3, the Colorado State Patrol (CSP), local governments, the Colorado Tourism Board [defunct as of project notice-to-proceed--voters elected, in November 1992, to stop program funding], corridor transit companies, ski and recreational organizations, local chambers of commerce, local residents, and the traveling public.

No committee structure is defined. Although CDOT will provide the names of representatives from each of its disciplines, participation from other outside agencies will be less certain. Education of potential participants to the opportunities and benefits of IVHS technologies may be needed. Development and approval of committee(s) and other organizational structure(s) to suit the study methodology is expected.

The task will include the assessment of the potential for implementation of 25 identified IVHS features:

1. *additional variable message signs on westbound in advance of the Loveland Pass exit, eastbound in advance of Floyd Hill exit, Dowd Junction, Vail Pass, and other needed locations;*
2. *upgrades of computer equipment to provide better automatic message handling of the new and existing message signs along the corridor;*
3. *sensor-actuated environmental warning and predictive systems for ice, snow, and high winds at numerous locations along the corridor including, but not limited to, Dowd Junction, Vail Pass, Floyd Hill, and Glenwood Canyon;*
4. *automatic avalanche and rock slide warning systems for road maintenance crews and travelers at high-hazard locations;*
5. *an initial cellular reporting program, to be expanded as coverage of the corridor becomes complete;*
6. *public cellular-based roadside telephones in remote locations;*
7. *corridor courtesy patrols;*
8. *Glenwood Canyon and Eisenhower Tunnel-based control centers for ITS along the corridor;*
9. *real-time traveler information links to facilities provided by the Colorado Tourism Board [now defunct];*
10. *"intelligent" rest areas;*
11. *a transit/rideshare site adjacent to the Morrison interchange with real-time road information, transit schedules, and weather information;*
12. *other intermodal [multi-modal] ties to public transportation systems (including recreation-specific buses) along the corridor;*
13. *the inclusion of HOV lanes/ramps at locations where future congestion levels may warrant widening;*
14. *the placement of portable message signs and highway advisory radio units at strategic locations throughout the corridor for use in incident management;*

15. *road and weather information distribution via privately supported information kiosks at airports, various ski areas, via cable TV, and other media;*
16. *retrofit of lighting and reflective coatings of both bores of the Twin Tunnels to reduce accidents and improve capacity;*
17. *remote controlled b&directional lane controls for the Twin Tunnels to provide increased capacity through a 3:1 [lane] split;*
18. *remote video surveillance of the Twin Tunnels and approaches, Genesee to Morrison exit, Dowd Junction, Vail Pass and Floyd Hill for faster accident detection and response;*
19. *model the benefits of automatic median barrier relocation equipment creating a 3:2 [3:1] lane split near Idaho Springs with a filled median;*
20. *traveler information links with the CSP [Colorado State Patrol] and commercial traffic reporting agencies;*
21. *digital AM, FM, or pager-based radio sub-carrier traffic message channels;*
22. *data and communications links to the CDOT-sponsored traffic operations center;*
23. *data and communications links with the CSP;*
24. *satellite or earth-based personal radio mayday systems; and*
25. *other potential ITS features identified during the needs assessment.*

The needs assessment will be summarized in a report format.

Deliverable: *Needs Assessment Report*

The Needs Assessment process for the I-70 Rural IVHS Corridor Planning and Feasibility Analysis enabled defmition and assessment to validate technological solutions for the I-70 West Corridor. Additionally, user needs were examined with respect to transportation and the institutional barriers that can deter implementation of ITS to solve system-wide and area-specific problems.

During activities for the Needs Assessment phase, numerous ITS solutions for potential implementation were scrutinized, based on:

- the user needs;
- the potential that each technology holds for inclusion in the evolving national architecture;
- data gathered from the Information Search task; and
- field surveys and stakeholder outreach processes.

Involvement by relevant stakeholders included:

- the CDOT ITS Program Office and Engineering and Planning Regions;
- the Colorado State Patrol;
- local governments;
- Colorado tourism and resort industry associations;
- economic development organizations and chambers of commerce;
- enforcement, safety, and emergency services districts;
- public transportation service providers;
- recreational/resort area representatives groups;
- broadcast and printed media organizations;
- a few local citizens and travelers; and
- private sector organizations and businesses.

The national ITS Planning Process, adopted by the FHWA, begins with problem formulation and system definition processes. During the initial planning phases, the FHWA guidelines call for an inventory of the existing transportation system to establish ITS composition and the composition of ITS subsystems, including all information pertaining to the available resources and the operating environments. The system definition can then be used to identify deficiencies and opportunities; to create a vision of the desired transportation system; and to develop a list of the functional and technological system requirements to achieve the envisioned system and begin the implementation process. The Needs Assessment fulfills these early planning activity guidelines.

The assessment of needs concentrated on the following system wide goals:

- safety measure applications;
- congestion reduction;
- mobility improvements;
- enhanced economic productivity;
- energy efficiency;
- environmental quality; and
- public image.

Focusing on the above goals, the evaluation of inventory of the existing technologies deployed within the Corridor, included:

- variable message signs (VMS);
- environmental sensors;
- highway advisory radio;
- microwave communication systems;
- cellular telephone antennas;
- automatic vehicle location systems; and
- ramp metering.

Aspects of the existing transportation system that emerged as potential areas for improvement opportunities included measures related to:

- weather/weather-related conditions;
- roadway conditions/symptoms;
- safety;
- information sources;
- communications;
- traveler mobility;
- organizational structure; and
- institutional barriers.

A thesis, prepared as a part of a graduate Master's degree program in Transportation Engineering at the University of Colorado at Denver, is appended to the Needs Assessment document. It compiles and reports on the results from databasing historical traffic volumes along I-70 (from permanent traffic counters located between Denver and Frisco) into a Geographic Information System (GIS). Spatial queries, made within the GIS, identify graphically, hot spot congestion times and link travel times.

The Needs Assessment presents the findings of a thorough feasibility analysis of several ITS technologies and applications considered for implementation. These technologies and applications are related to the following ITS features:

- VMS;
- sensor-actuated environment;
- cellular telephone;
- call boxes;
- corridor courtesy patrols;
- regional traffic operations centers;
- real-time traveler information;
- mass transportation;
- other intermodal ties;
- high occupancy vehicle infrastructure;
- incident management;
- roadway delineation;
- lane controls; and
- video surveillance.

The analysis and documentation focuses on the ability of each of the above ITS applications to respond to user needs throughout the I-70 West Corridor. It additionally addresses how technologies support various ITS user service functional requirements. Corresponding to the Action Team Review Groups organized for the I-70 Rural IVHS study, the ITS functional categories include:

- commercial vehicle operations;
- communication systems;
- data collection/aggregation;
- education/training;
- emergency response;
- enviromnentaVeconomic impact;
- institutional issues;
- public/private partnerships;
- public transportation/alternate modes;
- safety/warning;
- traffic management/operations; and
- traveler information.

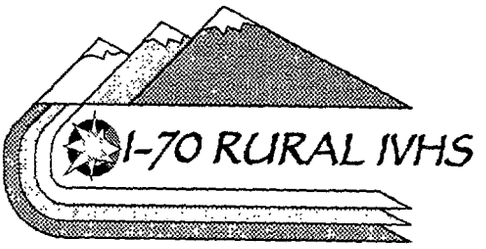
The technologies to support the functional areas are thoroughly described in the Information Search document. The specific application of those technologies to the transportation needs and problems within the I-70 West Corridor are evaluated in the Needs Assessment report.

Assessment of the institutional barriers associated with the development and operation of transportation systems within the I-70 West Corridor relied on an examination of the organizational structure of the agencies and organizations pertinent to implementation of an ITS program for the Corridor. The overview identifies the intra-agency and inter-agency program needs, and outlines the institutional barriers associated with each, including policy, financing, legislative, and cooperative matters.

The Needs Assessment explores the need for public/private partnerships for the I-70 West Corridor ITS implementation, with respect to cost/revenue-sharing, risk/liability, information exchange/ownership, policy/rules/regulations, and legislative action. Emphasis is placed on the assessment of the local, regional, intrastate, and interstate users needs.

Based on the technologies and institutional actions identified in this report, a wide range of projects and programs are identified in the Early Action Projects and Corridor Master Plan documentation. The recommendations in these reports reflect the solutions to specific transportation problems and needs, and not simply an application of advanced technologies just because they are available.

The Needs Assessment report evaluates the results of the Transportation Needs Survey, conducted to solicit perceived and real issues and problems identified by stakeholders within the I-70 West Corridor. The responses to the survey provide an overview of the prevailing expectations for transportation and level of knowledge of ITS, supporting development of the Business Plan and Marketing Strategy for implementation of ITS technologies in the Corridor.



CORRIDOR

MASTER PLAN

SECTION IV

EARLY ACTION PROJECTS SUMMARY

SECTION IV EARLY ACTION PROJECTS SUMMARY

OBJECTIVES

- *Identify Showcase Projects with Potential for High Public Acceptance and Low Cost Implementation*
- *Select 15 Top Priority Projects for Early Deployment*

PROCESS

- *Identify Problems/Needs Assess Current Operational/Maintenance Capabilities*
- *Match Technology Applications to Resolve Problems/ Address Needs*
- *Develop a Comprehensive Early Action Project Set*
- *Develop Criteria/Screen Global Project Set*
- *Distinguish Subsystem Parameters, Costs, Potential Partners, Implementation Schedule*
- *Prioritize/Select Top 15*

SOURCES

- *Study Steering Committee*
- *In-House and National Technical Experts*
- *ITS-America ARTS Technical Committee*
- *FHWA 's Rural ATIS Study*
- *MnDOT's Guidestar Rural Scoping Stua'y*
- *CDOT's C-Star Strategic Plan*

Scope: Prepare a list of early action items of IVHS technologies that clearly promise early success and relative ease of funding and implementation and for which there is no significant advantage in delaying implementation. The list shall be in report format.items in the list of early action items shall also be included in the Corridor Master Plan.

Deliverable: *Early Action items*

The Early Action Item task for the I-70 Rural IVHS study involved the definition of high-priority, cost-effective, and potentially highly-acceptable ITS projects to showcase and promote advanced technology application benefits to policy/decision-makers and the transportation system users. Eighty (80) projects were initially defined as potential actions. These were documented in an Early Action Projects Appendix to serve as a vision of what types of systems could be implemented within the I-70 West Corridor.

An Early Action Projects Executive Summary was developed, from the global project set described in the Appendix, to serve as a guidance document for initiating and deploying the 15 top priority Early Action Projects. These projects were identified as integral to immediately resolving a critical problem and/or addressing a high-priority transportation need within the I-70 West Corridor from Denver to Glenwood Springs.

One of the elements scoped in the contract for the I-70 Rural IVHS study required that early action items be identified and detailed prior to completion of the Corridor Master Plan. The Early Action Projects Executive Summary describes those projects. Based on new information, changes within the organizations, and emerging technologies, the top 15 Early Action Projects have been enhanced and augmented for their inclusion in the Corridor Master Plan.

The Early Action Project Executive Summary was developed as an early guide for CDOT and its potential public and private partners to identify and recommend feasible projects that each are willing to undertake. The effort has resulted in developing and deploying pivotal advanced technology application projects

that address predominant transportation problems and needs within the I-70 West Corridor from Denver to Glenwood Springs.

The recommended projects, identified in this Corridor Master Plan, are anticipated to be processed for funding in the Department's 1996 to 2000 5-year capital improvement plan. They have been submitted for incorporation into the STIP A corridor-wide agency outreach program was conducted to identify problems and needs associated with travel along the I-70 West Corridor from Denver to Glenwood Springs. Based on the input received, the 80 potential projects were defined to address each problem/need either individually or as a group. Each problem was described and evaluated for its resolution to the problem, its user benefit, and its approximate cost. Agencies that would participate in the development and deployment of each project were identified.

The agency input to the outreach program, in conjunction with the established goals and objectives for the study, was used to prioritize the suggested projects. The top 15 Early Action Projects were selected through a subjective ranking process based on 9 implementation goals established by the I-70 Rural IVHS Study Steering Committee as important to meet the goals and objectives established for the project. Those goals are:

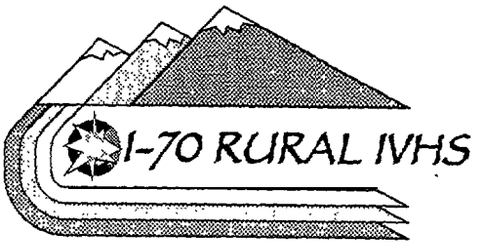
- enhance traveler mobility;
- increase safety;
- improve environmental quality;
- augment communications/user interface;
- high public/political acceptance;
- promote transit usage/improve transit service;
- encourage public/private sector involvement;
- innovative use of advanced technologies; and
- reinforce economic benefit.

As noted above, the ranking process was subjective, resulting in a "rough"' assignment of the most important projects recommended for deployment within the next 5 years. Each of the 15 projects have an enormous potential to benefit the users whom they are identified to serve. They each reflect a solution to a recurrent problem or essential need. Most will achieve significant public approval. All will provide a piece of the necessary foundation for future ITS applications within the I-70 Corridor.

The Top 15 Early Action Projects are:

- Voice/Data Communications Upgrades;
- Vail Super-HAR/VMS Program;
- Dumont/Downieville Automated Port of Entry;
- Summit Stage Transfer Center APTYATIS Operational Test;
- Incident Investigation Sites;

- Automated Reversible Lane Program;
- Mobile Emissions Testing Stations;
- Advanced Technology Roadway Delineation;
- Hot Spot Courtesy Patrols;
- High-Capacity Data Transmission Links;
- Corridor-Wide Call Box System;
- Tunnel Control Center Upgrades;
- Emergency Response Information Systems;
- Advanced Ice Detection Warning Systems; and
- Georgetown Gusty Wind Sensor/VMS System.



CORRIDOR

MASTER PLAN

SECTION V
USER SERVICE PLAN

SECTION V USER SERVICE PLAN

CORRIDOR USERS

During the Information Search process, a comprehensive outreach program was initiated to identify the realm of potential stakeholders and their respective concerns and needs with respect to transportation within the I-70 West Corridor. As a result of the investigation, the various stakeholders were categorized into the following major groups:

- General Travelers;
- Governmental Agencies;
- Transportation Service Providers;
- Public Service Organizations;
- Business Enterprises;
- Information Service Providers; and
- Special Interest Groups.

Major stakeholders are tabulated into stakeholder groups in Table V-l. The matrix maps those stakeholder groupings into the 12 ITS functional area interests for the I-70 West Corridor. It is anticipated that, as specific ITS programs and projects are developed, additional stakeholders will become interested.

PROBLEMS AND NEEDS

To assess the needs and concerns of the stakeholders, individual/group interviews, surveys, and meetings were conducted to determine key issues that surround travel, mobility and management of that mobility internal and external to the I-70 West Corridor. Collection of the respective perceptions and concerns provide the definition of transportation problems for the Corridor. Each transportation need and problem was aggregated into 17 problem statement categories. The problem statements were further assembled into early action (short-term), medium-term, and long-term priority levels as defined by the stakeholders through survey, interview, and meetings. Priorities were based on a majority opinion of the urgency when a particular problem statement should be addressed.

The needs and concerns are prioritized by degree of importance (a quantitative and qualitative summation of the number of notations of the problem and the relative severity, to a majority of the affected population, of the issue) in Table V-2. If a problem is relegated to a medium or long term priority, it does not mean it should not be addressed--only that other problems and needs necessitate earlier attention. For example, road closures are ranked as needing early action. It is almost unanimous by all stakeholders that this problem needs a good solution as quickly as possible. At the same time, the lack of existing alternate routes negates "alternative routing" as one road closure

solution. Development of alternate routes or modes of travel (such as commuter/passenger trains or high-speed rail lines) is, therefore, delegated to future (long-term) implementation when financing resources and ridership can be maximized.

Problems and needs have been characterized by the various stakeholders. To manage the interrelationships and specifics of the issues, they have been categorized and summarized in the following statements:

Limited Financial Resources. Most stakeholders believe that, with enough money, any problem can be solved. Unfortunately, each stakeholder believes some other stakeholder should take that responsibility, and none want to allocate more of their own resources to separately or jointly fund a resolution. This is not unique to transportation nor to the I-70 West Corridor.

Most taxpayers believe that they pay enough, if not too much, for existing transportation services and improvements. Local taxpayers, within the I-70 West Corridor, conclude that their taxes are spent on the Denver community, not them. Local municipal and county governments have indicated that they do not receive their fair share of state transportation fund allotments. The Colorado DOT's are hard pressed to stretch their annual operating budgets beyond needed roadway repair, improvement, and maintenance projects.

State legislators, under public scrutiny, must allocate resources to a variety of public services in addition to transportation. Increasing the state gasoline tax to fund additional roadway improvements is politically unpopular. The federal government is decentralizing--passing more responsibility to state transportation departments. Under the federal deficit, less money is distributed to state coffers.

Congestion. The I-70 West Corridor, between the Denver metropolitan area and Eagle County (Vail/Avon area), was frequently noted as having traffic congestion similar to urban area commute peaks. At the opposite end of the corridor, similar problems occur for daily commute trips in Eagle and Garfield Counties where resort and recreation area workers are housed. Because I-70 provides the link to roadways that serve other communities and tourism areas, and no continuous alternative routes are available, congestion impacts other roadway facilities and operations connected to the corridor (US 6, SH 119, US 40, SH 9, SH 13 1, SH 82).

Congestion is relatively predictable once an event occurs or a known peak travel period commences. It is recurrent in specific locations when high traffic volumes enter the system on winter weekends (late Friday afternoon and early Saturday morning inbound and late Sunday evening outbound) and during holidays year-round. It is recurrent during morning and evening commutes between Eagle, Glenwood Springs and Aspen. It can be recurrent at specific locations (Floyd Hill, Eisenhower Tunnel approaches, Vail Pass, Dowd Junction) due to adverse weather conditions along steep grades and sharp curves where travel speeds are reduced because of poor visibility, lane blockages (avalanche, accidents), and icy and snow-packed pavement. It can be predicted when necessary

roadway maintenance activities (resurfacing, restriping, shoulder work) slow or obstruct traffic flow. Each occurrence elicits a different reaction and perception by those involved.

The results of congestion are articulated as a disparate set of problems. For most users, congestion is inconvenient, untimely, and enormous in its impact. From a recreational traveler and commuter perspective (those with a definite destination within the corridor or the return trip out of the area), this congestion is translated to personal delay (loss of time) and frustration (there is always an urgency to achieve one's destination quickly). From a commercial vehicle operator's perspective, the congestion is translated to delay (loss of time, and therefore loss of revenue from late delivery of goods). From the operating agency perspective, the congestion creates additional public pressure to remedy a peak capacity problem for which there is no universally acceptable solution. From a local resident's perspective, the congestion inhibits personal mobility and reduces the pristine quality of life by contributing, otherwise absent, air and noise pollution. Conversely, from a local entrepreneurial perspective, there is missed opportunity to attract more consumers to purchase products or services.

Road Closures. Congestion is a nuisance; road closures are dire. Since road closures are not as frequent as congestion, it has a subsequent rank to congestion in the problem definition. Road closures most often occur during the snowy winter and spring run-off months. They are caused by obstructions blocking the road (wreckage, avalanche, rock and mud slides), impassable roadway surfaces (ice, snow, mud, boulders), or zero visibility (blizzards or white-outs). Road closures, although more predominant between the Hogback and Vail, can occur anywhere within the I-70 West Corridor (mudslides are frequent in the Glenwood Springs area).

Road closures affect all users. General travelers experience varying degrees of frustration and loss, depending whether they are on the road behind the closure or on the opposite side of their destination. Delay can be translated to money lost (additional expense for food, shelter, and other travel fees), as well as time. Safety becomes a consideration if a traveler is caught without the proper survival equipment in a rugged, isolated area.

Businesses either reap profits or suffer losses. Resort areas, hotels, and restaurants might gain additional revenue if customers are trapped for a longer stay. On the other hand, they may not get that business if their customers are kept away from the resort destination. During one relatively long closure of I-70 in the Spring of 1995, casino owners in Black Hawk and Central City were angry when Denver area customers assumed bad weather/road conditions affected all mountain areas. Many anticipated "garners" did not attempt to travel to the gaming areas, even thought those roads were clear. The resulting revenue losses to those destination towns was significant.

Someone or some thing must be blamed, and it's not usually the weather. The Colorado DOT bears the brunt of road closures, not only from intense public outcry, but from the manpower and resources that must be invested in clearing the obstruction to re-open the road. In the case of an accident, the

Colorado State Patrol and local emergency service providers must also invest significant resources to respond to life-threatening results.

No Alternate Routes. When congestion or a road closure occurs, there are, generally, no other routes where traffic can be diverted once it is within the corridor. Bypass routes take travelers hundreds of miles out of direction and can often be equally or more treacherous to travel, if not impassable.

Recurring Incidents at Known Locations. Because of terrain, roadway geometrics, drainage patterns, traffic volumes, and a host of other environmental factors, specific segments along the I-70 West Corridor are consistent "hot spots" for weather, roadway, and traffic-related problems. It is often easy to predict that, when a winter storm moves into the mountains, certain areas will become difficult to negotiate setting the stage for "an accident waiting to happen." Winter weekend and holiday traffic will clog the system is specific areas where speeds are slower to negotiate curves, grades, and tunnels. Even when weather and roadway conditions are good, driver inattention and inexperience traversing winding and/or steep roadway segments are consistently troublesome areas for loss of control and run-off road accidents.

Inadequate Communications Systems. Substandard communications equipment and services is a particularly demanding problem for facility operations, maintenance, and enforcement. Voice and data communications are inadequate to serve information gathering and dissemination and monitoring, reporting and enforcement needs by the public agency stakeholders. In addition to the lack of high-quality, reliable voice and data communication services and equipment, operations and maintenance crews have minimal electronic management tools to increase efficiency and effectiveness in their daily, as well as special event and emergency response, work processes.

Inefficient Management of Goods Movements. The I-70 West Corridor is one of the few regional east/west corridors for the trucking industry to transport goods. This industry helps maintain the economic stability of the entire nation. The inadequacies associated with difficult terrain, inadequate geometrics, and inclement weather are often better than alternate routes with respect to other potential adversities and travel distances. For the trucking industry, time is money.

From a transportation system management perspective, trucks do the most harm to roadway subgrades and surfaces. States, therefore, levy fees and taxes on commercial vehicle operators to help pay for roadway maintenance. States do not charge the same fees and taxes and apply the same regulations, creating barriers to trucking industry efficiency. Commercial vehicle operators do not always comply to the rules imposed by the states, so additional resources must be expended to enforce those regulations.

From both the State transportation and revenue department and trucking industry perspective, better management of goods movement is needed to streamline truck throughput, fee collection, and regulatory compliance and enforcement.

Limited Confidence in State Government Services. A common theme voiced by citizens and local governments within the I-70 West Corridor is a lack of confidence in the Colorado DOT. Some of the frustration stems from the very existence of the Interstate facility, marring, with its constant traffic the pristine setting of the Rocky Mountains. The local populace would prefer less traffic without adversely affecting their economic livelihood. Many believe that transportation improvements beget growth.

Local communities want a proactive voice in the decision-making and planning processes with respect to any improvements to the I-70 West Corridor. They also want innovative solutions to transportation problems--ones that take cars and trucks off the road.

Lack of Coordination/Cooperation. Inadequate communications and overlapping responsibilities and jurisdictions has been cited as a problem in all facets of inter- and intra-agency relationships. For example, with respect to incident and emergency management throughout the I-70 West Corridor, many organizations have overlapping authority to respond and often do not know if they or some other group is responsible. Within the I-70 West Corridor, and other rural areas, emergency response and medical actions are volunteer. The Colorado DOT, the Colorado State Patrol, county fire and law enforcement districts, municipal public works divisions, and local volunteers provide services for transportation-related incidents through uncoordinated dispatch and response actions. Each has indicated a desire for a systematic management plan that utilizes appropriate resources and brings efficiencies to each of their respective operations.

Agencies at the state, regional, and local levels have disparate opinions regarding transportation and often do not coordinate efforts. Irma-agency relationships are polite, but generally autonomous. Local publics and their elected representatives view transporation problems from a different perspective that lacks coordination with the responsible agencies.

Minimal coordination and cooperation among all stakeholders is a real institutional barrier.

Ineffective Information Dissemination. More reliable and accurate dissemination of information regarding road, weather, and traffic conditions can increase traveler responsibility for trip-making decisions, potentially alleviating many of the actions and incidents that create delays and reduce mobility. For example, if prevailing information can be provided before a trip is made, a traveler may delay the start or choose an alternative mode of travel. If advisory and advance warning information can be provided while a trip is in progress, it can inform the traveler of what to expect ahead and encourage that traveler to take appropriate and safe actions.

Collection of accurate and reliable raw data and processing of that data into an understandable format must precede dissemination of information to the public. Multiple methods and assorted equipment is needed to cost-effectively pass information to mass aggregations of the public.

Commercial Vehicle Use of the Corridor. Travelers and local communities perceive large trucks as the impetus of many congestion and road closure problems along the I-70 West Corridor. Big rigs are perceived, by many locals, as the most prevalent cause of accidents that result in road closures. These stakeholders believe that trucks cannot negotiate steep, icy grades, so the driver loses control, resulting in a rig jack-knifed across the entire travel way. Big rigs also travel too slowly up steep grades, impeding normal traffic flow. If the rig is speeding downhill, the driver may lose control or burn-up the brakes while trying to slow the weighty vehicle. Some commercial vehicles transport hazardous materials. If such a rig is involved in an accident, dangerous substances may spill onto the roadway and run-off into streams that provide drinking water to local communities. From the local perspective, commercial vehicles should be prohibited from using I-70.

Shortage of Transit Services. Many stakeholders assert that more mass transportation service will take automobile traffic off of the I-70 facility, thereby reducing congestion and weather-related accidents. It is believed that existing services are in short supply and additional services will attract more riders. Some stakeholders suggest that transit services be provided by other fixed guideway technologies to discourage travel of large buses on I-70. Large buses are generally perceived as causal factors to congestion, slow moving traffic, and air and noise pollution. Some stakeholders promote increasing shuttle (20-passenger vans or smaller) and carpool/ride-sharing services. Coordinating the various public transportation and private transit operations and schedules can optimize ridership.

Environmental Impacts. The costs of mobility to the natural environment are clearly a concern by stakeholders with interest in the I-70 West Corridor. The implications encompass a wide range of environment concerns. Air quality (non-attainment of ambient standards) and noise pollution from the increasing numbers of vehicles traveling the corridor; sanding and deicing chemicals that run off into waterways and percolate into groundwater; growth in resident and visiting populations that consume other natural resources and crowd a once sparsely-populated environment (quality of life issues); needed public services (local transportation options, education, health care) for a growing rural population; and economic and financial strains from both private enterprise and agency service perspectives are the prevalent environmentally-related issues.

Poorly Delineated/Maintained Travel Ways. Not isolated to the I-70 West Corridor, but more extreme and noticeable, freeze/thaw cycles and heavy vehicle loadings play havoc in maintaining safe travel ways. Common complaints about surface pavement conditions (rutting, cracks, potholes), inadequate shoulders and pullout areas, and lack of travel way delineation (striping, roadside reflectors, lighting) contribute to driver discomfort and frustration. From a maintenance standpoint, lack of resources (staff, money, time) are cited as impediments to maintaining the highest quality surface conditions. I-70 is conditioned to a standard that preserves reasonably safe travel.

Lack of Personal Travel Security. As with any rural corridor, long distances between populated areas and limited area-wide patrols can mean trouble to stranded motorists. Although not a constant concern the travelling public has indicated a need for a sense of security as they travel through the

isolated areas of the corridor. Knowing that contacts can be made and that help will be dispatched, if and when a traveler has problems, would provide that desired level of travel security.

Vehicular/Animal Conflicts. Although "road kill" incidents are more controlled along I-70 in known animal migration areas with roadside fencing, animals entering the roadway are still a tremendous problem in other areas and on other roadway facilities. Not only do such accidents inflict personal injury and property damage, but resources must be diverted to emergency response, medical attention, clearing of travel ways, and carcass removal. Agency equipment and manpower allocation costs are problems, particularly during known migration periods in the spring and fall.

Driving Inexperience/Excessive Speeds. The agencies responsible for transportation and enforcement cite driving inexperience in adverse weather conditions and mountainous terrain and excessive speeds as major contributors to the resulting trasnportztion problems throughout the I-70 West Corridor. These two causal factors induce most accidents that result in traffic back-ups and road closures which, in turn, require additional resources to respond, manage, and maintain isolated incidents.

ITS National Program Plan Integration

In accordance with the ITS National Program Plan (NPP), the User Service Plan focuses on known transportation problems and issues within the I-70 West Corridor, applicable to this rural setting. The term "user" refers to the general traveler, commercial vehicle and mass transportation operators, public agencies, and local communities and businesses as the primary benefactors within the I-70 West Corridor transportation network.

Currently, 29 User Services have been defined as part of the national program planning process. (A 30th User Service, Protection at Railroad Crossing is in the developmental stage.) It is not intended that this set of User Services remain fixed for any length of time, rather, the set is expected to evolve significantly as public and private sector perception of ITS advances. The NPP User Services provide a framework for defining specific User Services for the I-70 West Corridor, founded on the definition of problems and needs and the resulting User Services Objectives.

ITS User Services are comprised of multiple technological elements which perform a variety of functions, that are not unique to any particular service. Different User Services may require some of the same functions and technologies; allowing cost-sharing opportunities across certain deployment scenarios. Consequently, User Services are often strategically deployed in combination with other services that share common technology or functionality.

Based on such commonalities, and institutional perspectives, the NPP groups User Services into User Service bundles, in an effort to induce User Service integration opportunities. The User Service bundles may be selectively deployed in any combination. The User Services and User Service bundles are shown in Table V-3.

User Services for the I-70 West Corridor were developed to provide a framework for implementation of ITS services to address the known transportation-related problems and concerns. Where other services were needed, but not defined through the National Program Plan, they were developed specifically to meet the needs within this rural, recreational corridor.

For each I-70 West Corridor User Service, the User Service Plan identifies the user need that the service is designed to meet, how it relates to the established User Service objectives, any known implementation impediments, and an estimate of the potential costs and benefits. Rather than dictating a specific project deployment, the User Service Plan presents a conceptual vision of how each User Service should function within the corridor. It describes potential technologies that can be deployed for each service, as well as alternative deployment scenarios.

The User Service Plan does not attempt to imply a system architecture or define implementation policy. Instead the Plan lends itself to compatibility with national, regional, and statewide long-range plans, consistent with the framework of the evolving national ITS architecture and standards.

FUNCTIONL AREAS

The I-70 Rural IVHS Corridor Planning and Feasibility Analysis began prior to the final development of the ITS NPP development (and resulting User Service categorization). To proceed with the I-70 West Corridor ITS implementation planning process, and to adhere to the developing program plan guidelines in the absence of nationally-accepted User Service definitions, 12 functional areas were established specifically for the Corridor.

The relationship between the I-70 West Corridor functional areas and the recently-defined National Program Plan User Services is matrixed in Table V-4. The relationship between the functional areas and the User Service bundles is matrixed similarly in Table V-5.

Corresponding to the Action Team Review Groups organized for the I-70 Rural IVHS study, the following interrelated functional areas represent the User Services planned for the I-70 Corridor ITS:

Commercial Vehicle Operations. Services that increase productivity; reduce risk of commercial vehicle crashes; reduce costs; and ease restrictions in compliance with safety regulations will help create safer travel corridors; lower shipping costs; and better efficiency of commercial vehicle operations (CVO). Advanced CVO applications can contribute to seamless border crossings, safe transport of hazardous materials, vehicle tracking, and information dissemination to the driver, as well as regulatory agencies, regarding size, weight, and vehicle condition. ITS applications to CVO can include:

- automated roadside safety inspection;
- electronic purchase of credentials;

- automated mileage and fuel reporting and auditing;
- on-board safety monitoring;
- real-time communications; and
- electronic payment services.

Communication Systems. Communication systems are a combination of facilities, stations, and electronic circuits that transfer information through wireline and wireless communications media. Collection and dissemination of information relies on communications systems to send raw data for processing and to transmit reliable information to the end user. Enhanced voice, video, and data transmission links will allow more efficient use of the transportation network by providing the means for the information exchange necessary to better inform system users of corridor conditions and to support transportation system operations.

Wide-area communication systems, and localized roadside communication capabilities, that provide information links to and from the transportation infrastructure can be used to provide driver advisories and input for probe reporting. Communication links within the transportation infrastructure that interconnect field devices, traffic operation centers, and supporting agencies and organizations are necessary to support freeway traffic management systems. Vehicle-to-vehicle communication systems can be used to provide vehicle coordination operations for safety and warning systems, and to implement long-range automated highway systems.

Data Collection/Aggregation**.** Data collection includes all hardware and software functions necessary for the collection, management, and quality control of all historical and real-time data pertaining to ITS, such as data used for routing, scheduling, traffic prediction, control strategies, and incident management. Data collection also includes all in-vehicle, roadside, and central computer processing, data fusion techniques, and computer algorithms which are used for navigation and for making traffic management decisions.

Aggregation of data is accomplished at a central facility so that appropriate information can be disseminated to travelers via kiosks, signs, and in-vehicle systems as well as to operating agencies and service providers. Data aggregation includes all software and hardware to collect, categorize, and separate data from sources for processing and distribution to information centers, roadside systems, and in-vehicle systems.

Education/Training**.** Successful implementation of ITS requires the education and training of a variety of stakeholders, to launch a paradigm shift in traditional planning procedures for future transportation needs. An educational program would increase understanding of ITS technologies and services, improve awareness of potential for return on investment, foster interest in, and promotion of, ITS within agencies from planning through design and construction to operations and maintenance. Program guidelines, for team-building and partnering techniques would enable each agency to continue to build internal acceptance of ITS.

A wide range of familiarity and levels of skepticism exist among the I-70 corridor stakeholders, particularly among the rural staff members. The educational program must be tailored for each specific audience, including the transportation consumer, academia, the trucking community, elected and appointed officials, and public transportation officials in the disciplines of design, administration, planning, operations, and maintenance.

As advanced technology applications are implemented, public agency staff members will need training to understand, operate, and maintain new systems. Training program guidelines will outline how staff members can be retrained and cross-trained, how that training will proceed, and how the learning curve will affect when a particular system can become fully operational.

Emergency Response. An improved ability to expedite response to emergencies by emergency service providers, such as law enforcement, rescue, fire, and hazardous material clean-up services, would decrease incident-related congestion, reduce property damage, and save lives. Emergency notification systems can reduce the time it takes to contact the appropriate personnel and initiate response. Emergency vehicle management systems which semi-automate dispatch operations, route guidance systems, and signal priority systems are all emergency response services that focus on reducing the time it takes, after notification, for emergency vehicles to arrive at the scene of an incident.

Emergency response applications can include:

driver and personal security systems;
automated collision notification; and
hazardous materials incident notification.

Coordination between the Colorado State Patrol, CDOT maintenance crews, local police and fire districts, emergency medical teams, hospitals, and other response teams,, to assist travelers with breakdowns, provide emergency medical services, and clear accidents, will be paramount.

Environmental/Economic Impact. In general, ITS technologies hold the potential to improve the environment by reducing vehicle emissions, decreasing the amount of wasted fuel, and decreasing noise pollution. In particular, advanced vehicle emissions monitoring and testing can be used to improve air quality within the I-70 Corridor. Monitoring emission levels would provide data that can be used for pseudo-real-time vehicle routing systems for pollution mitigation, and for traffic prediction and demand management systems. On-board and roadside testing systems could be interfaced with driver information systems that alert vehicle operators that are in violation of pollutant emission standards.

ITS applications, such as intelligent rest areas and information centers, and multi-modal transit/transfer facilities, can precipitate regional travelers into rural communities to use local services. Local involvement can create economic development opportunities. High-occupancy

vehicle lanes, ramp metering, and advanced communications systems can contribute to the flow and distribution of travelers to help support local policies and activities.

Institutional Issues. Institutional issues are those administrative and organizational rules, regulations, and procedures that affect how public agencies can conduct business. This functional area includes strategies to mitigate institutional barriers within existing legislation and policy that may prevent certain ITS activities and/or programs from being realized, and build inter-agency coordination.

Some examples of institutional issues that can affect ITS deployment include:

- use of public right-of-way by the private sector;
- sole-source working relationships between a public agency and a for-profit organization;
- the competitive bid process;
- equipment procurement by more than one agency;
- intra- and inter-agency cooperative programs (public-public partnering);
- intra- and inter-agency communications;
- governmental monitoring and regulation of commercial vehicle operations;
- invading general public privacy through use of monitoring and surveillance systems;
- design/build contracting;
- private sector operating of government-owned systems (privatization); and
- advertising on governmentally-controlled equipment and property.

Public/Private Partnerships. Public/private partnerships are those potential associations where private sector businesses join forces with the CDOT and/or other local transportation agencies to help design, finance, implement, construct, operate, and/or maintain the infrastructure that supports proposed ITS applications. Generally, private sector partnering opportunities offer benefits in the form of technical expertise, marketing experience, and the potential to reduce funding requirements.

Financial support, and/or shared use of rights-of-way, to construct and equip the transportation infrastructure in return for the advertising of a product or service is a public/private partnership opportunity envisioned for I-70 West Corridor implementation. The installation of hardware to collect and use information that can be sold to the public is another typical example of a potential public/private partnership application.

Public Transportation/Alternate Modes. Enhancing the efficiency, convenience, cost effectiveness, safety, and security of transit/bicycle/pedestrian systems can encourage single-occupancy vehicle devotees to alternate mode use, potentially reducing traffic congestion and environmental impacts. The public transportation/alternate modes category includes public transit in fixed route, route deviation, and demand-responsive modes and services operated by smart buses, high speed mass transit, commuter rail, car-pool, and private and non-profit vehicle fleets.

En-route information systems at multi-modal facilities, advanced intersection traffic control systems, automated fare payment systems, and public transportation management systems that automate operations, planning, and management functions, are all applications aimed to improve traveler efficiency and mobility within the transit system. Carpool, dynamic rideshare, personalized public transit, and intelligent bicycle/recreational trails are services that can support traveler flexibility, making public transportation and alternate travel modes more appealing.

Safety/Warning. This functional area includes advanced technologies and systems that provide warnings about driver, vehicle, cargo, infrastructure, and environmental safety. By monitoring conditions, appropriate warning information can be transmitted to system users. Safety monitoring and warning systems provide critical information that can reduce the number and severity of collisions caused by impaired drivers, vehicle component failures, and degraded infrastructure conditions.

Traveler safety and security systems, and MAYDAY transmissions can be integrated with incident management and emergency response functions. Law enforcement officials could read the safety status of in-motion vehicles equipped with on-board safety monitoring systems as part of automated roadside safety services and electronic clearance CVO services. Other safety/warning applications can include:

- impaired driver warning and control override;
- vehicle condition warning;
- in-vehicle infrastructure condition warning;
- vision enhancement for crash avoidance;
- longitudinal/lateral collision avoidance; and
- automated pre-crash restraints (belts, air bags, rollbars).

Traffic Management/Operations. Traffic management and operations applications include all systems that reduce congestion, improve mobility, and increase safety by incorporating changes to the roadway infrastructure and/or operational characteristics. Traffic management functions also include coordination requirements between traffic operation centers, the Colorado State Patrol, and other agencies across the multiple jurisdictions within the corridor.

Traffic management services include incident management, demand management, network monitoring, traffic control, parking management, and construction management systems. Each system uses a central processing system to process data obtained from field devices, and to generate the necessary information to inform motorists, and to control traffic flow. Other examples of traffic management and operations applications include:

Transportation Demand Management (TDM) techniques to encourage non-peak period travel (demand education through congestion pricing);
identifying and improving alternative routes;

- creating reversible lane configurations during peak periods;
- incorporating HOV/bus lanes into roadway cross-section;
- adding new facilities; and
- improved methods and algorithms for signal, ramp metering, and sign control.

Traveler Information. The traveler information functional area encompasses the traveler interface services and technologies that provide information to the traveling public, in order to help travelers make informed decisions. Traveler information functions also include the development of marketing programs to determine the type, extent, and quality of information needed to attract travelers to using information services such as roadside kiosks and intelligent rest areas.

Information on road and weather conditions, heavy traffic volumes, roadway incidents, and skiing, gaming, and tourist information can be disseminated to the traveling public via television, personal computer, telephone, and radio receiver to information centers, signs, and in-vehicle communication devices. Schedule, fare, and routing information can be used for pre-trip planning and for en-route decision-making to ensure best-route, and best-mode trips.

Infrastructure, roadside, and in-vehicle traveler information applications can include:

- roadside kiosks;
- intelligent rest areas;
- highway advisory radio;
- variable message signs;
- in-vehicle navigation and route guidance systems;
- road/vehicle communications;
- electronic "yellow pages"; and
- links with tourist/recreation facilities.

CORRIDOR-SPECIFIC GOALS AND OBJECTIVES

The ITS NPP discusses the importance of establishing a set of objectives to help decide what User Service applications to provide. It is also important to define the overall direction that addresses transportation problems and needs within the I-70 West Corridor through the application of ITS technologies. The development of goals and objectives leads to the establishment of "candidate actions"--those generic activities that define what ITS can do to accomplish prescribed goals and objectives. The resulting ITS User Services are formulated and described to carry out the candidate actions. The candidate actions address the User Service Objectives.

Based on the implementation goals established by the I-70 Rural IVHS Study Steering Committee, to meet the regional needs of the Corridor in the short-, medium-, and long-term, the following User Service Goals, related to the overall definition of problems and needs, are:

- enhance traveler mobility;
- increase safety;
- improve environmental quality;
- augment communications/user interface;
- encourage high public/policy-level acceptance and positive perceptions;
- promote transit usage/improve transit service;
- stimulate public/private sector investment;
- use existing advanced technologies in innovative ways; and
- reinforce the economic benefits of transportation.

For clarity, these overall User Service Goals are mapped to the I-70 West Corridor ITS functional areas and National Program Plan User Service Bundles in Table V-6 and Table V-7, respectively.

Through the corridor-wide stakeholder outreach program conducted to identify needs and concerns associated with travel and operations along the I-70 West Corridor, global User Service Objectives were developed to relate causal factors to the problems and needs. The objectives include:

- increasing operational capacity;
- reducing delays;
- reducing peak period vehicular demand;
- reducing accident frequency and severity;
- reducing emergency response times;
- developing better access;
- augmenting transit/bicycle/pedestrian facilities, services, and accessibility;
- strengthening management/oversight of commercial vehicle operations;
- developing incident and congestion management strategies;
- leveraging funding sources;
- identifying and committing investment partners;
- capturing economic benefits;
- developing multi-modal opportunities;
- creating "competitive" travel times/modes;
- reducing vehicle emissions;
- gathering, processing, and disseminating reliable weather/road/traffic condition data;
- monitoring hazardous materials transport/overheight & overweight commercial vehicles;
- advancing traffic operations management and control;
- evaluating and improving current processes and regulations;
- creating and supporting a cooperative working environment (team work/partnering/quality improvement philosophies);
- educating all stakeholders;
- reducing unnecessary trip-making; and
- developing new staff capabilities (training/hiring specialists).

Within the I-70 West Corridor ITS functional areas, the User Service Goals and Objectives are expected to promote significant user benefits. Benefits have been identified as follows:

- Commercial Vehicle Operations:
  + improve highway safety;
  + improve service levels and mobility;
  + reduce energy and environmental impact; and
  + enhance productivity.

- Communication Systems:
  + provide reliable information links;
  + upgrade existing communication capabilities;
  + enhance efficiency of communications;
  + enhance data sharing; and
  + reduce implementation and operation costs.

- Data Collection/Aggregation:
  + provide reliable data collection and processing.

– Education/Training:
  + increase public/private awareness;
  + improve public/private understanding; and
  + build public/private acceptance.

- Emergency Response:
  + enhance safety;
  + reduce severity of accidents;
  + eliminatesecondary crashes; and
  + reduce public service costs.

- Environmental Economic Impact:
  + reduce vehicle emissions;
  + reduce wasted fuel; and
  + improve air quality.

- Institutional Issues:
  + build inter-agency coordination;
  + ensure inter-jurisdictional cooperation; and
  + establish high public/private acceptance.

- Public/Private Partnerships:
  + reduce public risk,

+ enhance project revenue; and
+ improve development and operations efficiency.

- Public Transportation/Alternate Modes:
  + enhance multi-modal services;
  + reduce congestion;
  + improve environmental quality; and
  + enhance traveler flexibility and mobility.

- Safety/Warning Systems:
  + reduce accidents and fatalities; and
  + secure traveler peace of mind.

- Traffic Management/Operations:
  + reduce energy consumption;
  + improve safety;
  + increase efficiency;
  + enhance productivity; and
  + enhance mobility.

- Traveler Information Systems:
  + inform travelers;
  + reduce congestion;
  + decrease fuel waste;
  + enhance traveler convenience; and
  + improve safety.

ITS Candidate Actions

ITS Candidate Actions relate the User Service Objectives to the problems and needs, taking advantage of current and emerging technologies to satisfy corridor-wide transportation goals. The agency input to the outreach program, in conjunction with the established goals and objectives for the study, was used to identify the initial Candidate Actions, categorized by functional area:

- Commercial Vehicle Operations: .
  - automate the DumontLDownieville Port of Entry;
  - upgrade Eisenhower Tunnel overheight vehicle detection systems; and
  - integrate multi-state one-stop shopping program into CVO surveillance/enforcement systems throughout the l-70 West Corridor.

- Communication Systems:
  - upgrade voice and data communications between CDOT and CSP facilities within the I-70 West Corridor. Existing telephone equipment and land lines are unreliable, old, and dysfunctional;
  - create a cellular reporting program; and
  - develop traffic message channels.

- Data Collection/Aggregation:
  - upgrade computer equipment to provide improved automatic message handling of the new and existing message signs along the corridor; and
  - develop data fusion algorithms for multiple applications at the traffic operations centers.

- Education/Training:
  - develop an educational program to "sell" ITS and its potential benefits to all stakeholders;
  - create a corridor-wide public acceptance program to tiorm local interests about current developments and actions by CDOT;
  - establish in-house programs to cross-train existing staff in ITS operations and maintenance functions; and
  - extend the CDOT ITS Implementation Team program to include other public and private sector organizations.

- Emergency Response:
  - implement privately-operated Courtesy Patrols at high-incident locations;
  - construct alternative service roads for emergency access; and
  - automate answering/dispatch system to coordinate regional emergency/incident response.

- Environmental/Economic Impact:
  - place mobile emissions testing stations and advisory signage at known high-pollution locations within the corridor;
  - implement voluntary retrofit of fleet vehicles to alternative fuel systems for government agencies and private sector operations; and
  - establish a coalition of governments and businesses for exchange of economic development strategies.

- Institutional Issues:
  - encourage proactive legislative/organizational change campaigns that identify positive changes to promote technological advances and improve the I-70 Corridor transportation system.

- Public/Private Partnerships:
  - implement high capacity transmission systems through joint rights-of-way use.

✓ Public Transportation/Alternate Modes:

-design and deploy a multi-modal transfer center in the Frisco area to test and evaluate integration of advanced public transportation systems with advanced traveler information systems, to accommodate regional trips along I-70. A similar multi-modal transit center can be established near the Vail/Gypsum area;

-enhance the Hogback multi-modal transfer center concept (at an acceptable location) to provide improved public transportation services and adjacent roadway traffic operations;

- establish a multi-modal/rideshare facility adjacent to the Morrison interchange that provides real-time road condition data, transit schedules, and weather information;

-automate tracking of public transportation and private transit system fleets for schedule adherence and operations management; and

-provide two-way data exchange links and in-vehicle sensor systems for private transit shuttles to serve as probes throughout the corridor.

✓ Safety/Warning Systems:

- construct pull-outs at known high-incident locations throughout the I-70 West Corridor, with emergency call boxes, automatic entrance gates and signage, and security systems;
- retrofit lighting and reflective coatings for both bores of the Twin Tunnels and install roadside lighted guidance systems at poorly delineated segments of the travel way to reduce accidents and increase safety;
- install emergency call boxes throughout the corridor;
- sensor-actuate the corridor with environmental warning and predictive systems for ice, snow, and high winds at numerous locations along the corridor, including Dowds Junction, Vail Pass, Floyd Hill, and Glenwood Canyon;
- develop and instrument roadside areas with automatic avalanche and rock/mud slide warning systems at hazardous locations;
- implement in-vehicle MAYDAY systems;
- design a sanding/storm water runoff sensor system near Straight Creek;
- develop excessive speed warning systems; and
- manufacture and install animal alert warning systems at high incident locations.

- Traffic Management/Operations:

- automate the Eisenhower Tunnel 3: 1 area lane split operation;
- extend the Eisenhower Tunnel 3: 1 area lane split operation to the Twin Tunnels area;
- upgrade existing tunnel control centers (Hanging Lake and Eisenhower) to serve as regional ITS TOC hubs;
- dedicate high occupancy and/or slow-moving vehicle lanes and ramps, equipped with automated entry/exit controls, at locations where future congestion levels may warrant widening the corridor;
- instrument Twin Tunnels and approaches, Genesee to Morrison exit, Dowds Junction, Vail Pass, and Floyd Hill with remote video surveillance equipment to improve incident detection and response;

+ outfit vehicles as probes with two-way communications and sensor equipment to improve data collection, surveillance, and information dissemination between regional TOCs;
+ develop regional congestions/incident management plans for recurrent/non-recurrent events linked to computerized applications at TOCs for plan selection and implementation;
+ identify ramp toll collection systems for peak period travel in high-congestion locations; and
+ automate surveillance/enforcement systems for peak period travel restrictions.

- Traveler Information Systems:
  - -locate highway advisory radio and variable message sign traveler information systems for Vail area and the heavily traveled approaches. Additional variable message signs on I-70, in advance of Loveland Pass, Floyd Hill, Dowds Junction, and the Vail Pass. Portable variable message signs and highway advisory radio stations throughout the corridor can be used for incident management.
  - -establish real-time traveler information kiosks and live broadcasts to public and private facilities (other than CDOT owned/operated);
  - -design and construct intelligent rest stops throughout the corridor;
  - -sell or trade road, traffic, and weather information to the media and privately-supported information kiosk providers at airports and ski areas;
  - -design intelligent bicycle systems; and
  - -establish a transit referral service hotline for local public transportation service and private shuttle operations serving the corridor.

Table V-8 tabulates problems and needs, goals, objectives, and candidate actions to show interrelationships; establish the direction in which ITS can resolve transportation problems; and provide the framework for the development and implementation of ITS strategies.

USER SERVICES

The I-70 Rural IVHS Corridor Planning and Feasibility Analysis project was implemented prior to the development of the NPP User Services. The Functional Areas established for the I-70 West Corridor ITS development are essentially the corridor-specific User Services. To maintain integration of state-wide ITS initiatives, Table V-9 maps the problems and needs and candidate actions to the NPP User Services. This will ensure that recommendations and projects for this study correlate to all current and future state-wide ITS programming, the Smart Path program, and incorporation of ITS projects into the Statewide Transportation Improvement Program.

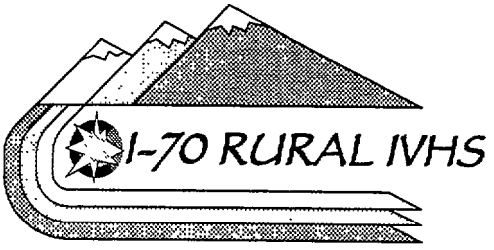
Implementation of the Functional Areas/User Services will occur through the development, design, and deployment of the short (early action), medium, and long-term project recommendations within

this Corridor Master Plan. Other initiatives already or currently being undertaken, and others that will be identified as emerging and new technology applications are tested and perfected. Section VII identifies implementation strategies for recommended and proposed projects. Existing and planned systems can serve as "vehicles" to accelerate early action projects, key to initiating the Functional Areas/User Services for the corridor. These include:

- Eisenhower and Hanging Lake Tunnel operations centers;
- ✓VMS, call box, sensor, and weather station infrastructure;
- cellular, microwave, and fiber telecommunications infrastructure;
- multi-state CVO one-stop shopping program;
- MAYDAY, emissions testing, am broadcast (HERALD) operational tests;
- avalanche detection research and
- variety of touch-screen static traveler information systems.

The private sector is continuing to develop tools and install infrastructure that can be used to accelerate implementation of various Functional Areas/User Services. In-vehicle devices, transportation management and traveler services information software, and artificial intelligence and neural networks will support earlier and more complex deployments.

Other potential improvements to the I-70 West Corridor (high speed rail, light rail, and commuter rail systems; adding lanes for capacity) are not considered as ITS applications. Where ITS technologies can enhance the functionality of such systems (if they become a recommended major investment for the corridor), they should be integrated into those plans.



CORRIDOR

MASTER PLAN

SECTION VI

PROGRAM DEVELOPMENT AND EVALUATION

SECTION VI PROGRAM DEVELOPMENT AND EVALUATION

PERFORMANCE CRITERIA

In order to measure the success of the I-70 West Corridor ITS to satisfy the User Service objectives, criteria have been established by which recommended system performance can be evaluated. The performance criteria are comprised of quantitative and qualitative measurements to indicate how well the functional requirements can satisfy identified system needs. Corridor-specific criteria relate back to the implementation goals set by the 1-70 Rural IVHS study Steering Committee.

System-Wide

System-wide performance criteria establish the measures by which an integrated, corridor-wide ITS architecture will address the functional requirements. They include:

- Quantifiable Appraisals:
  - + travel time
  - + fuel consumption
  - + energy usage
  - + vehicle occupancy rates
  - + emission rates
  - + accident rates
  - + transit usage rates
  - + transit service reliability
  - + economic stimuli
  - + public investment
  - + private investment
  - + capital costs
  - + operating costs
  - + maintenance costs
  - + traffic counts

- Qualitative Appraisals:
  - + user attitude
  - + public reaction
  - + political will

Project-Specific

Project-specific performance criteria establish categories for measuring how individual projects will meet user needs. They include:

- ✓ enhance traveler mobility;
- ✓ increase safety;
- ✓ improve environmental quality;
- ✓ augment communications/user interface;
- ✓ high public/political acceptance;
- ✓ promote transit usage/improve transit service;
- ✓ encourage public/private sector involvement;
- ✓ innovative use of advanced technologies; and
- ✓ reinforce economic benefit.

Each project considered for implementation was judged based on a tailored version of the above performance criteria. The appropriate criteria used to measure a project's success depends on the User Services provided, and the objectives of the agency(ies) responsible for implementation.

SYSTEM ATTRIBUTES / FUNCTIONS

The inherent characteristics of the system are driven by the specific functions that will be performed by the system, the information flow, information processing, staffing, and other requirements necessary to fulfill the system needs. For each functional requirement, the underlying system attributes required to achieve the specific activities related to executing the function, at the desired level of operation, are defined through an iterative process. Commonalities between the User Services, revealed during the process of identifying functional requirements, influence the system architecture development and technology screening processes; and in return, feedback from the system architecture development and technology screening processes affect the system attribute definitions and functionality requirements.

The system attributes needed to support the functional requirements of I-70 West Corridor ITS include:

Communications. Most activities involve the transmission of information to support a particular function. Each activity will produce unique types of information, both vital and non-vital. In defining the supporting communication subsystems, it is important to know the formats of information (voice, data, or video); how often and how fast information must be sent (capacity/bandwidth); and the origination and destination of data "traffic" (topology).

The need exists to improve high-capacity communications within the I-70 West Corridor that strengthens inter-agency coordination and information dissemination services. Specifically, a communications infrastructure is needed to interconnect the statewide and regional traffic management centers, in order to facilitate coordination between the various operating agencies and supporting organizations, and to collect data from field devices.

Information Flow/Processing. Within the overall system, information is exchanged among the various subsystems, and information is process&d and reprocessed through multiple iterations. Databases and computer algorithms will be shared and/or linked between multiple subsystems and functions. These information flow/processing system attributes are defined through an analysis of the interaction between subsystem activities and system-wide information flow and processing.

Data processing will take place at each traffic management center. Supervisory computer systems will be provided for each major subsystem, to control the data collection, processing, and follow-on activities. The system operating software for each computer system will manage the information flow between subsystems, monitor the systems for failed components or links, and provide a fiiendly operator interface for human control and override of the automatic systems.

Support Requirements. Staffing and training requirements for operations and maintenance of the subsystems is highly dependent on the specific deployment scenarios implemented. The level of support needed and the functions within the system where that support is needed, will become increasingly evident as the system architecture matures. The philosophy and policies of the implementing agencies will dictate a majority of the support requirements.

The system attributes are formulated to support the functional requirements of the I-70 West Corridor ITS. The specific activities/functions that the various subsystems will perform relate back to the functional areas, also referred to as the I-70 West Corridor ITS User Services. These include:

- commercial vehicle operations;
- communication systems;
- data collection/aggregation;
- education/training;
- emergency response;
- environmental/economic impact;
- institutional issues;
- public/private partnerships;
- public transportation/alternate modes;
- safety/warning systems;
- traffic management/operations; and
- traveler information systems.

SYSTEM ARCHITECTURE

A system architecture provides the framework around which detailed technologies and interfaces can be specified. The system architecture identifies where, within the overall system, various subsystem activities and functions take place. It defines the interaction between these ITS subsystems.

There are three basic "organizational" architectures that were examined as candidates for the I-70 West Corridor ITS: centralized, decentralized, and hybrid. These candidate system architectures were evaluated for their compatibility with existing systems already deployed and planned for the corridor and their ability to fulfill the necessary requirements of future systems. They were also reviewed in comparison to the expectations of the operating agencies--retaining autonomy while having redundancy and back-up support during system failures and staffing shortages.

To arrive at the optimal architecture for the I-70 West Corridor, a narrowing in on existing ITS components and fragmented architectures, allowed resolution of subsystem functions and compatibility. Future architecture requirements were advanced so that candidate architecture elements and components could be further examined and evaluated. Correlation with the conceptual distributed architecture, where individual processing centers can interconnect through an ITI network, allowed further refinement to arrive at a consistent and interoperable framework. As a

result of this iterative development and evaluation process, a proposed system architecture was conceived for the I-70 West Corridor ITS.

Existing ITS Components. The I-70 West Corridor has an existing, albeit fragmented, ITS architecture comprised of subsystems and services, infrastructure, and traffic operations centers within the corridor. The I-70 Rural IVHS information search task documentation (Information Search Memorandum) specifies in greater detail these existing components.

CDOT and CSP are currently operating ITS components and providing services throughout the corridor. These services include systems for remote call-in, traveler information advisories, commercial vehicle management (Eisenhower Tunnel), weather/road condition detection, dynamic truck speed warning, icy road warning (static signs with automatically activated flashers) and computer-aided dispatch for incident response. The existing infrastructure throughout the corridor includes various devices: vehicle detectors including inductive loops, CCTV, over height and weigh-in-motion detectors; variable message and speed signs; highway advisory radio; environmental pavement sensors and weather stations; radio and cellular call boxes; and communications links including land lines, microwave, cellular, and fiber optics.

Five existing traffic operations and communications centers provide traffic, information dissemination, and emergency response management functions within the corridor at the Hanging Lake Tunnel in Region 3, the Eisenhower Tunnel in Region 1, the interim TOC in Lakewood, and the CSP Computer-Aided Dispatch (CAD) services in Lakewood and Eagle. The Hanging Lake and Eisenhower TOCs currently operate ITS functions throughout the tunnels. The Interim TOC in Lakewood provides a variety of statewide information dissemination services and is currently operating and enhancing the variable signage for the eastern half of the I-70 West Corridor for Region 1. CSP operates the computer-aided dispatch system from headquarters in Lakewood, with communications links to the Eagle center via land lines.

Architecture Requirements. The system architecture for the I-70 West Corridor must meet the following requirements to be consistent and interconnected with local, regional, and national, as well as corridor-unique functionality:

- The system architecture should support coordinated corridor-wide ITS.
- The system architecture should attempt to utilize the existing ITS components and architecture currently in place.
- The system architecture should allow the various agencies and organizations to effortlessly share information and coordinate common transportation activities on the local, regional, state, and national levels. This information also needs to made available to the public. The following agencies and organizations should be interconnected to allow for this information exchange:

  + FHWA (Colorado Division and Region 8);

- ✢ CDOT Engineering Regions (headquarter offices, Hanging Lake and Eisenhower tunnel complexes);
- ✢ CDOT iTOC and future C-TMC;
- ✢ CSP;
- ✢ Local City and County Governments;
- ✢ Local Law Enforcement;
- ✢ Fire/Rescue Districts;
- ✢ Regional Transit Service Offices;
- ✢ Commercial Traffic Reporting Services (Metro Traffic Control);
- ✢ Media (television, radio);
- ✢ Emergency Service Providers (paramedics, ambulance, hospitals);
- ✢ Authorized Private Towing Services; and
- ✢ Colorado Incident Management Coalition (CIMC).

- The system architecture should be, to the greatest extent possible, automated, to avoid additional staffing and space requirements at existing regional control centers (Eisenhower and Hanging Lake).
- The system architecture should be developed with an "open" configuration to ensure national compatibility over the long term, accommodate future connections, encourage competition among suppliers, and provide the flexibility that will facilitate system evolution over time.
- The system architecture should be modular in design to permit phased implementation that encourages public and private partnering opportunities, and so that the system is adaptable to the needs of each region/jurisdiction within the corridor, for both short-term implementation and long-term projects.
- The system architecture should allow for local requirements to be readily addressed (autonomy, regional and local control of subsystem operations).
- The system architecture should take advantage of functional area integration opportunities (for example, using one computer to process ATMS and ATIS data) to eliminate unnecessary, underutilized, and/or redundant systems that have common hardware and/or software requirements. By integrating functions within functional areas, the overall system and maintenance costs are reduced, and the operating effectiveness and efficiency is enhanced.
- The system architecture should fit within the framework of the statewide architecture concept (ITI Network).

Architecture Structures. The three organizational structures for the system architecture (centralized, decentralized, and hybrid) are identified and described below. These architectures are graphically represented in Figure VI- 1.

A centralized architecture assumes that all collection, processing, and dissemination of corridor-wide would occur in and operate out of one location. A single operations center would collect data

from roadside and vehicular devices throughout the entire corridor, aggregate that data, process it, and implement corridor-wide response plans. The single TOC would also control and activate all corridor-wide advisory and warning devices (VMS, HAR, in-vehicle systems) and other traffic management equipment. A centralized architecture benefits from of economies of scale (less hardware capital and software development costs for a single installation) and centralized, uniform data handling.

A decentralized architecture assumes traffic operations throughout the I-70 West Corridor would be handled at various locations, segmented by the Engineering Region's current jurisdictional boundaries. These local operations would be implemented at the regional TOCs (Hanging Lake and Eisenhower). Each regional TOC would control the respective roadside, in-vehicle, and operations center, collecting and processing that region's data, and implementing traffic and response management measures. Communications between the regional TOCs would be limited, restricted to voice communications. This architecture allows greater flexibility and responsiveness to local needs and maintains regional control of infrastructure.

A hybrid architecture combines the positive aspects of the centralized and decentralized architectures. Regional TOCs and the C-TMC would have coordinated functions. The regional TOCs would collect and process local data that is not required for corridor-wide and statewide operations. Locally-collected data could be sent "in the raw" or partially or fully-processed to the C-TMC. The C-TMC would collect and process corridor-wide data as agreed to by the responsible agents, in addition to collecting and processing statewide data of significance to regional operations. The C-TMC would operate subsystems and functions as requested by the regions and serve as a back-up for subsystem failures and staffing shortages. The regional TOC's would be responsible for implementing traffic and response management plans. The hybrid architecture offers wide-scale, global information sharing mixed with local control of various ITS subsystems. It also allows redundancy for continual operations.

Architecture Selection. A comparison of the architecture structures to system architecture requirements of the responsible agencies and existing systems within the I-70 West Corridor resulted in the identification of a hybrid architecture as best-suited for all corridor operations. A summary of this analysis, designating the criteria applied to make this comparison, follows.

Integration of Corridor-Wide ITS Functions. All three architectures will support subsystem integration throughout the corridor. However, only the centralized and hybrid architectures provide the necessary data sharing capabilities to coordinate and integrate functions on a corridor-wide level. Although coordination can be provided by a decentralized architecture, voice communications are inefficient and unreliable.

Utilization of Existing Subsystems. A decentralized architecture will best utilize the existing operating center and roadside infrastructure because this type of architecture, to some extent, is how the subsystems are currently operating. A hybrid architecture can utilize the existing subsystems and

devices by expanding their functionality and linking them together. A centralized architecture would require communications linkages from all devices to the C-TMC (including those functions that operate the tunnel control systems) and modification and/or replacement of incompatible subsystems and devices.

Information sharing. A centralized architecture would collect corridor-wide data into a single repository. Processed data can then be accessed by any linked agency within the corridor after communications media and end equipment is acquired and installed. This is the best form of information sharing. The hybrid architecture would interconnect each local operations platform. Although the information may not all be stored in a single database at a single location, all data is accessible by each entity. The decentralized architecture does not allow for information sharing, except through initiative by human means to communicate it, as each entity collects, stores and uses data independently of all others.

Automation. Automated subsystems can be accomplished within any of the architectures. However, automation of corridor-wide traffic management or incident response can only be accomplished if centralized or hybrid architectures are deployed. These architectures allow data communications via expert systems so that operations can occur at a corridor-wide level. A decentralized architecture typically requires voice communications to enact multi-jurisdictional response plans, however, with the vision of a statewide IT1 network, coordinated plans could be communicated automatically through a processing center.

Open Configuration. An "open" configuration demands that additional subsystems can interface within the overall system (similar to the "plug and play" architectures currently available with personal computer equipment). Centralized and hybrid architectures can be adapted to allow an "open" configuration. The hybrid architecture is extremely conducive to this "open" configuration. A decentralized architecture, consisting of existing technology applications, may not have "open" subsystem and equipment configurations. The restrictions that define a decentralized architecture are more apt to be "closed" in their configurations.

Modularity. A decentralized architecture allows the most modularity since it is composed of many virtual standalone systems--these, by their very nature, are extremely modular. The hybrid architecture can be modular, however, after the foundation system is entirely built. The centralized system is the least modular. The initial infrastructure requirements are immense. Modularity can only be achieved after the base system is operational.

Local Requirements. The desire for autonomy and regional/local control without interference by an umbrella authority are best met by the decentralized architecture. System and subsystem control remains in the hands of the local operator. A centralized architecture removes the control from the local operator to a single control center. Centralized operation typically commands and directs activities from a global perspective, making it less likely to fulfill local needs. The hybrid

architecture can retain local control of certain ITS subsystems and functions, allowing some coordinated system-wide operations while promoting local functions and benefits.

Redundancy Costs. Having redundant systems is good from a systems failure aspect, but has high capital, operating, and maintenance costs associated with numerous systems and subsystems. The elimination of redundancy to keep costs down is best accomplished through centralized and hybrid architectures. These architectures allow certain ITS components to be utilized by a variety of functions and users. A decentralized architecture requires that each entity deploy its own fully-operational system. Since communications are limited to voice, data collection, processing, and sharing cannot be accomplished automatically.

Fit to Statewide Architecture Concept. The statewide distributed architecture concept envisions a "many-to-many" linkage via a node that contains the ITI Network. This "plug and play" core allows each TOC to connect via any communications medium to exchange data (raw or processed). The centralized architecture does not fit with this concept. The decentralized architecture, while made up of modular components, does not have the flexibility to interconnect each module into a common connection with the ITI Network. The hybrid architecture amasses the various subsystems functions into a core, allowing interconnect to the ITI Network.

The comparison of centralized, decentralized, and hybrid architectures, using the system requirements previously identified, shows that, while the centralized architecture scores higher ratings in more categories than the decentralized architecture, the hybrid architecture (combining positive centralized and decentralized architecture characteristics) can be designed to enhance the positive aspects of both. A hybrid architecture is, therefore, the architecture "of choice" for the I-70 West Corridor ITS. A subjective comparison of how well (high, medium or low) each architecture meets the requirements is compiled in Table VI-l.

Recommended System Architecture. The hybrid architecture selected for the I-70 West Corridor ITS can accommodate regional TOCs, the C-TMC, and various interfaces with local public agencies and private entities. The ITI Network will interconnect all transportation management/operations centers, as well as local operations and communications centers.

The Hanging Lake and Eisenhower traffic control centers currently control subsystems related to tunnel operations. The functionality of these operations centers will be expanded to include additional ITS subsystems to allow management of traffic, information, transit, emergency services, and commercial vehicle functions within the designated CDOT Engineering Region. The existing facilities can be designated and serve as regional TOCs, or if desired by the Engineering Regions, as distinct TMCs that exercise complete functional control of I-70 West Corridor ITS and subsystems. The tunnel control systems currently in place at those facilities will continue to be controlled from the respective operating systems-those subsystems and devices that have utility for transportation functions will be modified (or replaced if necessary) and interconnected via base ITS operating equipment so that data exchange can occur.

TABLE VI-1 ALTERNATE ARCHITECTURE COMPARISON			
REQUIREMENTS	**CENTRALIZED**	**DECENTRALIZED**	**HYBRID.**
Integration of Corridor-Wide ITS Functions	high	low	high
Utilization of Existing Systems	low	high	medium
Information Sharing	high	low	high
Automation	high	low	high
"Open" Configuration	high	low	high
Modularity	low	high	medium
Local Requirements	low	high	high
Redundancy	high	low	high
Fit to Statewide Architecture Concept	low	low	high

The Eisenhower tunnel control center has limited capacity for additional equipment and staff assignments. A plan will need to be developed to determine at what level CDOT Region 1 will require assistance from the C-TMC to manage and operate ITS functions.

Raw data that has corridor- and/or statewide traveler information significance and is collected from field devices and in-vehicle sources by the C-TMC, will be transmitted to the central supervisory computer system at the C-TMC via the IT1 Network. The raw data will be processed and disseminated to the appropriate ITS services and equipment, then fed back to the regional TOCs for traffic control, emergency response, and information dissemination applications.

Local TOCs (such as Denver, Colorado Springs, Aurora, and Lakewood centers) and other CDOT regional TOCs (Engineering Regions 2,4, and 5)can be plugged into the distributed architecture as they come on line. These centers will have access to I-70 West Corridor processed information with respect to road, weather, and traffic condition data via the ITI Network ring interconnect. At this time, it is not anticipated that all CDOT Engineering Regions will operate their own TOC. For example, CDOT Region 5, will likely rely on the C-TMC for ITS management and operations of any subsystems in southwest Colorado.

The C-TMC may assume some ITS subsystem operations, at the request of the Regions. It will, in that case, serve as a hub to the I-70 West Corridor architecture. To ensure interoperability, and to ease system integration tasks, the technologies, functions, and devices implemented within the corridor must be compatible with the equipment and functions developed for and operation at the C-TMC.

The C-TMC is currently in the initial stages of implementation. Several CDOT Region 1 ITS functions, including the traffic management/operations/control, incident management, inter-agency communications, and traveler services information, are being collected, compiled, and distributed by the ITOC systems. As the current area of coverage is expanded, Region 1 must determine whether systems will continue to be controlled by the ITOC (and eventually the C-TMC) or if the Eisenhower tunnel controls will be expanded (space and functionality).

The CSP envisions collocation of its CAD functions into the C-TMC so that traffic control and emergency response teams can coordinate and manage activities. This functionality would be extended to encompass similar functions for the I-70 West Corridor. Certain data collected and used by the CSP is confidential, restricted to secured viewing. This creates some institutional barriers to finalizing the collocation and joint use. The ITI Network may allow remote interface of between CSP and CDOT functions, allowing seamless interface and data coordination to overcome this institutional concern.

The C-TMC will be interconnected through the ITI Network to public transportation ITS services and inter-modal operations that function within the I-70 West corridor. Local data collection, processing, and dissemination activities will be correlated to regional TOC and C-TMC planning and data fusion activities. The C-TMC will function as an information clearinghouse for all system users and participating agencies and organizations. Corridor-wide traveler services information functions should be provided and managed via the C-TMC.

Other public agencies, such as the CSP, Denver's Regional Transportation District (RTD), city and county police, fire, and emergency units, Denver International Airport, and educational institutions plan to institute remote TMCs interfaced through the ITI Network. As these systems come on line, additional data can be provided to the I-70 West Corridor ITS for management and operating functions.

Private entities (shuttle service operators, rail services, commercial information providers) will be able to interface with the I-70 West Corridor ITS through the ITI Network, receiving useable road, weather, and traffic condition information for further value-added dissemination to the general public.

The hybrid architecture recommended for the I-70 West Corridor is depicted in Figure VI-2.

FUNCTIONAL REQUIREMENTS

The I-70 West Corridor system architecture must be able to support a variety of ITS functions and subsystems. The hybrid architecture must adhere to a multitude of functional requirements to be able to support the ITS projects and programs recommended for implementation throughout the corridor. Preliminary functional requirements for hardware, communications, and operational and maintenance staffing have been developed.

The ITS functional areas for the I-70 West Corridor were developed to support future system and subsystems so that technological applications and opportunities can be established for each recommended project and program. The FHWA ITS Planning Process references the Mitre User Services documentation which describes Mitre-developed functional areas. Each of the Mitre functional areas need to be correlated to the I-70 West Corridor functional areas established in Section V, User Service Plan.

ITS User Services can have overlapping functions While a particular User Service may contain one or more functional areas, it may also support other User Service categories. This is particularly apparent when evaluating the Mitre functional areas for communications and data processing (which also happen to be two of the I-70 West Corridor functional areas); and the I-70 West Corridor functional areas for education/training, environmental impact, institutional issues, and public/private partnerships. These two examples exhibit several overlapping requirements. Grouping prevalent functional areas into individual categories avoids inadvertent duplication within a project-specific architecture for its various ITS components, or dictation of vendor-specific technological products.

The Mitre functional areas are mapped to the I-70 West Corridor functional areas in Table VI-2. The mapping correlates the required system functionalities for the I-70 West Corridor ITS. The Mitre functional areas are described below.

Surveillance. A collection of traffic and roadway data including speed, volume, density, travel time, queue length, vehicle position, vehicle weight, vehicle height, incident location, road surface conditions, and roadway conditions, that is used in real-time traffic management decisions and stored to provide a historical record of traffic conditions.

Communications. A combination of facilities, stations, and electronic circuits that transfer information through wireline and wireless communications media to various ITS components.

Traveler Interface. Technologies that allow travelers to interact with the ITS subsystems to obtain road, weather, and traffic condition updates and other information from TMC databases, including access to information via telephone lines, television, radio, kiosks, and in-vehicle devices.

TABLE VI-2
MAPPING OF MITRE FUNCTIONAL AREAS TO I-70 WEST CORRIDOR FUNCTIONAL AREAS

I-70 WEST CORRIDOR FUNCTIONAL AREAS	MITRE FUNCTIONAL AREAS						
	Surveillance	Communications	Traveler Interface	Control Strategies	Navigation/ Guidance	Data Processing	In-Vehicle Sensors
Commercial Vehicle Operations	–	–	–	–	–	–	–
Communications Systems		–					
Data Collection/ Aggregation	–	–				–	–
Education/Training		–	–	–			
Emergency Response	–	–	–	–	–	–	–
Environmental/ Economic Impact		–	–	–	–		
Institutional Issues		–		–		–	
Public/Private Partnerships	–	–	–	–	–		–
Public Transportation/ Alternate Modes	–	–	–		–	–	–
Safety/Warning Systems	–	–	–	–	–	–	–
Traffic Management/ Operations	–	–	–	–	–	–	–
Traveler Information Systems	–	–	–	–	–	–	–

Control Strategies. Strategies that can be implemented from TMCs to automatically control demand levels on the transportation network and ensure traveler safety. For example, the automation of electronic or mechanical processes and facilities.

Navigation/Guidance. The on-board systems that assist drivers in route planning, navigation, and guidance. These may or may not incorporate information about real-time conditions.

Data Processing. The management and quality control of all data pertaining to ITS.

In-Vehicle Sensors. The in-vehicle devices that monitor vehicle and driver performance and those elements of the external driving environment that pertain to vehicle operations.

The Mitre functional areas were used to examine the hardware and communication requirements of the corridor as well as the operations/maintenance demands of these requirements.

Functional hardware requirements are broken down by functional area. Each functional area has a list of specific ITS components and the required placement of each component. The placement of each component is a suggested location or frequency for the component and is not necessarily the optimal placement of that component. Functional hardware requirements corresponding to Mitre functional areas are listed in Table VI-3.

Functional communications requirements are mapped to the seven Mitre functional areas, similar to the analysis process used for establishing hardware component requirements. In addition to the various component placements, communications requirements identify data flow, data rate, and polling rate for each component.

Data flows identify how meaningful data is input and/or output. The flow of data is defined with respect to the TMC. Input data is that data traveling from a component to the TMC; output data is that data provided to a component by the TMC. The data referenced here is significant or meaningful data. For example, a CCTV camera requires output data specifying pan/tilt/zoom requirements for it to provide input data containing an image of the roadway. The input data is considered the significant data, since it defines the component's capabilities. It is used as the basis for data flow designation. Most components that provide input data will require some sort of output data feed for special instructions and on-line status checks, however, this instructional data is not used to define the data flow requirement for the component.

Data rate is a specified range or rate at which the data is transferred. It should be noted that many components tie into a controller, such as a Type 170 Traffic Controller, to send their data, and therefore the data rate specified is actually the data rate of the controller. For multi-function components requiring multiple communications, such as a transportation management center, it is impractical to specify a data rate. In these cases, the data rate is noted as "high bandwidth link". This indicates the communications link must be able to support voice, video, and data information.

TABLE VI-3
FUNCTIONAL HARDWARE REQUIREMENTS

MITRE FUNCTIONAL AREA	COMPONENT	PLACEMENT
Surveillance	✓ Inductive Loops	per lane before/after interchanges and every 1/3 mile in detector areas
	- CCTV	before/after interchanges and every 1/2 mile sight distance (more if geometrics reduce sight distance)
	- Weight Sensors	per lane at weigh stations
	- Overheight Detectors	prior to tunnel entrances and low overhangs
	- Ice Sensors	high preferential icing areas
	- Wind Sensors	high wind areas
	- Avalanche/Rock Slide Sensors	high avalanche/rock slide areas
	- Cellular Telephones	participating motorists
	- Call Boxes	at interchanges and every 1/2 mile
	- Maintenance Crews	per each crew
Communications	- Surveillance	data link between field devices and regional TOC
	- TMCs	data link to all centers interconnected to IT1 Network
	- Local Police, Fire, Emergency	voice/data link to regional TOC
	- Maintenance Sections	voice/data link to TMC
	- Local Transit Operators	voice/data link to TMC
	- Other Information Distributors	data link to C-TMC
Traveler Interface	-VMS	every 1/4 mile
	-HAR	locations with 3-5 mile transmission range (topography dependant)
	- Kiosks	rest areas and transfer centers
	- Telephones	dial-up phone line
	- Television (CATV)	television channel
Control Strategies	- Automated Lane Controls	tunnels and high traffic locations
	- Ramp Meters	on-ramps
	- Adaptive Traffic Controls	arterials with high peak traffic
	- Advanced POE	Dumont-Downieville POE
	- Advanced Parking Information	resort towns/areas
Navigation/ Guidance	- Static In-Vehicle Units	participating vehicles
	- Dynamic In-Vehicle Units	participating vehicles
Data Processing	- TMC Computers	TMCs
In-Vehicle Sensors	- Automatic Vehicle Location	participating vehicles
	- Emergency Call Buttons	participating vehicles

Polling rate identifies the frequency at which data should be accessed. This frequency will either be listed as continuous, on demand, or actual time. Continuous implies that this information is continuously broadcast and received. On demand denotes data which is polled only when it is required. Examples of "on demand" include weight sensor data being polled only when a truck passes over the detector or automatic lane control data being sent only when it is desired to change the lane configuration. When an actual time is specified, it is the recommended polling rate for that component. The actual polling rate is dependent on the particular function and application of the component and may differ slightly from the recommended polling rate identified.

Table VI-4 identifies the various components of the functional areas and indicates the necessary communication requirements for these components.

Operational staff are necessary for continuous monitoring and implementation of incident and traffic management functions. Some incident response and traffic operation modification plans can be automated, but most agencies prefer some sort of human interface to confirm a situation before implementing a preplanned action. These stations require 24-hour staffing.

Data collection is usually automatic. Data that is continuously polled is stored in a database that can be accessed at regular or time-specific intervals for other planning and system modification assignments. Dissemination of traveler information to roadside devices is usually tied to preplanned congestion and incident management strategies. These can be automated or manual.

Maintenance staff, trained in testing and repair of electronic equipment and devices, is necessary to ensure reliable and continuous operation of ITS equipment and devices. Maintenance, for upkeep of components, is typically scheduled for periodic intervals, based on manufacturer recommendations.

ALTERNATIVE TECHNOLOGIES

Alternative technologies, that have potential for implementation in the I-70 West Corridor, are identified and detailed in the Information Search and Needs Assessment documentation. Using that information, the suitability of each candidate technology to support the functional requirements was evaluated based on performance, reliability, cost, compliance, and potential environmental impacts.

Other technology-related considerations include:

- existing components integration;
- procurement alternatives;
- operational and maintenance strategies; and
- funding arrangements.

TABLE VI-4
FUNCTIONAL COMMUNICATIONS REQUIREMENTS

FUNCTIONAL AREA	COMPONENT	DATA FLOW[1]	DATA RATE	POLLING RATE
Surveillance	- Inductive Loops	input	1200bps-19.2kbps[2]	15-30 seconds
	- CCTV	input		
	+ full motion		Analog 6 MHZ	Continuous
	+ compressed		112 kbps	On Demand
	- Weight Sensors	input	1200bps-19.2kbps[2]	On Demand
	Overheight Detectors	input	1200bps-19.2kbps[2]	On Demand
	- Ice Sensors	input	1200bps-19.2kbps[2]	1 minute
	- Wind Sensors	input	1200bps-19.2kbps[2]	1 minute
	- Avalanche/Rock Slide Sensors	input	1200bps-19.2kbps[2]	On Demand
	- Cellular Telephones	input/output	64 kbps	On Demand
	- Call Boxes	input	64 kbps	On Demand
	- Maintenance Crews	input	64 kbps	On Demand
Communications	- Surveillance	input		--
	- Other TOCs	input/output	high bandwidth[3]	On Demand
	- Police, Fire, Emergency	input/output	high bandwidth[3]	On Demand
	- Maintenance Departments	input/output	high bandwidth[3]	On Demand
	- Transit Operators	input/output	high bandwidth[3]	On Demand
	- Other Information Distributors	output	high bandwidth'	On Demand
Traveler Interface	- VMS	output	1200bps-19.2kbps	On Demand
	- HAR	output	64 kbps	On Demand
	- Kiosks	output	19.2 kbps	On Demand
	- Telephones	output	64 kbps	On Demand
	- Television (CATV)	output	Analog 6 MHz	Continuous
Control Strategies	- Automated Lane Controls	output	1200bps-19.2kbps[2]	On Demand
	- Ramp Meters	output	1200bps-19.2kbps[2]	On Demand
	- Adaptive Traffic Controls	output	1200bps-19.2kbps[2]	1 second[4]
	- Advanced POE (transponder)	input	1200-9600 bps[2]	On Demand
	- Advanced Parking Information	input/output	1200bps-19.2kbps[2]	1 minute
Navigation/ Guidance	- Static In-vehicle Units	input/output	1200-9600 bps	30 seconds
	- Dynamic In-Vehicle Units		1200-9600 bps	30 seconds
Data Processing	- TOC Computers	input/output	N/A	N/A
In-Vehicle Sensors	- AVL	input	1200-9600 bps	On Demand
	- Emergency Call Button	input	1200-9600 bps	On Demand

'with respect to the TMC.
'data rate of controller.
[3]must support voice, video, and data information.
[4]15-30 controllers can be multidropped to reduce data requirements.

The technology screening process provided valuable information for further refinement of the system architecture concept. The following issues need to be considered further during the identification and screening of alternative technologies for specific projects:

Performance and Reliability. The performance and reliability requirements of the various technologies are dependent upon each specific application. For example, the band width requirements for video transmission are much greater than the requirements for data; the fault tolerance requirements for automated traffic control devices are much greater than the requirements for ramp meters; and the capacity requirements for an incident detection supervisory computer system is much greater than the requirements for a changeable message sign supervisory computer system. Performance and reliability requirements also apply to software components and personnel.

Cost. Economic analyses are performed to examine the total cost of the system over its entire useful life, in the context of the budget and personnel currently available. The total cost of the technology includes all up-front capital costs, future expansion/upgrade costs, operation and maintenance, and replacement costs. Replacement costs include the replacement of failed systems components, as well as the replacement of outdated technology. Technology that is considered modem in 1995, may very possibly be obsolete by the year 2000. Some technologies are more sensitive to this phenomena than others; analog fiber optic systems and some computer operating systems are two examples.

Standards. Nonstandard technology, or technology that is not in compliance with evolving standards, is generally not acceptable except for certain customized standard products. Proprietary technology has a great potential to increase costs because it eliminates vendor competition, and forces nonstandard interfaces and peripherals that may be difficult to acquire. Standard technology ensures compatibility with new products and services emerging into the market, and with future state, regional, and national ITS deployments. While nationally-accepted standards are still evolving for most ITS technologies, other transportation and non-transportation industry standards, such as the National Electrical Manufacturers Association (NEMA), Society of Automotive Engineers (SAE), and Open Systems Interconnect (OSI) standards, are currently available.

Existing Components Integration. The I-70 West Corridor ITS is designed to retain maximum use of the existing transportation infrastructure, systems/services, technology, and facilities that are up-to-date and in good condition. Many of the existing corridor systems, such as the variable message signs and field sensors, are operating as independent modules. The recent transfer of control of Region 1 variable message sign systems to the iTOC allows the retrofit and addition of new equipment into a compatible environment. It is expected that retrofitted and new signs will be controlled by the same computer and software so that the component integration is complete.

Other field devices, such as pavement sensors, are controlled from various centers. It will be important, in the near future, to integrate these components into the I-70 ITS so that data can be collected, processed, and used to gain advantages. It is uncertain at this time if the proprietary

systems will be allowed, by the manufacturer, to be integrated. This is an institutional issue that the CDOT ITS Program Office needs to resolve.

The Hanging Lake and Eisenhower Tunnel subsystems and components must be integrated into the I-70 West Corridor ITS. Although Hanging Lake subsystems are relatively new, the inductive loop collection and processing software is proprietary. Region 3, with the assistance of the ITS Program Office, needs to investigated how this function can be integrated into future subsystem upgrades. The Eisenhower subsystems are old but a long-term strategy has been designed to upgrade the devices and equipment. The integration scheme to incorporate local functions with regional ITS needs should be developed jointly by the tunnel control staff and the ITS Program Office so that regional traffic management subsystems can have joint use of the data collected for local traffic management within the tunnel.

Procurement Alternatives. Procedures for procuring ITS technology components cannot always be obtained through low bid construction contracts. The I-70 West Corridor ITS system components include unique variations of computer hardware, software, communication devices, and electronic equipment. The devices will be obtained through multiple construction contracts, requiring innovative procurement methods. CDOT does not currently have a mechanism to allow alternative procurement methods.

Other contracting methods that should be investigated jointly by the ITS Program Office and the Attorney General's office include:

- sole source
- two-step (a+b method)
- design/build
- lane rental
- warranty clauses
- system manager
- design/build/operate
- privatization

Operations and Maintenance. Analysis of the operational and maintenance resources required to implement each technology indicates that the personnel, skills, and equipment that will be required to operate and maintain the I-70 West Corridor ITS will exceed the resources currently dedicated to the corridor's transportation system. The exact operation and maintenance requirements will depend on the philosophy and policies of the implementing agency(ies), and the specifics of the individual deployment scenarios, especially those strategies that will require integration of new ITS subsystems with existing components.

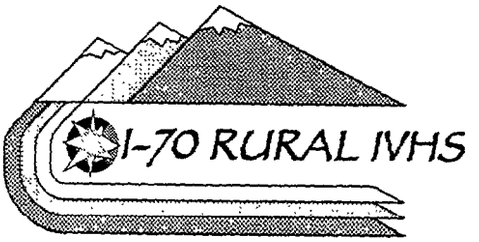
Environmental Impacts. Although one of the goals of ITS is to improve the environment, it is possible that certain ITS technologies may actually defeat this purpose. ITS strategies that accommodate increased travel and support higher speeds create non-compliant nitrogen oxide emission levels. Other environmental effects are not as evident as vehicle emission pollution. For example, aesthetically displeasing roadside equipment that is not concealed may degrade environmental quality; mass transit systems with routes that are not considerate to the community

livability may foster negative societal implications; and under-utilized public services could negatively impact the economy.

National Consistency. During the national ITS system architecture development process, some ITS User Services and functions are expected to evolve significantly, and others are expected to be dropped from the NPP. For each of the technologies considered for the I-70 West Corridor ITS, the potential for inclusion in the national architecture is an important factor. For example, future implementation of certain infrastructure-dependent technology, such as automated highway systems, is uncertain in rural corridors such as I-70 West. At this time, the financial risk in developing such a system is very high. On the contrary, certain field-tested technology that is currently unproven may eventually find a stronghold in the national architecture and prove to be a worthwhile long-term implementation project.

The following technologies are feasible for integration into the I-70 West Corridor ITS. As proven applications that meet the needs and established User Services for the corridor, there is high probability that these will remain consistent with national strategies.

- vehicle probes
- microwave sensors
- aerial surveillance
- automatic vehicle location
- auto vehicle identification
- two-way radio
- cable television
- spread-spectrum microwave
- lighted guidance delineation
- incentive programs
- high speed rail
- automatic movable barriers
- electronic parking controls
- central computer systems
- wide area networks
- global positioning systems
- video surveillance
- variable speed signs
- ramp metering
- weather sensors
- radar sensors
- computer-aided dispatch
- fiber optics
- roadside beacons
- cellular radio
- satellite
- digital am/fin subcarrier
- automatic lane controls
- commuter/passenger rail
- dead reckoning
- data fusion
- ramp metering
- local area networks
- HOV lanes
- map matching
- video broadcasting
- 2-way call boxes
- information kiosks
- infrared sensors
- closed-circuit television
- weigh-in-motion devices
- highway advisory radio
- transponders
- cellular telephone
- landlines
- pager-based radio
- road use pricing
- light rail transit
- route selection algorithms
- real-time traffic prediction
- incident detection algorithms
- adaptive signal control
- signpost odometer
- video monitoring
- variable message signs
- solar power
- loop detectors



CORRIDOR

MASTER PLAN

SECTION VII
IMPLEMENTATION PLAN

SECTION VII IMPLEMENTATION PLAN

Coordination with all ITS activities within the State of Colorado is an additional effort that has been undertaken by the I-70 Rural IVHS study team. A concerted attempt has been made to keep abreast of all continuing ITS-related actions, with respect to the allocation and use of federal, state, and local funds for ITS initiatives within and connected to the I-70 West Corridor. This plan addresses recent ITS developments and actions by the CDOT ITS Program Office, the Engineering Regions, and the Statewide ITS Implementation Team (Smart Path) to ensure responsive coordination and complementary activities between the recommendations herein and the continuing efforts of the involved ITS community.

Certain regional and corridor-wide actions must take place to establish a "base" system for ITS functions and operations. Individual projects and existing systems must be integrated under a common framework. The Implementation Plan includes an Action Plan that recommends organizational and institutional endeavors that must be accomplished to ensure the success of ITS strategies as a "system."

The Implementation Plan provides a time line to guide deployment of the top priority Early Action Projects to address the needs and objectives documented in the User Service Plan. Early Action Projects include those identified in the Early Action Projects Executive Summary (July 1994; Revised October 1995), other initiatives defined by the CDOT Statewide ITS Implementation Team in the Smart Path documentation, and recent developments defined by the ITS Program Office and the Engineering Regions.

Potential medium and longer term project initiatives are suggested and time referenced for implementation to meet additional transportation-related needs within the Corridor. These build on the early action recommendations, based on what is known today. Rapid advances in technology, evolving institutional changes, and implementation of other state-wide ITS initiatives continue to impact what can occur within the I-70 West Corridor. For this reason, medium and long-term project recommendations can, and will, change over time, and, therefore, this study can only presuppose what the future I-70 West Intelligent Transportation System can accomplish.

ACTION PLAN

The Action Plan defines necessary corridor-wide programs and state-wide initiatives to ensure project and program integration. These typically address the institutional and organizational (non-technical) issues and requirements that can individually or collectively affect each potential project and should be addressed at a more global level.

The Action Plan defines procedures that are necessary for development and implementation of every ITS project. Because the processes must be developed specifically for each project, general

guidelines and plan contents are denoted herein. Each project development, design operations, and maintenance manager should have the latitude to organize and format each of the procedural documents in a manner that serves the project team in successful management, administration, and deployment of the particular project.

ITS Program Institutional Actions

Coordination/Cooperative Strategies. The major frustration, voiced by all stakeholders involved and interested in Colorado's ITS Program, is the inability and/or unwillingness to share information and work together toward acceptable transportation solutions. Secretive collusion (advancing an idea, project, or program) by individuals and groups to leverage resources and satisfy and/or secure an exclusive, self-fulfilling arrangement breeds similar activity by other individuals and groups, enforcing segregation, opposing actions, and continual "finger-pointing." This type of process is non-productive and threatens the positive and successful advancement of ITS programming in Colorado.

A cooperative, coordinated, "team" effort can only be achieved when individuals and groups are committed to and responsibly follow the same ground rules. Processes to promote cooperation and coordination include information sharing, oversight, team-building, partnering, facilitation, mediation, and, above all, precise communication.

Communication, by and between leaders and stakeholders, is key to coordinated and cooperative efforts. Communication means that each person must define his/her respective requirements and ensure that others understand what is meant and needed. Leaders have the responsibility to know and understand what they want so that their "customers" can respond appropriately. Too often, plans and programs are developed that do not meet the identified needs because the individuals or groups do not define their requirements adequately. All stakeholders must communicate their needs and concerns on a rational level, avoiding personal emotion.

Communication also means honesty and integrity. Promises cannot be made and not kept without up-front discussion with all involved parties. Direction cannot be given, then a change made, without advising all affected parties that a modification is in effect. Circumstances change, and flexibility, by all leaders and stakeholders, must be sustained so that plans and programs can be altered to meet unforeseen fluctuations, particularly with respect to technology developments, but also with respect to individual perceptions and needs. Communicating changes in direction and opinion must occur when the change occurs.

To maintain a balance between and within state, regional, and local agencies, formal organizational structures for the development, implementation, and management of ITS activities should be adopted by all. Recommended structures can be built on existing processes and systems to institute a cooperative, coordinated business strategy. Figure VII-1 illustrates a recommended organizational structure for management of ITS activities and actions for the I-70 West Corridor.

The following organizational components are recommended to ensure essential coordination and cooperation so that ITS implementation within the I-70 West Corridor is integrated with all other state-wide ITS functions and programs:

I-70 West Corridor Coalition. A corridor-specific steering committee would be represented by state, regional, and local agencies specifically to continue and promote support for I-70 West Corridor ITS activities. The Coalition would meet regularly (perhaps bi-monthly); all meetings should be announced in advance and open to the public. Membership should include a technical and policy representative from each of the CDOT Engineering Regions, CSP, and each county. Colorado Ski Country USA, the Colorado Motor Carriers Association, the Colorado State Transit Association, the Colorado Municipal League, AAA of Colorado, and Sierra Club should provide a single representative for each of these special interest groups. Other local economic or social organizations can be appointed representation as determined by the core coalition membership.

The Coalition could have responsibilities, including, but not limited to:

- annual review and modification of the Corridor Master Plan for acceptance by the operating/approving agencies;
- implementation of local education/outreach, policy, and coordination programs;
- development of partnering relationships with potential private sector investors;
- establishment of corridor-specific technical and non-technical standards and guidelines;
- execution of local ITS programs (these may be managerial or administrative);
- creation of local congestion and incident management plans;
- preparation of Corridor-Wide ITS Operations Plan;
- generation of draft inter-/intra-agency and private sector partnering agreements; and
- recommendation for staffing, training, operational, and maintenance requirements.

E-Mail Reporting System. All State of Colorado personnel have access to and use the State's e-mail. Any ITS initiative should be reported to all interested and potentially affected parties, at all stages of development. Individuals and groups outside the State system can be granted special use of the system on an application and approval basis. The e-mail system provides the medium to accomplish information sharing. Electronic forms should be developed to report on each phase of a potential initiative, from idea formulation through each stage of development.

Annual Regional Management Overview Sessions. These required "staff" meetings offer an educational forum for regions and the central office to advise and gain input from staff at all levels about ITS ideas, initiatives, and programs. An ITS topic session should be included at each annual Management Overview meeting to relate regional and statewide activities.

ITS should be cross-cutting at all regional/central office management overview meetings--ideas and applications initiated by one region should be communicated to all other regions and the central

office. One way to accomplish this would be to have the ITS Program Office Statewide ITS Engineer report on all past year ITS-related activities at all annual sessions.

Statewide ITS Implementation Team. The foundation of this Team, bringing together representation from each of the CDOT Regions as well as the ITS Program Office founders, fostered the beginnings of cooperation and coordination within CDOT. The Team program needs to be reinstated on a regular schedule (annually, semi-annually, or quarterly) to maintain momentum and facilitate statewide ITS program integration. The Team should be expanded to include local government participation. This will provide an opportunity to nurture positive relationships between state and local agency representatives.

ITS Rocky Mountain. The formation of a regional chapter of ITS America is intended to serve Colorado and its neighboring states as a forum to breakdown barriers to ITS implementation and deploy interstate ITS products and services. As individual states are implementing advanced technology applications, the time is "ripe" to establish partnerships to develop an interstate strategic deployment plan so that a regional network of integrated ITS projects evolves to the benefit of all users. Those involved in any ITS activity within Colorado should participate, at a level commensurate with their position (project development, decision/policy-making, legislative), to help sow the seeds for what could be the first comprehensive regional ITS in the country.

ITS Oversight Committee. A working group subset of the Statewide ITS Implementation Team or an Executive Director-assigned Engineering Management Team, an ITS Oversight Committee would meet or communicate monthly to oversee all ITS activities. The Committee, composed of a representative from the ITS Program Office, each Engineering Region, the State Procurement Division, and the AG's and Governor's Offices would report directly to the Executive Director. The Committee could have authority to:

- review and comment on any ITS initiatives to be taken before the TCC;
- monitor ITS funding appropriations to ensure fair and objective distribution to programs;
- identify and recommend needed policy and legislative actions to the Executive Director, the TCC, the Attorney General's Office, the Governor and the State Legislator, and national transportation lobbying groups;
- appoint special committees to investigate, develop, and implement state-wide and project-specific education/outreach programs, legislative actions, marketing objectives, and partnership agreements beyond the staffing and/or budgetary resources of the responsible office, department, division, or region;
- assist in development of MOU's MOA's, and other inter- and intra-agency agreements;
- review and approve standards setting and guidelines development by regional or local committees; and
- define policy statements, including development, review, approval, and inclusion of ITS projects in the local TIP's and the STIP.

Education/Outreach Programs. Education and outreach activities cannot end--this is a continual and timeless task. Several educational programs were initially identified as potential Early Action projects (see Early Action Project Appendix). It was concluded by the study's Steering Committee that non-technical strategies should not compete with functional ITS deployment projects. These programs are therefore left up to the discretion of the ITS Program Office, the Engineering Regions, and the I-70 West Corridor Coalition to develop and implement on an as-needed basis.

Education and training projects are extremely important to continuing the outreach efforts that were initiated as a part of the I-70 Rural IVHS study and are worthy of mention in this Corridor Master Plan. Simple, inexpensive, community-oriented programs have great potential to build better relationships between agencies and their publics. Getting the locals involved on a voluntary basis provides opportunities to educate about ITS concepts to a few that can be spread, by word of mouth and action, to many other interested parties.

For example, a Trained Caller Program, similar to the television station remote temperature/precipitation reporting program that is aired during the weather report on news programs, provides a base of volunteers who "validate" local conditions. The I-70 West Corridor Coalition might be responsible for organizing and directing an observation and reporting program for travel information throughout the corridor and surrounding areas. Volunteers could be recruited from local agencies and businesses or advertised for through local media outlets. Agencies and businesses would provide communications devices for reporting up-to-date road, weather, and traffic condition information. Volunteer training sessions--about ITS and how to use advanced technology devices--offer the "touchy/feely" medium to educate an unaware public. Similar to the old saying that "for every lie told, seven more have to be invented," for every volunteer trained, each tells many more, resulting in an exponential word-of-mouth messaging system that sheds positive light on the transportation program for the corridor and delivers the ITS message with minimal effort and expense.

Seminars, local radio/television station broadcasts, and other public acceptance programs, similar to the "'town meeting" concept currently programmed by CDOT Region 1 to interface with its constituents within the eastern half of the I-70 West corridor, have excellent opportunity to educate the public and unite the stakeholders. It is up to the agencies and committees who are responsible for implementing this Corridor Master Plan to be visionary and creative in devising programs that find champions and use the local resources to spread the word.

Education and outreach programs are tied to the Marketing Strategy as detailed in the companion Business Plan and Marketing Strategy document. By following the action plan identified in the marketing strategy and using the ideas envisioned in the development of early action projects for education and training, the I-70 Corridor Coalition, the ITS Program Office, the Statewide ITS Implementation Team, and ITS Rocky Mountain can band together to build on these ideas to get the message delivered.

ENTERPRISE (a multi-state/country ITS organization) has allocated funds to develop an outreach program to local governments that establishes the benefits of ITS for small rural communities. This project will be piggy-backed onto a federal initiative to develop a Simple Solutions instrument that provides ideas to rural state and local governments on how they can use existing ITS technologies to make management and operations of their transportation responsibilities easier. Programs such as these can provide additional insight and materials for the I-70 West Corridor ITS Program marketing strategies as well as create an opportunity to expand on those initiatives specifically for I-70 West Corridor ITS outreach and coalition-building.

Regulatory Barriers/Legislative Actions/Legal Issues. Of several institutional barriers that may block implementation of certain ITS projects, rules and regulations imposed by legislation in the State of Colorado will be the most difficult to overcome. Recent legislative modifications allow some flexibility for CDOT to initiate ITS-related activities on the Interstate system (MOVE-IT and REMOVE-IT laws for clearing obstructions from the travel ways, allowing courtesy patrol operation and incident management plan implementation).

The PUBLIC/PRIVATE PARTNERSHIP legislation (HB 1267), passed in 1995 and intended to provide CDOT with a process to exchange rights of way for communications capabilities, essentially back-fired when a strong private sector lobby effectively changed the language so that, if one company is allowed into the right-of-way, then all others have the same opportunity. Previous Federal regulation and State law protected CDOT from having to deal with utilities within Interstate rights-of-way where maintenance disruptions could affect traffic operations and create traveler safety hazards. The new legislation sets the stage for loss of control over such obstacles if numerous companies lay communications lines within the rights-of-way.

Conversely, the legislation offers other opportunities for CDOT to initiate public/private partnerships, such as allowing privatization of traveler services information systems within public rights-of-way. One example would allow CDOT to contract with a private sector vendor to develop, install, operate, and maintain an information system at a state-owned rest area. CDOT would be given data collected by that system in exchange for use of the right-of-way. The private vendor would be allowed to sell advertising or resell the data to other private sector markets.

Federal Communications Commission (FCC) regulations do not allow broadcast advertising over public sector-owned devices. One way to "pay" for traveler advisory and information systems is to "sell" advertising like the media does to support their respective operations. Applying for new rule-making is an arduous process that should be initiated immediately so that ITS projects and programs have this added-value outlet that can be designed into the system.

Procurement regulations currently restrict CDOT and other local public agencies from entering into sole-source arrangements with private sector entities. The private sector, particularly those that have interest in or products related to the ITS realm, are more than willing to make investments if they can realize a future profit from that investment. Governments should be allowed to take advantage

of those proposals that allow them to participate in the research, development, and evaluation of an advanced technology system and/or product.

State procurement procedures inhibit innovative contracting for construction of projects. The "low bid" process for ITS procurements will end up in "you get what you pay for" status. With advanced electronic and communications technologies, CDOT and the other operating agencies cannot afford to have inadequately functioning system components. Not only does it create more problems for the already under-staffed maintenance forces, but it is "bad press" when an agency is trying to sell an innovative solution to a transportation problem.

Other governments in Colorado have been able to initiate innovative contracting practices. The E-470 Public Highway Authority has a design/build contract in place for completing the toll facility from Parker Road to 120th Avenue. Design/Build allows the contracting agency to identify expected end results and establish design criteria minimums. Prospective bidders develop design and construction proposals that optimize the cost and time to deliver the end product. Design is essentially fast-tracked so that construction of some elements can begin while the design is still being completed. The Contractor assumes greater risk and responsibility for the successful completion of the project. FHWA's Office of Chief Counsel has reviewed the design/build approach for compliance with federal regulations and has determined that Federal-Aid funds can be used for a design/build contract as long as approvals are obtained under the Special Engineering Project No. 14 (SEP 14) program and competitive bidding procedures are used.

Variations on the design/build concept include design/build/operate and design/build/operate/transfer. Design/build/operate is a form of privatization. Design/build/operate/transfer privatizes the facility during a warranty period. Once the system or facility has been accepted, operations are transferred to the owner. These scenarios can leverage funds to build a system where construction and operating capital don't exist.

The A+B Method (also known as 2-Step and Cost-Plus-Time Bidding) of contracting has been used in Colorado. The "A," or cost, component allows traditional bidding for contract items that denotes the dollar amount to perform the work. The "B," or time, component establishes the number of days to complete the project. The lowest bidder is selected on a weighted average of both components, not just lowest cost.

Reconstruction of Sheridan Boulevard and the Hampden overpass in Denver was accomplished using a Lane Rental contracting concept where the Contractor pays a fee for lane closures during construction based on an estimated cost of delay to road users. Variations of this technique have good potential for establishing public/private partnerships to deploy an ITS projects.

Warranty Clauses have been successful in other states on non-Federal Aid projects and in other countries. As ITS moves states closer to consideration of privatization, guarantee of the operation of a system for a period of years after construction completion may become more attractive. If the

Contractor can benefit from some value-added service or product during the warranty period, more risk is apt to be taken.

The actual procedure to procure services is also complicated and time-consuming. When the bureaucracy requires numerous reviews and approvals, often by a single individual within the approving office, contracts and agreements end up in the pile waiting, often months, for signature. The ITS arena is changing so rapidly that one project or program can become obsolete during the 6 months that the contract is being authorized. These processes must be changed or streamlined. Again, the private business sector has many models for making projects and programs happen, and happen fast. Governments need to change the way they do business, particularly in the ITS field.

Foremost as a precursor to further ITS activities in the I-70 West Corridor and statewide, all institutional regulations must be examined and resolved as soon as possible. An individual or committee of individuals needs to tackle the regulatory barriers head-on, and perhaps full-time. An ideal solution would be to hire a full-time legal or paralegal staff member that can scour the rules, work with the Attorney General's office, and implement rule and legislative changes so that, as ITS programs and projects come on-line, any potential roadblocks have been torn down.

An acceptable framework (although a slower-moving process) could support a subcommittee of the ITS Steering Committee, the I-70 West Corridor Coalition, or the Statewide ITS Implementation Team to devote several individuals working part-time on overcoming regulatory and legislative issues. The message cannot be delivered strongly enough, in this ITS Corridor Master Plan, in other ITS documents, and in public forums--change the way business is done; do it now; don't wait!

TIP/STIP Inclusion. A process, to include ITS projects in the Transportation Improvement Plan (Regional TIP) and Statewide Transportation Improvement Program (STIP), must be established as ITS Program policy to ensure that all ITS project development managers follow mandatory procedures for I-70 West Corridor project implementation. Early Action projects and some statewide medium-term projects have been identified as candidates for implementation in the STIP. However, none of these projects have confirmed funding sources. Without actual dollars committed to a project, it cannot be initiated.

The Denver Regional Council of Governments (DRCOG) has jurisdiction over ITS projects in Jefferson, Clear Creek, and Gilpin Counties because those regions lie within the Mountains and Plains Region of the Denver metropolitan planning area. Specific ITS projects impacting these counties must be approved by DRCOG and included in the Denver metropolitan area TIP. Projects identified in this Corridor Master Plan currently represent a "wish list" and are not included in DRCOG's financially-constrained TIP.

The steps that must still be accomplished for the I-70 West Corridor Master Plan so that each ITS project can proceed into project development include:

- submitting applicable projects to the responsible Metropolitan Planning Organization (MPO) and Council of Government (COG), where appropriate, for inclusion in the Regional TIP;
- working with the 15 Transportation Planning Regions (TPRs) as they develop and update their respective Regional Transportation Plans (RTPs); and
- developing an Intelligent Transportation Management System, similar to the 6 management systems identified in the ISTEA legislation, so that effective statewide database and management procedures can be accessed and used by all affected organizations.

Inter-/Intra-Agency Agreements. Agencies typically operate autonomously, recognizing the chain of command for the transportation network to process the appropriate paper work that coordinates the interface with a facility not under their respective jurisdictional control. In Colorado and in the I-70 West Corridor, the Interstate and State Highway systems are operated and maintained by CDOT. These systems comprise all the freeway and major arterial routes in the I-70 West Corridor study area.

CDOT does share or turn over operations and maintenance functions of state highways within incorporated municipal boundaries. In most cases, CDOT maintains some control by requiring access permitting through the regional engineering jurisdiction. Often, CDOT will operate and maintain the signal systems at access intersections to the facilities.

Exclusive control of components and subsystems within the I-70 West Corridor ITS is not necessarily in the best interest of CDOT. Local jurisdictions, able to implement a subsystem to serve local needs, are not necessarily willing to turn over control to a regional or state agency.

Coordinated incident response plans and cooperative local traffic operations need uniform standards and processes for operations and maintenance. Information sharing (including data gathering and dissemination) to provide advanced traveler information services will require cooperation between all jurisdictions, both public and private. Any cost sharing mechanisms will require agreement (on who pays what and who will be responsible for what) between participating organizations.

It is appropriate to develop standard agreements that protect the rights and responsibilities of any agency or organization. CDOT, counties, and municipalities have entered into standard contractual arrangements with service consultants, vendors, and contractors. Written contracts stipulate the rules for an outside organization to provide the agency with a product or service in exchange for monetary compensation.

Interagency agreements do not necessarily exchange a product or service for money from one agency to another. These are "gentlemen's" agreements, not bound by a handshake, but by a written document, intended to protect both parties in the longer term as personnel and/or relationships change (where handshakes become less obligatory). Interagency agreements provide a legal, contractual document that binds each agency to act or serve, along with the other, in a prescribed arrangement.

Interagency or inter-organization agreements may be executed to show "good faith"' participation in a multi-agency/organization undertaking. A "Memorandum of Understanding" (MOU) between two or more organizations is typically executed at project initiation, indicating that each agency or organization involved intends to participate in the program or project. MOU's are non-binding--they only set a precedent for a particular organization's interest in a project and the intent to participate. Any party to the MOU can withdraw at any time. MOU's should be developed for every I-70 West Corridor project where more than one group has responsibility for an action or an operational function for the project.

A Memorandum of Agreement (MOA) is similar to an MOU but is legally binding. This instrument relegates each party to specified terms and conditions. Clauses for termination by one or more parties may allow compensation, in some form, to the other party or parties. These agreements are particularly important for establishing ownership, responsibilities, and cost-sharing arrangements. Where multiple organizations are involved in a particular ITS project or program, MOA's should be executed to bind funding for design and construction.

Operations and maintenance (O&M) agreements define roles and responsibilities of participating agencies and organizations for multi-jurisdictional involvement to maintain adequate operation of ITS technologies. O&M agreements should be executed prior to testing and start-up for all subsystems, (variable message signs, highway advisory radio, video surveillance, information kiosks) where more than one entity will have responsibility for operating and/or maintaining the equipment and staffing the operation.

Joint Powers Agreements may be considered in place of individual agreements between organizations and/or agencies. Joint Powers Agreements, like MOA's are legally binding. Execution of such an agreement between multiple agencies/organizations establishes the roles and responsibilities of each agency/organization and may include cost-sharing arrangements and ownership clauses.

All interagency/organization agreements should be developed with advise from legal counsel representing each group involved. Terms and conditions for formal, binding agreements should endeavor to cover all bases to protect all parties. ITS agreements, executed by other state and local agencies and organizations, are readily available for constructing specific project and program agreements for the I-70 West Corridor ITS. The involved groups are very willing to discuss the outcomes and consequences of their agreements.

Because of the organizational nature of CDOT, it may be appropriate for CDOT to execute intra-agency MOU's. Because ITS technologies cross jurisdictional boundaries, particularly with respect to the I-70 West Corridor, establishing non-binding understandings of roles and responsibilities between the ITS Program Office, the C-TMC, and the Engineering Regions with respect to subsystem development, implementation, operations, and maintenance will enhance an atmosphere of trust and cooperation.

For example, the Engineering Regions are constrained by staff shortages, making it difficult to stay on top of operating advanced technology subsystems such as variable message signs. At the same time, the Engineering Regions have the technical expertise to maintain the equipment. MOU's between the C-TMC and the Engineering Region can spell out the roles and responsibilities with respect to operations and maintenance, strengthening the cooperative arrangement. Similarly, such MOU's may be important between Engineering Regions as advanced technology subsystems (lighted guidance tubes, vehicular probes, emergency response, congestion management) cross regional boundaries.

Training. Staffing ITS operations is one of the major issues elsewhere that has left deployment at a standstill. For example, the HELP, Inc. CVO program (electronic credential checking at ports of entry in many western states) funded and built a state-of-the-art automated POE south of Las Cruces, New Mexico. Because the New Mexico State Highway and Transportation Department (NMSH&TD) does not have experienced personnel to operate the facility, all systems are idle.

The CDOT Engineering Regions have limited staff to perform design checks, operate, and maintain electronic and computer systems necessary for ITS. Currently, the region traffic engineers have been designated as the regional ITS engineer, but, with all their other traffic engineering responsibilities, little time is left for education, training, and oversight of electronics, telecommunications, and systems operation. Each region will eventually need dedicated ITS specialists who can respond to the planning, design, and construction requirements. This individual(s) can either be hired in from the marketplace or cross-trained from within. If the regions decide to cross-train an current staff member, those individuals should be identified and trained as soon as possible so that no lapses in capability and need occur.

In CDOT's Region 1, capable personnel operate and maintain tunnel control operations at the Eisenhower tunnel complex. Tunnel complex management has indicated that there is no freedom among the electronic/computer specialists to take on addition assignments. For the region to take over operation and maintenance of ITS subsystems, additional personnel are needed. In CDOT's Region 3, ITS and tunnel control staff are in place. Region 3 management needs to stay abreast of current staff work loads as new ITS applications are deployed to ensure that personnel numbers and capabilities keep pace. In CDOT's Region 6, additional staff are being added as metropolitan ITS subsystems are deployed. At the interim TOC, staffing continues to be addressed as new systems and subsystems are brought on line.

ITS Program Technical Actions

Corridor-Wide Operations (Strategic Deployment) Plan. A process must be developed to create a Corridor- Wide Operations Plan. The production of this document must be a cooperative effort between the CDOT ITS Program Office and the 3 Engineering Regions with jurisdiction over I-70. The Plan should include the following elements to identify how each project and sub-system are integrated into the corridor-wide system:

- detailed system architecture definition;
- lines of responsibility and procedures for inter-jurisdictional:
  + cooperation,
  + operations,
  + maintenance,
  + financing,
  + staffing and training, and
  + program follow-through; and
  + program controls for:
  + implementation budgets,
  + implementation schedules,
  + procurement,
  + public and private sector partners, and
  + system/sub-system integration.

The Corridor-Wide Operations Plan should be updated annually. It should also be distributed to all engineering, operations, and maintenance supervisors (state, regional, and local) to serve as their guidance document and reference manual for systems operation.

The I-70 West Corridor-Wide Operations Plan needs to document and further define alternative technologies to provide concrete guidelines for recommending specific technologies within project-specific development plans. The following considerations have been initially assessed during the identification and screening of alternative technologies (highlighted in the Information Search and Needs Assessment companion documents) and during the development of the corridor-wide system architecture concept (documented in Section VI, ITS Development and Evaluation):

+ performance and reliability;
+ cost;
+ standards;
+ integration of existing components;
+ procurement opportunities;
+ operations and maintenance resources and capabilities;
+ environmental impacts; and
+ consistency with state-wide and national plans.

A list of existing communications, computer, and electronic technologies has been developed, each item having appropriate applicability for implementation of ITS Candidate Actions within the I-70 West Corridor. These include:

+ vehicle probes	+ weather sensors	+ infrared sensors
+ microwave sensors	+ radar sensors	+ closed-circuit television
+ aerial surveillance	+ computer-aided dispatch	+ weigh-in-motion devices

+ automatic vehicle location	+ fiber optics	+ highway advisory radio
+ auto vehicle identification	+ roadside beacons	+ transponders
+ two-way radio	+ cellular radio	+ cellular telephone
+ cable television	+ satellite	+ land lines
+ spread-spectrum microwave	+ digital am/fm subcarrier	+ pager-based radio
+ lighted guidance delineation	+ automatic lane controls	+ road use pricing
+ incentive programs	+ commuter/passenger rail	+ light rail transit
+ high speed rail	+ dead reckoning	+ route selection algorithms
+ automatic movable barriers	+ data fusion	+ real-time traffic prediction
+ electronic parking controls	+ ramp metering	+ incident detection algorithms
+ central computer systems	+ local areanetworks	+ adaptive signal control
+ wide area networks	+ HOV lanes	+ signpost odometer
+ global positioning systems	+ map matching	+ video monitoring
+ video surveillance	+ video broadcasting	+ variable message signs
+ variable speed signs	+ 2-way call boxes	+ solar power
+ ramp metering	+ information kiosks	+ loop detectors

In conjunction with the standards setting and specification development recommendations, a consultant or team of ITS specialists within the organization need to define, in the Corridor-Wide Operations Plan, the appropriate applications and functions of these technologies within the I-70 West Corridor ITS Program framework. This will ensure corridor-wide compatibility between subsystems so that the system-wide vision is met.

The Corridor-Wide Operations Plan should also spell out system-wide measures of effectiveness for the entire I-70 West Corridor ITS performance. Each subsystem will be evaluated separately--it is equally important to recognize how the corridor-wide system functions as a whole and well as how it functions in context with the statewide ITS. A initial set of system-wide performance measures were developed to provide criteria for architecture development. These are equally measurable appraisals for evaluating the effectiveness of the system-wide ITS:

+ Quantifiable Appraisals:

+ travel time	+ fuel consumption	+ energy usage
+ vehicle occupancy rates	+ emission rates	+ accident rates
+ transit usage rates	+ transit service reliability	+ economic stimuli
+ public investment	+ private investment	+ capital costs
+ operating costs	+ maintenance costs	+ traffic counts

+ Qualitative Appraisals:

+ user attitude	+ public reaction	+ political will

Performance measures need to be detailed so that a quantifiable measurement can be regularly taken to make comparison of "before and after" operations. Unfortunately, many "before" statistics are

not readily available. For example, travel times are documented as a "period of congestion" or a "delay occurring due to an incident" or "the volume through the tunnel on Friday, March 20 between the hours of 4 and 7 pm was 50,000 vehicles." Everyone recognizes that these events occurred, but they are not quantified in terms of "x minutes of delay." When new ITS infrastructure is deployed, delay times can become quantifiable. The goal for establishing reasonable performance measures includes being able to measure that performance with available data.

Reasonable performance measures will this the owner/operator of the facility to evaluate ITS technologies and the benefits thereof. It will also provide useful information that can be used to sell the advantages to those who allocate transportation improvement funds and to those who use the system.

Corridor-wide functional requirements have been established with respect to the I-70 West Corridor ITS architecture. This initial assessment is documented in Section VI, Program Development and Evaluation. Functional requirements must be further detailed in the Corridor-Wide Operations Plan so that, as each individual project is brought on-line, they meet the existing and emerging system-wide requirements. This will ensure interoperability and compatibility among technology applications. Initial functional requirements have been conceptually identified for the following components:

- monitoring and surveillance (and roadway/roadside data collection sources);
- system/sub-system communications (data distribution);
- infrastructure/vehicle/traveler interface;
- control strategies;
- navigation and guidance;
- data processing; and
- in-vehicle sensors.

The Corridor-Wide Operations Plan must also include the "how, when, where, why, and what" elements for information collection, processing, and dissemination. If this is developed at the system level, it will be much easier to develop and design the requirements for individual subsystems (within the recommended projects).

Retrofit/Dismantle/Replacement of Proprietary Subsystems.Connectivity of existing equipment to new systems is imperative if a fully integrated system is to be achieved. If the data collected from one sensor or detector cannot be utilized by new software and hardware, that data is essentially useless. An inventory of the "openness" of existing devices needs to be made prior to the deployment of new subsystems.

Some equipment and devices can be retrofitted to provide interconnectivity. Others may have proprietary operating systems, incompatible or inadequate communications media, or out-dated controls. A benefit-cost analysis, of each device or group of like devices, should be performed,

using life-cycle costing methodologies, to determine if it will be cheaper and/or more beneficial, over the long run, to continue to use existing equipment/systems or scrub them for new devices.

Implementation Plan Updates. Annual updates to this Implementation Plan will maintain future consistency with all other programs and projects (those initiated for the I-70 West Corridor and its linkages to the rest of the northwest and Denver metropolitan regions), as well as state-wide and national ITS initiatives and programs.

This may be as simple as updating recommended project schedules and budgets. It may involve documenting other ITS initiatives that have been developed and not recognized in this plan. It may need to include private sector initiatives that have changed the development and/or implementation parameters of the projects identified herein (for example, US West/CDOT may establish an agreement for fiber installation along the length of the corridor that allows elimination of interim communications media).

This can be a good activity for the I-70 West Corridor Coalition. By having an established annual activity, the members of the Coalition will make a better attempt throughout each year to stay abreast of other ITS activities and perform regular evaluations of this Plan to make sure it meets emerging needs and changing requirements.

Standards Setting. Standards for communications and electronic technologies and procurement and construction specifications have yet to emerge within the State of Colorado. Engineering Regions have tested an assortment of equipment, such as variable message signs. The respective operations and maintenance supervisors/staff continue to purchase specific brands or configurations for various reasons (for the variable message sign example, bulb matrix signs are believed by some to provide better visibility for both day and night; others prefer flip disk because it is easier to maintain since bulbs don't have to be changed).

Because ITS technologies will be deployed throughout the state, this is a state-wide issue. Colorado is already installing numerous technologies with little consideration for easy use and recognition by the user. Because this will be an issue as ITS technologies and subsystems, that cross regional boundaries, are implemented within the I-70 West Corridor, it is appropriate that a recommendation arising from this study encourages development of statewide standards and protocols.

A recommendation to achieve statewide standards as early as possible (I-70 West Corridor Early Action projects are scheduled for development and implementation within the next five years), a subcommittee of the Statewide ITS Implementation Team should be appointed to develop specifications. A technically knowledgeable individual from each Engineering Region, the ITS Program Office, the Division of Telecommunications, the Colorado State Patrol, and the Division of Revenue (ports of Entry) should serve on this committee to bring knowledge of system operations and functions.

Outside help should be sought where necessary. Standards-setting organizations [Institute of Electrical and Electronic Engineers (IEEE); American Society of Testing and Materials (ASTM); Society of Automotive Engineers (SAE); American Association of State Highway and Transportation Officials (AASHTO); Institute of Transportation Engineers (ITE); Transportation Research Board (TRB); International Standards Organization (ISO)] have developed standards and protocols for a variety of ITS-related technologies. The Standards and Protocols Technical Committee of ITS America and the Standards and Protocols Committee of the ITE ITS Council have experts addressing this issue. CDOT may consider hiring a consultant, well-versed in standards development, to assist the committee in developing Colorado's ITS statewide standards.

Cost/Benefit Comparison for Selection of Competing Transportation Improvement Projects. There is currently no process for making a reasonable decision as to which transportation improvement projects should be funded and when they should be deployed. This is usually accomplished by subjective, personal bias and/or by political pressure. A comparative methodology needs to be developed that prioritizes projects based on need. Projects that will be funded by other sources should be excluded from the priority listing so that CDOT can concentrate on the remaining projects that provide the greatest benefit to the majority of users.

This is a statewide concern, but has grave implications for the early implementation of ITS projects within the I-70 West Corridor. If the authority that allocates the funds is more predisposed to spend budgeted dollars on a routine resurfacing project (whether from political pressure or personal belief that the constituency will want this most), an ITS project, competing for the same "pot of gold," will be put on the back burner, whether it has more long-term benefit for the majority or not. A comprehensive, quantifiable appraisal of all competing projects would allow that authority is *make* better, more informed decisions about which projects to fund--much like the assumption that a more informed traveling public will make better decisions as to when, how, and where to make a trip.

The CDOT ITS Program Office should coordinate with the other Divisions to establish how, when, and by whom to develop such a process. Until the process exists and is in use, the ITS Program in Colorado may continue to be leveraged through political processes, continuing to alienate the constituents that the program is trying to serve and bring into the fold. Early action projects for the I-70 West Corridor will remain a statewide responsibility without regional advocacy and will eventually become medium- or long-term actions as the schedules slip due to lack of funding. With the dynamics of ITS, they can become 'non-projects" very quickly.

Technical Components for Project-Specific Actions

Project Development Guidelines. Every project needs a solid plan of action to guide its development and implementation. Similar to CDOT's Work and Management Plan for traditional transportation projects, the Project Development Guidelines should provide detailed information on how each project will be managed, administered, planned, and designed.

The Project Development Guidelines should be a working document--a plan that all project partners can reference and follow to ensure that each element of the project is carried out. As a dynamic and flexible document, it should be organized so that information can be modified, changed, or deleted as the project development matures.

Project Management.A team of individuals should be selected from each of the involved partners. The lead agency or organization would be responsible for designating a project leader--that individual who can stay with the project through completion and into operations, when the Project Evaluation Plan is carried out.

Staffing assignments and responsibilities must be determined early on. All personnel, from every participating agency, for each stage of the project must be involved in the project from the start to the finish. This ensures understanding of all elements associated with planning, design, deployment, and operations by each of the team partners. The project team includes managers, workers, reviewers, and approvers.

Project management occurs throughout the project's life-cycle. The Project Development Guidelines detail the lines of responsibility (who reports to whom); the lines of communication (who should be aware of what, when); all project personnel names and contacts; and outside representatives through which the project must be coordinated. The type of procurement requirements and the processes for determining how those requirements can be met should be defined in the guidelines.

Project Administration. The Project Development Guidelines should describe outside consultation requirements--what types of services and products will be needed that cannot be provided by the project partners for all phases of project development and deployment. The roles and responsibilities of consultants and vendors must be detailed.

Procurement procedures for products, services, construction, operation, and training should be amended to the project guidelines one the procurement rules and regulations are defmed. If any procurement regulations are contrary to those that need to be followed, the process for modifying those regulations need to be documented so that they can be carried out during the planning stages of the project.

Budgets, schedules, and who and how costs will be monitored and controlled must be established in the Project Development Guidelines. Cost-sharing arrangements need to be specified. Methods for developing and executing inter-agency/organization agreements must be defined. Any consultant and vendor contracts should be included.

Quality assurance and control measures need to be established in the Project Development Guidelines to ensure technical accuracy and quality in the planning and design processes. A procedure for checking, review, and approval of all project documents (reports, plans, specifications,

standards) by an independent party will ensure that subsystem elements are integrated and operable with other elements within the system and other subsystems.

Planning and Design.A detailed scope of work must be incorporated in the Project Development Guidelines to define each task required for the planning and design phases.

There are many good models available for writing the Project Development Guidelines. A search of those that have been developed by private sector manufacturers, suppliers, and consultants can be investigated to find an appropriate model that fits the needs of each project. Once the Project Development Guidelines are written for the first project, it can become a model for subsequent project guideline development--modified, as necessary, to meet changing requirements.

Project Development Guidelines must document appropriate performance measures and functional requirements under which each sub-system must function. These should be derived from the measures and requirements developed for the corridor-wide ITS. Sub-system attributes should be defined during the planning stages, defining how, where, when, why, and what components are needed. This will facilitate the design of the sub-systems and deciding which technologies best meet the prescribed needs.

Project Operations Plan.Staffing, training, and operations and maintenance procedures need to be defined during the planning phases of the project and solidified as the designs are completed. The Project Operations Plan defines the staffing requirements for operations and maintenance of the resulting system. This includes which agencies or organizations will staff the system as well as where those individuals will come from (existing staff, new hires) and what kind of training those individuals will need and how they will be trained.

The Project Operations Plan must describe how systems will be operated and maintained and by whom. One partner may operate while the other maintains. Identifying the lines of authority and responsibility will be of prime importance as the project is being designed and deployed so that these personnel are involved in start-up and testing of the systems before they are fully operational.

Project Evaluation Plan.It is vital to ensure that envisioned benefits meet or exceed the actual capital, operating, and maintenance costs. The operating agencies must know that their expenditures of taxpayer dollars satisfy public expectations so that continued investment in a project can be justified. The Project Evaluation Plan establishes the process by which the responsible entity will measure “before and after” conditions associated with the project. It identifies what measures are to be used for comparison; who will collect, tabulate, and evaluate the data; how long the evaluation period should continue; what thresholds would be considered acceptable; and contingency requirements should the project not perform to expectation.

The Project Evaluation Plan needs to be developed during the planning phase of a project so that the right "before" information can be gathered. The established parameters for evaluation will help to determine how "before and after" data will compare as "apples versus apples."

EARLY ACTION PROJECT IMPLEMENTATION

Early action (short-term) projects have been identified by the stakeholders in the I-70 West Corridor as having the highest priority to effectively resolve current transportation problems within their respective jurisdictions. Site-specific implementation recommendations require leadership and initiation by the respective Engineering Regions and their constituents. The major thrust of these projects is to provide a showcase of advanced technology applications that policy/decision-makers and the general traveling public can experience and use. A "hands-on" demonstration is one of the most meaningful ways to reach-out to the masses and gain needed institutional and public acceptance and support.

Projects recommended as high priority on a corridor-wide basis are noted as such. These have implications for systems integration between the CDOT Regions and other national, state, and local organizations and agencies (CSP, Division of Telecommunications, Division of Revenue, local enforcement and emergency service jurisdictions, National Park Service, Bureau of Land Management, National Forest Service). These will require a cooperative effort in leadership to ensure project success.

High priority projects that have statewide significance would be initiated by the CDOT ITS Program Office, coordinated through the Engineering Regions and other national, state, and local agencies. Cooperative and coordinated activities between the various stakeholders will be the key to the rapid deployment and high acceptance of these projects and programs.

The early action project recommendations are:

- Road/Weather/Traffic Condition Information System:
  - Voice/Data Communications Upgrades (EAP CS-4/Corridor-Wide),
  - Call Box System (EAP ER-3/Corridor Wide; State-Wide),
  - Summit Stage Transfer Center APTS/ATIS Operational Test (EAP PTAM-l/ Region l),
  - Georgetown Gusty Wind Sensor/Variable Message Sign System (EAP TIS-l/ Region 1), and
  - Vail Super-HAR/VMS Program (EAP TIS-S/Region 3);
- Interstate Traffic Management System (State-Wide):
  - Automated Reversible Lane Program (EAP TMO-3/Region l), and
  - Hanging Lake Tunnel Control Center Upgrades (EAP CS-9/Region 3);
- Interstate/National Highway System Fiber Optic Backbone (State-Wide):
  - High-Capacity Data Transmission Links (EAP CS-2);

- Incident Management Programs:
  + Hot Spot Courtesy Patrols (EAP ER-l/Corridor-Wide),
  + Incident Investigation Sites (EAP SW-l/Corridor-Wide), and
  + Emergency Response Information System (EAP SW-8/Region 3);
- Dumont/Downieville Automated Port of Entry (EAP CVO-2/CVO Division; Region 1);
- Advanced Technology Roadway Delineation (EAP SW-4/Corridor-Wide);
- Advanced Ice Detection/Warning System (EAP DCA-7/Region 3; Corridor-Wide); and
- Mobile Emissions Testing Stations (EAP EEI-S/Corridor-Wide).

Figure VII-2 maps all recommended early action (short-term) projects to their respective locations within the I-70 West Corridor study area. Each project proposes a specific solution to transportation problems and needs, building on existing operations and current technologies. They each provide a foundation for initiating medium- and long-term ITS activities, as proposed herein, and as new ideas are formulated and new technologies are developed.

Many of the recommended projects, because they were identified in the ***Early Action Projects*** task of the 1-70 Rural IVHS study, are in the design and implementation stages.This is notable, enforcing the exceptional value of the study process and the cooperative and championing spirit of those involved. Additional financial partners (public and private alike) will be more inclined to participate in I-70 West Corridor ITS projects and programs (short, medium, and long-term) as they recognize this commitment by CDOT and other champions.

Early action projects are deliberately very generalized to allow flexibility in development and design of a system. Programs and projects, although not absolutely necessary in certain segments of the I-70 West Corridor, should not be viewed as "we don't need that" because personal opinion does not champion a particular cause and/or because funds or staff are not presently available to design, build, operate, and maintain them. This mentality does not look to the future to solve transportation issues. It also casts doubts on perception of governmental "integrity",

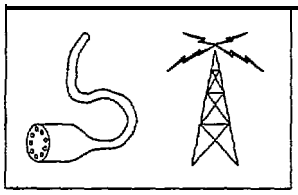
Recommendations should be regarded as opportunities to become more customer-focused. Each ITS project, while providing an alternative solution to a mobility and/or safety concern, can be highly visible and can create positive public endorsement. Implementors should take each recommendation and look for additional openings to enhance and expand the idea or program and leverage other investors into participation to the benefit of the organization and those using and impacted by the movement of people and goods along the I-70 West Corridor. Rejection of a proposed solution because its viewed by one stakeholder as not needed may not really be the attitude of the majority of stakeholders.

Because the development of the Corridor Master Plan was conducted by and for the operating agencies, several of the recommended early action projects (or portions thereof) have already been initiated, and, in some cases, deployed. This indicates the strong desire, on the part of the leaders

at the regional level, to be proactive about ITS. Evaluation, operation, and integration plan development is the next step for these projects.

Figure VII-3 schedules the overall implementation time-frame for each short-term project with respect to all others. The schedule suggests an aggressive and concerted effort by CDOT, within the next 5 years, to initiate and lay the foundation for further advancing an integrated ITS within the I-70 West Corridor. Unfortunately, current funding mechanisms may not allow a jump-start on these projects in the recommended time frame. However, each time line does give a good indication of the length of time that should be spent on each project.

Descriptions of the 15 recommended early action projects follow. Project data sheets, in the companion document, Early Action Projects Executive Summary, should be referenced to glean additional detail. Implementors of each project are encouraged to refer to other companion documents as they initiate, plan, and design their respective projects.



Voice/Data Communications Upgrades (EAP CS-4/Corridor-Wide)

Transportation Problem/Need:	Inadequate Communications Systems Limited Financial Resources
Corridor-Wide ITS Goal(s):	Augment Communications
User Service Objective(s):	Gathering/Processing/Disseminating Reliable Condition Data Advancing Traffic Operations Management/Control
Corridor Functional Area:	Communications Systems/Public-Private Partnerships
NPP User Service Bundle(s):	Travel-Transportation/Travel Demand/Emergency Management

Purpose: To provide interim communications equipment at appropriate sites/entities and linkages between those sites/entities to collect, process, and disseminate road, weather, and traffic condition data as a reliable and inexpensive immediate-need solution.

This project was originally defined due to the unreliability and inadequacy of telephone communications at remote sites along the I-70 West Corridor, particularly at the Eisenhower Tunnel Control Center and Vail Pass Rest Area. These two sites are perceived, by the traveling public, as centers where information should be available. The operations/maintenance staff at the Tunnel and Rest Area indicated frustration at being isolated from the "rest of the world." Lack of contact prevents advisory communications within the immediate area as well as responding to and advising others about road, weather, and traffic conditions beyond the immediate area.

By tapping into the current iTOC Public Information Officer (PIO) program, needed communications equipment and linkages can be installed as part of an ITS initiative. Each "site" can report on localized conditions and activity and be advised of circumstances/events at other "sites." The resulting ability to advise travelers on road, weather, and traffic conditions up- and downstream of the "information center" creates an invaluable and positively-received service to the traveling public.

Correlation To Existing Plans/Programs: The CDOT ITS Program Office is initiating a Communications Study for the I-70 West Corridor. This project, under contract with Lockheed-Martin through the Statewide ITS Pool Contract, will address communications requirements within the I-70 West Corridor. This project will be developed and designed based on the recommendations established from that study (which sites can be linked via fiber, TWP, or microwave and what components/materials will be required).

CDOT Region 1 prepared and presented an I-70 West Corridor action plan to the Colorado Transportation Commission that addressed coordination and communications issues including:

- current condition information is often unavailable and inaccurate;
- when condition information was available, it is often untimely and not credible;
- media reporting of condition information is not always consistent;
- the traveling public is ill-informed about current condition information; and
- traffic generators (resorts, airports) are not included in the information dissemination network, creating a secondary contribution to recurring traffic congestion and safety problems.

The proposed I-70 West Corridor Coordination and Communications Plan recommended the following actions:

- expansion of iTOC/C-TMC operations to 24 hours per day, 7 days per week;
- development of protocols to maintain accuracy of information received by the C-TMC;
- creation of processes for disseminating information to user groups and the traveling public in a timely manner; and
- implementation of ITS technologies, including dedicated telecommunications between road control and the C-TMC and communications improvements between Eisenhower Tunnel and the C-TMC.

This project provides an immediate and cost-effective solution that addresses these issues and coordinates with the overall plan proposed by CDOT Region 1.

The Smart Path Strategic Plan (one of a series of technical reports incorporated into Colorado's 20 Year Transportation Plan) recommends that condition information-dispensing services be provided to meet statewide information needs. This project was designed to build a program out of that vision.The Smart Path Business Plan identifies this project for implementation.

The ITS Program Office has identified a statewide Road/Weather/Traffic Condition Information System, incorporated into the STIP, that includes a plan to expand the current PI0 program and to deploy other advanced technology applications (kiosks, radio broadcasts, information signing) to disseminate information to the traveling public. This project is intended to provide an integrated solution for the I-70 West Corridor within that statewide initiative.

Nationally, the Advanced Rural Transportation Systems Technical Committee of ITS America recommends development of potential opportunities for public/private partnerships for funding and operation of regional traveler information centers that field test pre-programmed, read-only portable travel information systems (ROPTIS), kiosks with'automated service-provider update capabilities, and active logo-signing system demonstrations with multiple business participants. This project provides the first step in getting timely and accurate condition data to private partners so that they can develop and implement these types of field tests for dissemination of information to the traveling public.

The FHWA Office of Research Rural Applications of Advanced Traveler Information Systems (DTRH 61-93-C-00048) project recommends several similar nationwide projects based on a comprehensive survey of rural transportation needs. Applications include a Telephone/Fax Information System, Localized Radio Broadcast, Automated Kiosks, and Electronic Mail. This project provides the initial equipment and information collection/distribution system to implement similar traveler service features.

Operational/Organizational Relationships. A comprehensive program would provide connectivity between:

- CDOT iTOC/C-TMC Public Information Officer (PIO) Program--PIO's collect and disseminate road, weather, and traffic condition, and construction activity information data statewide;
- CDOT regional/field offices; CSP regional communications facilities; Eisenhower and Hanging Lake Tunnel Control Centers; rest areas (Vail Pass, Grizzly Creek, Hanging Lake, No Name);
- CDOT Public Relations Division;
- Local law enforcement and emergency response centers;
- Media outlets that broadcast information to the public (Metro Traffic Control, radio, television, and cable stations);
- Other media outlets/entities that provide information to the general public (local newspapers, ski resorts, town information centers, chambers of commerce); and
- Airport information centers (Denver International, Colorado Springs, Eagle, Aspen, Hayden).

Recommended Project Components. Building on the initial recommendations established for this project, additional sites are proposed. Coordination with entities outside of CDOT and CSP, to provide a comprehensive condition information dissemination program, extends beyond the current duties and functions of CDOT's PIO's The other entities would be responsible for providing the required equipment, communications media, and staffing to tie into the system.

Initial upgrade sites, within the I-70 West Corridor, were identified as the Eisenhower Tunnel Control Center (CDOT Region 1); the Road Control/County Field Office (CDOT Region 1); Vail Pass Rest Area (CDOT Region 1); and the Eagle Regional Communications Facility (CSP).

Equipment recommendations for data transmission, at a minimum, would include a dedicated transmission medium (copper twisted pair, fiber, microwave) and a computer/modem workstation (modem configured for 14.4 kbps minimum). A plain paper facsimile machine can serve as an alternate to the computer workstation for receiving data. A dedicated telephone/line is required for voice communications.

Communications links would be established between all sites. Those include each new/upgrade site previously identified plus additional sites where the operating agency/organization has the ability to provide advisory information to a group of Corridor users. CDOT Region 1,3, and 6 Regional and Field offices, the Colorado Traffic Operations Center (where the data is gathered and processed), and CDOT Public Relations Division are involved in the current PI0 Program. The project initially recommended that the upgrades and liiges be established at Eisenhower Tunnel, Vail Pass Rest Area, CSP's Regional Communications Center in Eagle, and the Region 1 Road Control/County field office at the Hidden Valley interchange in Clear Creek County.

To make the program as comprehensive as possible, other sites are recommended:

- Hanging Lake tunnel control center;
- local municipal, law enforcement, emergency dispatch centers;
- airports (Denver International, Colorado Springs, Eagle County, Aspen, Hayden);
- resorts (Loveland, Keystone, Breckenridge, Copper Mountain, Vail, Aspen);
- broadcast media stations (initially Metro Traffic Control, KOA, KUSA, KCNC, KMGH, KWGN); and
- local print media services (initially Rocky Mountain News, Denver Post, Summit County Sentinel, Vail Times, Glenwood Springs Post, Aspen Times, Grand Junction Sentinel).

Project Implementation/Phasing Plan. The C-TMC PIO's would serve as the data collection/dissemination central operative. Each remote site would report to the PIO's on a pre-planned reporting schedule (every hour or other time frame that is designed specifically for each site) and when a special or emergency "event" occurs. The PIO's would process the information and re-distribute it to all sites. Posting and/or announcing condition information to the general public would be at the discretion of each entity at their respective sites.

Table VII-l and Figure VII-4 refine the schedule for implementing this project at the 4 recommended upgrade sites. Sites at media and airport locations will not require extensive communications system design and can be phased in as space and equipment are dedicated to the project. In some cases, equipment and facilities are currently available; contacting and contracting with those entities to coordinate and implement the service may be the only requirement.

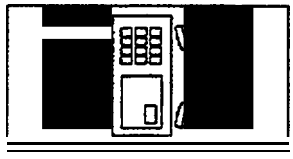
TABLE VII-1
VOICE/DATA COMMUNICATION UPGRADES (EAP CS-4)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	***Management:*** – Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress ***Administration:*** – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing ***Planning:*** – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP – Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	***$5,000*** ***$5,000*** ***$50,000***	***18*** months ***6*** months ***6*** months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	***$25,000***	***3*** months
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	***$5,000-$55,000*** per site	***6*** months
Operations/ Maintenance	**Staffing** Operating Timetable Maintenance Schedule	$10,000/Site	Monthly

For example, the ITOC PIO's could go on-line with Metro Traffic Control, KOA, and the television stations as soon as a cost-sharing arrangement is developed and agreed upon. These sites can conceivably be in operation as soon as the Project Development tasks are approved between the consenting agencies, as early as Summer/Fall 1996. For all initiatives, the site specific Operations and Evaluation Plans and Marketing Strategy are key to ensuring and tracking the success of each installation.

Project evaluation should continue through December 1998. At that time, a benefit cost analysis should be performed to determine if other sites should be added to the traveler information service network. Project staff should also remain abreast of other advanced traveler information services (both in-house and by others) that come on-line, making this system obsolete.

Call Box System
(EAP ER-3/Corridor Wide; State-Wide)



Transportation Problem/Need:	Lack of Personal Traveler Security
Corridor-Wide ITS Goal:	Improve Traveler Security
User Service Objective(s):	Increase Safety
Corridor Functional Area:	Emergency Response/Safety-Warning Systems
NPP User Service Bundle(s):	Emergency Management

Purpose: To provide cellular or land line telephone equipment along the roadside at regular intervals throughout the corridor to allow motorists to report problems or needs. The project would increase driver safety and security in many of the remote, sparsely populated areas of the corridor while providing accurate and timely incident information to corridor control centers.

Correlation To Existing Plans/Programs: Currently 40 call boxes are located approximately every 1/2 mile throughout Glenwood Canyon, in CDOT Region 3. The existing call boxes are one-way radio call boxes that are not adequate for emergency communications. A plan has been developed, and installation has been initiated, to replace those boxes with cellular, two-way equipment. The new call boxes will be located at the same 1/2 mile intervals. Additional call boxes will be located at the Edward's Rest Area and at the south end of the Canyon. Forty-two 2-way cellular call boxes are planned for the Glenwood Canyon area.

Within CDOT Region 1, 13 cellular, two-way call boxes have been recently installed as a result of the Early Action Project development for this study. CDOT Region 1 prepared and presented an I-70 West Corridor Plan to the Colorado Transportation Commission, addressing the communications requirements within that jurisdiction of the I-70 West Corridor. This 1-70 West Corridor

Coordination and Communication Plan provided justification for the installation of these boxes. The Commission voted to allocate a portion of the 1995-6 $2.5 million ITS funding allocation to the installation of these call boxes. In cooperation with the ITS Program Office, call box installation was completed in December 1995.

The Smart Path Business Plan identifies call box installations statewide and within the I-70 West Corridor. The project, I-70 West Corridor-Wide Call Box System, calls for communications companies to install and maintain call boxes at regular intervals throughout the corridor. The project, Statewide Call Box Service Program, supports the I-70 West project, calling, additionally, for regularly spaced call boxes throughout the I-70, I-76, and I-25 corridors. The project, Statewide Road and Weather Condition Information System, identifies an emergency call box system, in addition to other systems, to collect information, statewide, regarding roadway and weather conditions.

Appendix B to Colorado's 20-Year Transportation Plan identifies Emergency Response Information Systems as a non-programmed, but significant project for CDOT Region 3. This action includes emergency call box installations.

Operational/Organizational Relationships Implementation of the project would continue to be the major responsibility of the CDOT ITS Program Office and/or the Engineering Regions. Depending on arrangements made with private sector vendors, installation and maintenance of call boxes will continue to reside under CDOT authority. CDOT would assume an overview position, if privatization of tbis subsystem occurs, assisting in roadside improvements and legislative obstacles as well as promoting the completed system. This aspect of the project would allow CDOT the opportunity to enter into a public/private partnership which, while directly increasing the safety of the driving public, should be well received.

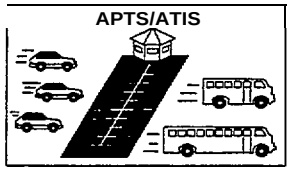
Institutional Issues. There are varying opinions within the CDOT Engineering Regions with respect to call box installation validity. Some purport that call boxes are an unnecessary expense because "all" motorists have cellular telephones for emergency calling. Others contend that call boxes are worth the added capital installation dollars to serve the majority of travelers who do not have in-vehicle cellular service. This issue needs to resolved within each region as individual segments of the I-70 West Corridor are instrumented.

Recommended Project Components: The ultimate configuration would result in cellular, two-way call boxes throughout the I-70 West Corridor spaced every 1/2 mile within both eastbound and westbound rights-of-way. The configuration for early action recommends, in addition to completed and planned installations, call boxes located at existing interchanges within the corridor and at 1/2 spacing along Vail Pass from the Shrine Pass Road Interchange (Exit 190) to the East Vail Interchange (Exit 180) as well as along the segment from the West Vail Interchange (Exit 173) to the Avon Interchange (Exit 167).

As in-vehicle ITS technology development evolves, there may be future opportunities for cellular telephone users to poll call boxes in cases of emergencies. This would compliment current and future MAYDAY applications where a motorist can make a call for help through the call box system without leaving their vehicle.

Project Implementation/Phasing Plan: Due to the initiative kindled by Regions 1 and 3, this project has undergone initial planning and implementation. To complete the recommended call box installations, an annual planning and design period (April to September) is proposed over the 5 years to determine the prioritization of locations to be instrumented. Installations of priority locations would occur annually between October and March.

Table VII-2 and Figure VII-5 identify the costs and schedules for remaining call box deployment.



Summit Stage Transfer Center APTS/ATIS Operational Test (EAP PTAM-l/Region 1)

Transportation Problem/Need:	Limited Financial Resources/ Lack of Coordination-Cooperation/ Ineffective Information Dissemination/ Shortage of Transit Services
Corridor-Wide ITS Goal(s):	Promote Transit Usage/ Encourage Private Sector Investment/ Use Technologies in Innovative Ways/ Encourage Public Acceptance/ Promote Transit Usage/Improve Transit Service
User Service Objective(s):	Disseminate Reliable Weather/Road/Traffic Condition Data/ Augment Transit Facilities, Service, and Accessibility/ Develop Multi-Modal Opportunities/ Identify-Secure Public and Private Partners/ Leverage-Funding Sources/ Cooperative Working Environment
Corridor Functional Area:	Public Transportation-Alternate Modes/ Public-Private Partnerships/Education-Training
NPP User Service Bundle(s):	Travel-Transportation and Travel Demand Management/ Public Transportation Operations and Management

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Purpose: To piggy-back the first intelligent traveler information service onto a planned transportation facility improvement that encourages use of alternative transportation modes. The

TABLE VII-2
CALL BOX SYSTEM (EAP ER-3)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	*Management:* – Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	$5,000 per annum	on-going
	Administration: – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordiite with Procurement/ Purchasing	$5,000 per annum	3 months
	Planning: – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP – Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$5,000 - $10,000 per site	3 months per year
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions		3 months per year
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$5,000 per site	6 months per year
Operations/ Maintenance	Promotional Campaign Staffing Operating Timetable Maintenance Schedule	$10,000 per annum	Monthly

relocation and enhancement of the Summit Stage Transfer Center opens up a prime opportunity to invest allocated funds toward potentially-high public acceptance and appreciation, while, at the same time, testing existing traveler service technologies along a rural corridor.

This project provides an opportunity to develop and test information sharing technologies between high-traffic tourist collection points (Keystone area ski resorts and Denver International Airport). It envisions a public/private consortium of local and state governments, ski resorts, transit service providers, private shuttle operators, local businesses, and airport operators and airlines to form a cost- and information-sharing partnership that can have dramatic benefits for all parties involved.

Correlation To Existing Plans/Programs: The C-Star Strategic Plan for IVHS Systems in Colorado, developed for CDOT, identifies a Travel Information Display project (TRAVELMAP) that would graphical display of travel information for presentation on computer terminals. It also specifies an Intelligent Rest Area (AQUI) that would provide travelers with a variety of regional and statewide data regarding travel and tourist information. A Rideshare Management and Matching project (RIDEMATCH), a School Bus and Transit Monitoring program (SAFEGUARD), and an Advanced Paratransit Dispatching program (RESPOND) propose elements that encourage use of alternate travel modes, real-time information dissemination, and automated service scheduling.

CDOT Region 2, after recently completing the new Cuemo Verde Rest Area, on I-25 near Colorado City, is in the process of implementing a kiosk that will, initially provide visitors with static tourist information on a touch-screen computer system. The ultimate vision for this rest area will include dissemination, via this computer system, of real-time traffic, weather, and road conditions for statewide travel.

The Interim TOC currently supports the collection of statewide road, weather, traffic, and construction activity information by PIOs. The information is currently faxed or modemed to information dissemination sources and can easily be transmitted to the Summit Stage Transfer Center information kiosk.

The Smart Path Business Plan incorporates this project in its Program Actions as a medium-term activity for providing intermodal transportation facilities. CDOT Region l's I-70 West Corridor Plan includes a Public Awareness/Education Plan that recommends actions to provide road and weather condition information to ski areas and cities/counties along the I-70 West Corridor to disseminate to customers and to provide information to tourists at Denver International Airport.

Additionally, the Colorado Transportation Commission allocated $1 million to Region 1 to assist in the construction of the new Summit Stage Transfer Center. Although a large portion of this money will be used to purchase property, some of the allocation could be used to leverage private dollars to jump-start the project.

Appendix B of Colorado's 20-Year Transportation Plan identifies the SH 9 corridor between Frisco and Breckemidge as a non-programmed priority operational and modal project that is included in this project's description statement. A Region wide Traveler Information System, that includes the Summit Stage ATIS portion, is also included in this priority plan. Summit Stage facility expansion is also included in Appendix C of the 20-Year Plan as a preferred long-range need.

As a part of a federal project for NCHRP, Kimley-Horn & Associates performed a Case Study of the Summit Stage APTS/ATIS proposal as a review of how a public-private-community partnership can be developed. This exposure at the national level can stimulate opportunities to leverage additional funding sources for the project. (The section of the Case Study report is included as an appendix to the companion *I-70* Rural IVHS study *Business Plan and Marketing* Strategy document.)

The Rural ATIS study, a federally-funded investigation into rural transportation needs and appropriate ITS applications for traveler information, recommends development of public/private partnerships to fund and operate regional traveler information centers. Recommendations from this study will carried forward by FI-IWA to fund those recommendations. The study also proposes preliminary concepts for vehicles as probes and automated kiosk development and recommends a prototype field test to equip a probe vehicle with sensors to collect condition data.

Operational/Organizational Relationships. Summit Stage and CDOT Region 1 are anticipated to be equal partners in the management and administration of this project. Each will assume cost-sharing roles commensurate with their respective abilities to provide funds for the project. Partnership participants and their respective roles and responsibilities, identified in the Early Action Project (reference: *Early Action Projects Executive Summary),* remain flexible until the project is formally initiated.

Other highly-potential partners include Denver International Airport (and the City and County of Denver), the Keystone Resort complex, Breckemidge and Copper Mountain resorts, and Resort Express. The Town of Frisco currently opposes the action due to a non-congenial relationship with Summit Stage. Other towns (Breckenridge, Silverthome, Dillon) may come to the table with in-kind services.

Local businesses have expressed great interest in the project because they are often bombarded by tourist traffic when I-70 is shut down. They are ill-prepared to serve a rapid, unplanned influx of customers during bad weather/road/traffic conditions.

Once operational, Summit Stage would assume responsibility for all transit service subsystems. CDOT (Region 1 or the ITS Program Office) would operate and maintain the computerized information subsystems. Arrangements have not been initiated for DIA's role and responsibility for planning, design, operations, and maintenance of an advanced traveler information center at their facility.

Recommended Project Components. A GPS/AVL system, similar in function to that being used by RTD, would be implemented for the existing Summit Stage transit system serving Breckenridge, Copper-Mountain, Keystone, Dillon, Frisco, and Silverthorne. Traveler information kiosks would be installed at the new transfer center and at DIA initially. Additional kiosks can be added at major Summit Stage stops in the towns it services as monies are identified.

It was initially assumed that data collection, processing, and dissemination would occur at the Eisenhower regional TOC. Because space and staff constraints, this operation may take place at the ITOC and eventually the C-TMC.

Resort Express, a private shuttle operator providing service between DIA and the Dillon Valley, has indicated a strong interest in participating in the program, particularly as a probe along the I-70 West Corridor to report and receive information regarding road, weather, and traffic conditions. This may initially be accomplished through radio or cellular reporting with future on-vehicle devices to sense, detect, and transmit data electronically.

The partnership with DIA would include developing a cooperative arrangement with the airlines to provide flight schedule information to tourists accessing the information kiosk in Frisco and future locations.

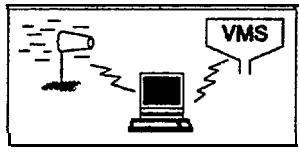
Future enhancements to the overall system are described *in the Early Action Projects Executive Summary.*

Project Implementation/Phasing Plan. The ideal time-frame is to start the project immediately. As part of Colorado's endeavor to apply for funding through the federal Model Deployment solicitation, a unique advantage to Colorado's proposal suggests interties with the I-70 West Corridor because of the impact of the Denver metropolitan area on travel and recreational activities in the mountains. If this project can be activated, some of the federal and state allocations could be relayed to this project. Cost-sharing mechanisms for this project could be counted as part of a local match to federal funds.

Table VII-3 and Figure VII-6 designate a recommendation to initiate this project in mid-1996. Some of the background development and coordination activities have been started by CDOT Region 1, Summit Stage, the Summit County Commission, and the I-70 Rural IVHS study consultant. With several strong agency, community, and business proponents, the Region has tremendous opportunity to gain outside financial (as well as management and coordination) support. A project team, including CDOT, Summit Stage, Denver International Airport, resort owners, other local businesses, area municipalities, and resort shuttle service operators, should be established immediately to plan and design system programs and components. It can be worthwhile to bring Vail area agencies and providers onto the project team in the early stages to identify if and when that area and transportation systems can be added to the overall program.

TABLE VII-3
SUMMIT STATE TRANSFER CENTER APTS/ATIS OPERATIONAL TEST (EAP PTAM-1)
IMPLEMENTATIN PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	*Management:* – Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	*$100,000*	6 months
	Administration: – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing	$100,000	6 months
	Planning: – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP – Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$200,000	18 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$400,000	12 months
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$1,440,000	15 months
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	$105,000 per annum	daily/ monthly



Georgetown Gusty Wind Sensor/Variable Message Sign System (EAP TIS-1/Region 1)

Transportation Problem/Need:	Commercial Vehicle Use of the Corridor Inadequate Communications Systems Ineffective Information Dissemination Recurring Incidents at Known Locations
Corridor-Wide ITS Goal(s):	Increase Safety/Use Existing Technology in Innovative Ways/ Augment Communications and User Interface
User Service Objective(s):	Monitor Commercial Vehicles/Reduce Accident Frequency/ Gather, Process, Disseminate Reliable Condition Data
Corridor Functional Area:	Commercial Vehicle Operations/Traveler Information Systems/ Data Collection-Aggregation/Safety-Warning Systems
NPP User Service Bundle(s):	Travel and Transportation Management/ Commercial Vehicle Operations/Emergency Management

Purpose: To provide motorists, particularly those in high profile vehicles that are susceptible to swerving and tipping in high wind gusts, with real-time wind speed advisories. This project is intended to reduce the risk of wind gusts to all motorists traveling along I-70 in the vicinity of Georgetown where recurrent high winds are a typical problem.

Correlation To Existing Plans/Programs: CDOT Region 1 prepared and presented, in the I-70 West Corridor Plan to the TCC, the need for increased public awareness. The Plan calls for road and weather information to be provided to ski areas and city and counties along the corridor for dissemination to their customers as well as to corridor travelers via VMS.

The Smart Path Business Plan introduces the project, Statewide Road and Weather Condition Information System, which proposes the collection and dissemination of road and weather information throughout the state. The Georgetown Area Gusty Wind system is also included as a medium-term activity to provide integrated traveler information services.

The C-Star document proposes the MESSENGER and ADVICE projects for traveler information systems. MESSENGER calls for the implementation of a statewide broadcasting service for road, weather, construction and other traveler information. Although MESSENGER specifies radio as the medium for dissemination, the identified need (to collect and disseminate weather information for travelers) is very similar to the Georgetown area Gusty project. ADVICE promotes VMS coverage to inform motorists of traveler information including weather and warning messages.

The Georgetown Area Gusty Wind project is included as part of the Region wide Traveler Information System, listed in Appendix B for Colorado's 20-Year Transportation Plan.

The Rural ATIS project, a federally sponsored study that focuses on rural transportation needs and appropriate ITS actions, recommended a preliminary concept for dynamic roadside signs and flashers. This concept features roadway-based infrastructure, additional warning beyond static signs, weather detectors, and remote controls.

The I-70 West Transportation Needs Assessment, prepared in April 1988 by CDOT, recommended that a study be conducted in 1990 to define optimal locations and installation of additional VMS within the I-70 West Corridor in Clear Creek, Summit, and Eagle Counties.

Operational/Organizational Relationships. This project would require an internal CDOT partnership between the ITOC/C-TMC and Region 1. The Georgetown VMS may be a part of the current initiative to turn operations of all I-70 West Corridor VMS within Region 1 jurisdiction over to the ITOC. Eight additional VMS and one overhead VMS are currently being designed for installation as a result of the Transportation Commission of Colorado (TCC) allocation for 1995 ITS funds to Region 1.

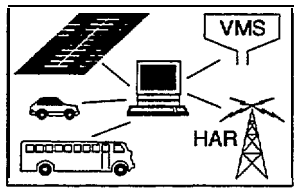
If the VMS remain under iTOC jurisdiction, it will be most appropriate for the ITOC to integrate and operate the weather sensor subsystem. Region 1 should participate in the development and funding of this project.

The ITS Program Office may be able to assist in certain cost-sharing arrangements with the private sector. Some proprietary weather stations are already installed within the I-70 West Corridor. Similar subsystems and arrangements may be appropriate for the Georgetown Area Gusty Wind project.

Since this project poses high benefit to increase safety for commercial vehicle operators, the trucking industry or a private carrier may be willing to share some of the equipment costs and/or installation costs. CDOT may want to provide additional incentive by offering some form of static advertisement on the VMS sign standard that indicates some part of the system donated or sponsored by a public and/or private partner.

Recommended Project Components. Wind speeds would be monitored by field sensors (weather stations). An expert system needs to be developed to process the raw data collected from the wind sensors and electronically transmitted, in motorist-readable format, to VMS advisories in advance of the affected area.

Project Implementation/Phasing Plan. The development and implementation of this project is proposed for initiation in 1997. Table VII-4 and Figure VII-7 illustrate the recommended schedule and identify conceptual costs for each of the project development activities.



Vail S u p e r - H A R S Program
(EAP TIS-5/Region 3)

Transportation Problem/Need:	Inadequate Communications Systems/ Ineffective Information Dissemination/ Limited Financial Resources
Corridor-Wide ITS Goal(s):	Augment Communications-User Interface/ Use Technologies in Innovative Ways/ Enhance Traveler Mobility/ Encourage Public-Private Investments
User Service Objective(s):	Gather, Process, Disseminate Reliable Condition Data/ Provide Traveler Information/Reduce Delays/ Evaluate Processes and Regulations/ Identify and Secure Investment Partners
Corridor Functional Area:	Communication Systems/Data Collection-Aggregation/ Traveler Information Systems/Institutional Issues/ Public-Private Partnerships
NPP User Service Bundle(s):	Travel and Transportation/Emergency Management Public Transportation Operations

Purpose: To reduce congestion in the Vail region, thus reducing the burden on I-70 operations and maintenance. To provide travelers with accurate, up-to-date information on the current operating status of the local roadway network and parking systems and to provide motorists with travel advisories to mitigate any problems. To promote public transportation by providing up-to-date information on local bus service.

Correlation To Existing Plans/Programs: Although not within CDOT Region 1 jurisdiction, travel to the area impacts I-70 operations between Denver and Vail. The Region, in support of all I-70 West Corridor functions, addressed the need for increased public awareness in its I-70 West Corridor Plan presentation to the TCC. The Plan calls for road and weather information to be provided to ski areas and city and counties along the corridor for dissemination to their customers.

The C-Star document proposes the MESSENGER and ADVICE projects for traveler information systems. The MESSENGER program calls for the implementation of a statewide broadcasting service (i.e. HAR) for road, weather, construction, and other traveler information. The ADVICE

TABLE VII-4
GEORGETOWN AREA GUSTY WIND SENSOR/VMS SYSTEM(EAP TIS-1)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	*Management:* – Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	$10,000	9 months
	Administration: – Determine Outside Consultation Requirements - Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing	$5,000	2 months
	Planning: – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities - Identify and Allocate Project Funding – Incorporate Project Into STIP – Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$5,000	2 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$25,000	3 months
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$375,000	2 months
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	$30,000 per annum	monthly

project proposes VMS coverage to inform motorists of traveler information including weather and warning messages.

The Vail Super HAR/VMS project is listed in Appendix C of Colorado's 20-Year Transportation Plan as a preferred long-range need for CDOT Region 3. The program continues to be of great interest to the Town of Vail.

The I-70 West Transportation Needs Assessment, prepared in April 1988 by CDOT, recommended that a study be conducted in 1990 to defme optimal locations and installation of additional VMS within the I-70 West Corridor in Clear Creek, Summit, and Eagle Counties.

ENTERPRISE is conducting a research program to use AM broadcast sub-carrier channels for transmitting traveler information messages to in-vehicle radios. They have recently had a tremendous breakthrough in rigging an inexpensive transmitter that effectively broadcast messages across mountainous terrain. This program may have significant implications for the implementation of the Vail Super-HAR/VMS project.

Operational/Organizational Relationships. This project is intended as an equal administrative, managerial, and funding partnership between CDOT Region 3 and local governments/businesses. The potential benefit to the Town of Vail and to the Vail ski resort is far greater than that to CDOT. This suggests CDOT's willingness to cooperate and participate to the extent that other more important programs are not compromised.

A public/private partnership with Vail Associates is quite probable. The ski resort owner has indicated previous interest in investment for high-success rate projects that will increase its customer base and demonstrate a valid community service. The owner may be willing to, in addition to installing an HAR transmitter on top of the Vail gondola tower, provide some capital for VMS equipment.

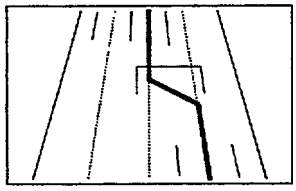
Business partners could be solicited if they can receive an advertising benefit as a return on their investment. Advertising over the HAR could include a sponsorship message, such as "This parking availability announcement is brought to you by..." If this relationship is desired, project implementors must make rule-making application to the FCC to allow advertising over publicly-owned broadcast systems.

Institutional Issues. CDOT Region 3 is supportive of this project, although some believe that it is more appropriate as a medium or long-term project. It is additionally purported that this project should be federally-funded (as an operational or rural model deployment project) and that it should be instigated by the private sector since advertising will be most beneficial to those organizations. These opinions and perceptions are well-founded and valid and should be discussed and resolved when the project is initiated. The previously-stated operational and organizational recommendations indicate that CDOT should be a participant but will not necessarily initiate or lead the program.

Recommended Project Components. The concept of a "Super-BAR" connotes something more than an HAR transmitter that broadcasts advisories. A "super" system includes a automated linkage between the HAR and the VMS to catch all motorists prior to the decision-making moment as to which exit from I-70 into the area should be taken. This also assumes that real-time messages, rather than pre-programmed messages, are transmitted to both devices. This presupposes an expert system and appropriate sensors so that data can be collected, processed, and transmitted electronically.

Instrumenting kiosks and local buses can be accomplished when the system is first deployed or at a later date. These are intended to enhance the system functions by providing additional sources for public access to the information.

Project Implementation/Phasing Plan. Based on CDOT's ability to participate in this program, as well as a 4 year implementation and evaluation time-frame, it is recommended that this project be initiated in 1997. Table VII-5 and Figure VII-8 represent the schedule for this project. Approximate costs for development, design, deployment, and operations are noted on Table VII-5



Automated Reversible Lane Program
(EAP TMO-3/Region 1)

Transportation Problem/Need:	Congestion/No Alternate Routes
Corridor-Wide ITS Goal(s):	Enhance Traveler Mobility/ Use Existing Technologies in Innovative Ways
User Service Objective(s):	Increase Operational Capacity/Reduce Delays/ Develop Congestion Management Strategies/ Advance Traffic Operations Management and Control
Corridor Functional Area:	Traffic Management/Operations
NPP User Service Bundle(s):	Travel-Transportation/Travel Demand Management

Purpose to reduce peak directional congestion at and between the Twin Tunnels east of Idaho Springs through the Eisenhower Tunnel. Continually increasing directional peak traffic volumes created by winter ski traffic and spring/summer/fall vacation travel results in heavy congestion on facilities that otherwise operate adequately under normal travel demands. Reversible lanes provide additional roadway capacity in the direction of high volumes to help alleviate congestion conditions. Manual reversible lane programs are cost and labor intensive when implemented in remote locations. Automation of reversible lane operations can provide a cost-efficient and seemingly instantaneous (to the traveler) method for accommodating peak hour traffic volumes.

TABLE VII-5
VAIL SUPER-HARVMS PROGRAM (EAP TIS-5)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	Management: – Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	$50,000	48 months
	Administration: – Determine Outside Consultation Requirements - Execute MOU's With Other Entities – Coordinate with Procurement./ Purchasing		6 months
	Planning: - Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP - Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$25,000	6 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$125,000	21 months
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$515,000	9 months
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	$30,000 per annum	monthly

Correlation To Existing Plans/Programs: CDOT personnel currently operate a manual reversible lane program at the Eisenhower Tunnel. The reversible lanes are implemented during pre-planned periods when high peak directional traffic is anticipated that shifts the 2:2 lane configuration to a 3: 1 configuration.

The C-Star document identifies the project AUTOLANE, the use of automatic barrier systems for implementation of reversible lane programs on areas of highway with high peak directional splits.

Region l's I-70 West Corridor Plan, presented to the TCC, includes a Statewide Plan that recommends operational and efficiency improvements within the I-70 West Corridor in the next 20 years. Mid-term capital improvements are identified, including tunnel improvements.

Region 1 will also initiate a Major Investment Study for the I-70 West Corridor to investigate, and hopefully, arrive at an adequate level of consensus, on a major investment that can alleviate the problems associated with recreational travel through the corridor. An automated reversible lane investment has greater potential for stakeholder acceptance than adding lane capacity (proposed by Governor Romer) and/or tolling the facility (proposed by Secretary of Transportation Pena).

The I-70 West Transportation Needs Assessment (April 1988) addressed the 3: 1 lane configuration, from both manual and automatic operation standpoints. Interestingly, this alternative placed last out of 17 options as a viable resolution of the capacity problems. Of the 17 candidate actions for 1991 to 2000, only the first (6-laning I-70 from the west tunnel portals to Silverthorne) and the last (implementing the 3: 1 lane configuration) were implemented.

Undetermined I-70 West Corridor improvements are identified as regional priorities in Appendix A of Colorado's 20-Year Transportation Plan. Three million dollars of a $49 million investment have been programmed in the STIP.

Operational/Organizational Relationships. CDOT Region 1 will probably continue as the sole operator. The ITOC/C-TMC may operate the associated VMS at the request of Region 1.

Because of the innovative use of an existing technology (movable barrier systems are currently used for developing detours around construction activities), and the high potential for positive public approval, an opportunity to leverage federal dollars may be feasible if a good marketing campaign is organized.

This project was initially designed to facilitate staffing requirements at the Eisenhower Tunnel for deployment of the existing system from manual to automatic control. A more real need for the 3:l lane configuration is apparent at the Twin Tunnels east of Idaho Springs. Because of the remote location (staff are not on-site as they are at Eisenhower), an automated system is more realistic than a manual operation.

Recommended Project Components. A manual field test for the Twin Tunnel area could be implemented to determine if a 3:l lane split configuration is a viable technique to improve operational capacity. If the results are positive, the automated system could be deployed.

The motors and hydraulic barriers are luggable (i.e., they are not installed permanently in one location, but they are not necessarily easily portable because of their size and weight). A field test could be performed at the Twin Tunnels, and, after implementation and evaluation, if not proven functional in this area, it could be "moved" to some other problem location. This would alleviate concern about the capital equipment investment if the system failed to operate as planned. This is also contingent on a need for use of such a system in other areas along I-70 or potential equipment-sharing with other CDOT regions.

Pop-up barriers could be used effectively within the tunnel(s) to delineate the two-way movement in one tunnel bore. Although additional maintenance will be required to keep the apertures clear of debris, there is some protection afforded by installing these inside the tunnel only. VMS that advise of a change in lane configuration in advance of the operation can be used for other traveler advisories when the normal 2:2 lane configuration is in place.

Project Implementation/Phasing Plan. It is recommended that this early action project be modified to field test a manual, then automatic system in one direction (potentially westbound during Sunday afternoon/evening peaks in the winter months) at the Twin Tunnels east of Idaho Springs. For the $3.5 million investment, this program may prove to be a significant improvement to traffic operations. Additional systems, if feasible, could be phased in along the segment of I-70 between the Twin Tunnels and Eisenhower Tunnel over a 20 year period as monies become available.

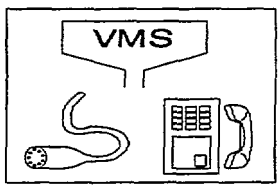
Table VII-6 and Figure VII-9 provide a proposed implementation schedule. Table VII-6 offers a modified cost estimate (from that established in the Early Action Project Executive Summary) to implement the system at the Twin Tunnels. Access modifications to carry traffic across the median between the eastbound and westbound lanes will be required.

Automated barrier-moving systems will become more attractive with respect to cost as more and more applications are deployed across the country. CDOT Region 1 should monitor which companies are improving and enhancing their respective manufactures to determine if subsystems and operational aspects are being devised to meet I-70 West area requirements.

The Region should also monitor deployed and evaluated applications elsewhere to ascertain if said systems provide ample benefit for the investment. For example, the Utah DOT purchased a moveable barrier system to improve efficiency in making lane configuration changes during construction activities. Conversations with operations and construction personnel will provide ample information as to the longer term benefits of that purchase.

TABLE VII-6
AUTOMATED REVERSIBLE LANE PROGRAM(EAP TMO-3)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development –	*Management:* Assign Project Leader and Staff - Establish Responsibilities for Work, - Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	$25,000	48 months
	Administration: – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing	$ 5,000	15 months
	Planning: - Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP – Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$25,000	21 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$50,000	9 months
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$3,000,000	9 months
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	$35,000 per annum	monthly



Tunnel Control Center Upgrades
Hanging Lake (EAP CS-9/Region 3)

Transportation Problem/Need:	Inadequate Communications Systems/ Ineffective Information Dissemination/ Lack of Personal Travel Security
Corridor-Wide ITS Goal(s):	Augment Communications-User Interface Increase Safety
User Service Objective(s):	Gather, Process, Disseminate Reliable Condition Data Develop Incident Management Strategies
Corridor Functional Area:	Communications Systems Data Collection/Aggregation Emergency Response/Safety-Warning Systems
NPP User Service Bundle(s):	Travel and Transportation/Emergency Management

Purpose: To upgrade the Hanging Lake Tunnel Operations communications system and improve video surveillance and call box systems in the Glenwood Canyon area, Better communications interface for data collection and dissemination is necessary between tunnel control and devices in the Canyon. Fixed position black and white cameras are inadequate to monitor traffic and traffic conditions. Existing call boxes in the Canyon do not provide adequate emergency communications for stranded and needy motorists.

Correlation To Existing Plans/Programs: Fiber optic communications media are in-place throughout the Hanging Lake Tunnel complex to interface tunnel control systems. The existing communications media infrastructure would allow upgrade of substandard surveillance and safety devices. CDOT Region 3 has prepared a strong and comprehensive plan for upgrading current systems and adding new operations for other roadway facilities (particularly SH 82 infrastructure) as the need arises and funding is allocated.

The C-Star HUB traffic management proposal suggests establishment of linked TOCs to serve as a focal point for IVHS activities. The program specifically references upgrades to the Hanging Lake operation.

The Smart Path document calls for the development and implementation of regional TOCs. The project specifically references the Hanging Lake Tunnel TOC and suggests that regional TOCs around the state be linked together. The project describes extensive monitoring, communications, and data dissemination systems for each facility.

The C-TMC vision for an open statewide system architecture includes a Hanging Lake Tunnel TMC as a regional control, linked to other TMC's through the IT1 Network. The Region 3 Long-Range Operations and Maintenance Plan for the Hanging Lake Tunnel and Glenwood Canyon complex describes these component upgrades.

The Glenwood Canyon Transportation Operation Center Upgrade is included in Appendix B as a non-programmed priority in Colorado's 20 Year Transportation Plan.

Operational/Organizational Relationships. All proposed subsystem upgrades will be operated by the controlling interfaces within the Hanging Lake Tunnel operations complex. Region 3 has announced its intent to have the Hanging Lake complex serve as a regional TOC. Its eventual linkage to the statewide ITI Network is will enable the intent to share information with other TMCs interconnected to the statewide system.

Recommended Project Components. Fiber optic communications media are needed to connect the existing VMS and video surveillance equipment in the Canyon and in Glenwood Springs with the tunnel control center infrastructure. This will ensure accurate and reliable data collection, processing, and dissemination between devices. Color cameras with pan/tilt/zoom capabilities will supplement and replace existing fixed-position black/white models. Two-way cellular call boxes with voice communications capabilities will replace existing one-way, push-button calls transmitted by radio frequency.

With the reconstruction of SH 82, a comprehensive ITS is planned. It is intended that these systems and subsystems will be operated out of the Hanging Lake complex. Communications and roadside infrastructure will be interconnected to current and enhanced systems within the tunnel control center.

Project Implementation/Phasing Plan. The communications, surveillance, and emergency call components identified in this upgrade project are vital to enhancing capabilities to provide traveler security within the Canyon confines. The recommended implementation plan suggests an annual phased approach to effectively use programmed funds. Planning, design, and installation would occur during the first half of each year; evaluation of system performance would take place during the second half of the calendar year.

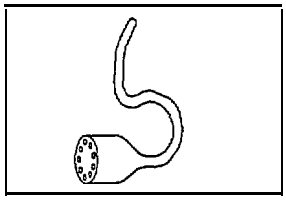
Table VII-7 and Figure VII-10 identify a phased schedule to upgrade the Hanging Lake complex with appropriate fiber connections and camera upgrades. The preliminary cost estimates provided in Table VII-7 identifies project development, deployment, and O&M costs. Design for fiber location is assumed to be included in the installation cost.

CDOT Region 3 should evaluate current and future staffing requirements on a regular basis to determine if and when additional resources will be needed to operate new subsystems as they come on line.

TABLE VII-7
TUNNEL CONTROL CENTER UPGRADES (EAP CS-9
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	~ TIME LINE
Project Development	*Management:* - Assign Project Leader and Staff - Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	$10,000	60 months
	Administration: – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing	$5,000	24 months
	Planning: – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP - Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance - Develop Project Evaluation Plan – Finalize Marketing Strategy	$10,000	30 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions		30 months
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$4,245,000	48 months
Operations/ Maintenance	**Staffing** Operating Timetable Maintenance Schedule	$30,000 per annum	monthly

High-Capacity Data Transmission Links
(EM CS-2/State-Wide)



Transportation Problem/Need:	Limited Financial Resources/ Inadequate Communications Systems
Corridor-Wide ITS Goal(s):	Encourage Private Sector Investment/ Augment Communications-User Interface
User Service Objective(s):	Identify-Secure Investment Partners/ Advance Traffic Operations Control/ Improve Current Processes
Corridor Functional Area:	Public-Private Partnerships/Communications Systems
NPP User Service Bundle(s):	All User Service Bundles

Purpose: To provide communications media that can handle data-intensive transmission throughout the entire I-70 West Corridor. Capability to support present and future ITS, as well as other communication applications, is paramount.

Correlation To Existing Plans/Programs: The I-70 West Corridor Plan, presented to the Transportation Commission of Colorado by CDOT Region 1, identifies a coordination and communications plan. The plan calls for the development of dedicated telecommunications between field devices and TOCs as well as communications improvements between the Eisenhower Tunnel and the Colorado-TMC.

The Smart Path document identifies an I-70 West Corridor Communications project. This project recommends the establishment of communications connections between the Colorado-TMC, the Eisenhower Tunnel Control Center and the Hanging Lake Tunnel Control Center. The C-Star HUB project suggests statewide TMC interconnect via appropriate communications media.

Several segments of the I-70 West Corridor have been laid with fiber. Fiber was placed within the I-70 rights-of-way in Glenwood Canyon during the reconstruction of that portion of the Interstate facility. This communications network is owned and operated by CDOT. Private telecommunications companies have placed fiber within other rights-of-way at various locations along the corridor. For example, US West laid conduit along the bike path between Frisco and Vail. CDOT may or may not be able to gain access or "light" excess fiber for transportation uses in these

third party conduits. The key will be to connect all existing fiber optic cables into continuous, corridor-wide coverage.

The enabling legislation in HB 1267 allows telecommunications companies to install fiber within Interstate and State Highway rights-of-way. Recent federal legislation, that deregulates the telecommunications industry, will enable smaller industry companies to compete for business. These firms may be willing to negotiate more acceptable resource-sharing mechanisms, but it will need to be accomplished soon, before the industry is no longer willing to "cut" special deals.

Operational/Organizational Relationships. Depending on who installs the fiber and what arrangements are made with respect to use of the I-70 rights-of-way, some relationship will exist between CDOT and one or more telecommunications companies. The ITS Program Office may be involved if a statewide "deal" can be negotiated. Regions should coordinate with the ITS Program Office so that numerous agreements are not made with a multitude of firms. The best arrangements can be made where large quantities keep unit costs low.

Operational relationships will also be dependent on the agreements entered into. If CDOT leases fiber, then operational and maintenance requirements will be necessary to interconnect trunk lines and local devices. If CDOT trades fiber for right-of-way, operations and maintenance of the entire fiber system, exclusive of conduit, will be CDOTs responsibility.

Recommended Project Components. Continuous fiber and appropriate interconnects to traverse the entire length of the I-70 West Corridor. Through the I-70 West Communications Study being conducted by Lockheed-Martin, functional requirements are being identified as to data flow and rate and polling rate so that adequate capacity can be defined for current and future uses.

Conduit and other associated apparatuses may or may not belong to CDOT. Lease arrangements need to be developed and negotiated. CDOT will be, more than likely, responsible for all interconnect and local feeds (as has been the usual negotiation for fiber deals by other State DOT s).

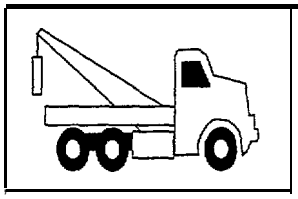
Project Implementation/Phasing Plan. The ideal project implementation time-frame is now. This will not occur any time soon if CDOT has to foot the entire bill. Identifying potential resource-sharing partners should begin as soon as possible or continue if they have been initiated.

Contacts with telecommunications companies to determine where and how much fiber can be laid in exchange for use of public rights-of-way must be made immediately so that agreements can be negotiated between the companies and the Attorney General's office.

Depending on what arrangements are negotiated, the project time line will be dependent on other third party schedules. Table VII-8 and Figure VII-l 1 identify location, a desirable schedule, and currently anticipated costs.

TABLE VII-8
HIGH-CAPACITY DATA TRANSMISSION LINKS (EAP CS-2)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	*Management:* ✓ Assign Project Leader and Staff ✓ Establish Responsibilities for Work, Coordination, Review, and Approvals ✓ Finalize Procurement Procedures ✓ Monitor/Coordinate Project Progress *Administration:* ✓ Determine Outside Consultation Requirements ✓ Execute MOU's With Other Entities ✓ Coordinate with Procurement/ Purchasing *Planning:* ✓ Refine Work Scope, Costs, Products, and Services ✓ Contact, Coordinate, and Contract Cooperating Entities ✓ Identify and Allocate Project Funding ✓ Incorporate Project Into STIP ✓ Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance ✓ Develop Project Evaluation Plan ✓ Finalize Marketing Strategy	$25,000 $25,000 $25,000	60 months 36 months 24 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	n/a	n/a
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$10-$50 per lineal foot	within the next 5 years
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	per agreement	annually



Hot Spot Courtesy Patrols
(EAP ER-l/Corridor-Wide)

Transportation Problem/Need:	Incidents/Personal Travel Security/ Reinforce Economic Benefits/Limited Confidence
Corridor-Wide ITS Goal(s):	Increase Safety/Enhance Traveler Mobility/ Encourage High-Level Acceptance
User Service Objective(s):	Reduce Delays and Emergency Response/ Develop Incident Management Strategies/ Improve Current Processes/Increase Operational Capacity
Corridor Functional Area:	Traffic Management-Operations/Emergency Response/ Institutional Issues/Education-Training
NPP User Service Bundle(s):	Travel Demand Management/Emergency Management

Purpose: To establish a "preventative" incident management strategy to quickly respond and clear vehicular obstructions (non-injury) from the travel way where motorist assists are warranted. To implement a program throughout the I-70 West Corridor that has know-n (and proven) high public acceptance. Service areas would include heavily traveled segments of the I-70 West Corridor and, potentially, can be enhanced by providing service along State Highways that feed into I-70 and serve other communities and resort/recreational areas (US 6, SH 119, US 40, SH 9, US 24, SH 13 1, SH 82).

Correlation To Existing Plans/Programs: The I-70 West Corridor Plan, presented to the Transportation Commission of Colorado by CDOT Region 1, identifies an incident management plan that calls for the provision of courtesy patrols at high incident locations within the I-70 West Corridor during peak travel periods.

CDOT Regions 1 and 3 currently operate an incident management patrol (of sorts) as part of the respective field crew responsibilities within and near the Eisenhower and Hanging Lake tunnel complexes. These teams are fully-equipped to assist with stranded motorists, accident clearance, and fire and hazardous material spill incidents.

The Colorado Incident Management Coalition (CIMC) [comprised of CDOT, the Denver Regional Council of Governments (DRCOG), the American Trucking Association Foundation (ATAF) and the Colorado Motor Carriers Association (CMCA), and the Institute of Transportation Engineers (ITE)] was tasked, in 1992, to develop a statewide incident management plan that would result in methods and techniques to reduce the subsequent congestion that occurs due to downstream

incidents. One of the CIMC's recommendations to accomplish this is the establishment of Courtesy Patrols.

Courtesy Patrols, as an implementation of the Colorado Statewide Incident Management Plan, are operating in the following corridors within the Denver metropolitan area:

- I-25 from Dry Creek Road to 84th Avenue
- I-70 from Federal Boulevard To Buckley Road
- I-225 from I-70 to Colfax Avenue

After a year long pilot project, these Patrols were such a "raving" success with the traveling public that funds have been allocated to continue the programs indefinitely.

The Smart Path document identifies Courtesy Patrol Expansion to augment Denver metropolitan area services through private sector sponsorships. A similar concept, proposed by the federally-sponsored Rural ATIS study team, suggests a "CVO Samaritan" program that interconnects en-route truckers to public agencies for notification about incidents and motorist assists they encounter along their travels.

Incident management programs are stipulated in Appendix D of Colorado's 20 Year Transportation Plan as non-programmed priorities for CDOT Regions 4 and 6. The preferred plan long-range needs include initiation and/or expansion of incident management strategies statewide. An incident management plan is currently being developed for the City of Pueblo by the CDOT ITS Program Office.

Operational/Organizational Relationships. "Hot spot" Courtesy Patrols would be funded by the respective CDOT Engineering Regions and operated either by a contracted private towing company or the respective Region's maintenance crews. Contract agreements would stipulate communications with CDOT maintenance crews, CSP, and local enforcement, fire protection, and emergency services providers. CSP would take incident reports and motorist assist call-ins through their computer-aided dispatch, routing calls directly to the Courtesy Patrol provider. Incidents occurring within or within the current service area of the Eisenhower and Hanging Lake tunnels would continue as a CDOT regional responsibility, with CSP and other service organizations providing assistants.

To minimize costs to CDOT, innovative marketing strategies can enlist cost and service sharing in exchange for advertising. Organizations to be included in such an endeavor might be local governments, the service providers, and other local private sector sponsors (businesses, ski resorts). Similarly, telecommunications companies may be willing to provide cellular telephones and air time to the Courtesy Patrol vehicles in exchange for sponsorship advertising. CDOT's Public/Inter-Governmental Relations Division may want to manage and administer this program or be intimately involved.

Institutional Issues. There is still some disagreement within the CDOT Regions that a Courtesy Patrol service is necessary. Courtesy Patrols are one method to manage non-accident-related roadside obstructions and provide traveler security. The implementation of such services are more apparent for Region 1 where large numbers of recreational travelers traverse the I-70 West Corridor within known periods on weekends and holidays. A program can be equally effective along the I-70 West Corridor in the Vail to Dowds Junction segment (Region 3 responsibility), where weather-related incidents and heavy traffic occur. It also has possible merit along the SH 82 in Region 3 where large volumes of commuter traffic accesses the Aspen area from Garfield and Eagle County communities and a significant recreational traffic volume traveling the roadway on weekends and holidays.

Each CDOT Region has a duty to examine the potential effectiveness of a Courtesy Patrol program (within segments of travelway where such a service might help) as they consider program implementation. That examination should include, not only the administrative, management, maintenance, and cost implications, but also the "peace of mind" perspective of the traveler and potentially high ratings from public approval. Courtesy Patrols, as an early action project, can be integrated with other incident management programs and plans so that comprehensive coverage to keep travelways as free-flowing as possible is a daily goal.

Recommended Project Components. Fully-equipped crews and vehicles, that can roam or be on-call, will respond to incident/motorist assist calls during peak travel times and during inclement weather at predetermined locations and/or heavily traveled segments of the I-70 West Corridor. Courtesy Patrols would need equipment/supplies to provide tows, gasoline, simple automotive diagnostics/repair, basic first-aid, and motorist lifts. Crews would be equipped with a cellular telephone to receive dispatch instructions and to allow a toll-free call by a stranded motorist.

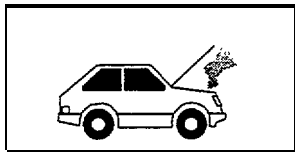
Project Implementation/Phasing Plan. Recommended project implementation is scheduled for start-up in mid-1996 (Denver to Vail segments of the I-70 West Corridor may be the first to be initiated as a CDOT Region 1 early action) and proposed to continue through 1998 at "test sites" so that the corridor-wide program can be fully evaluated. If partnerships can be formed to reduce publicly-funded operational costs, the program can be expanded after the test period and service continued indefinitely.

CDOT Regions 1 and 6 may desire to form a partnership to provide Courtesy Patrols along the western Jefferson and entire Clear Creek County areas as a test location for early action. Potentially expanding the service area of the Mile High Courtesy Patrol can be a first step toward evaluating the effectiveness of the recommended program in this highly traveled, and weather/incident-prone segment of the I-70 West Corridor. MOAs between the Regions can defme terms and conditions as to how the Regions operate and pay for a joint-use program.

Table VII-9 and Figure VII-12 delineate the recommended activities and costs and the ultimate service area and implementation schedule respectively.

TABLE VII-9
HOT SPOT COURTESY PATROLS (EAP ER-1)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	*Management:* – Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress *Administration:* – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing *Planning:* – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP – Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$20,000 $10,000 $50,000	30 months 18 months 24 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$50,000	6 months
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$600,000 per annum	6 months
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule		6 months/ then monthly



Incident Investigation Sites
(EAP SW-l/Corridor-Wide)

Transportation Problem/Need:	Recurring Incidents at Known Locations/ Lack of Personal Travel Security/ Commercial Vehicle Use of Corridor/ Incident-Related Congestion/Limited Financial Resources
Corridor-Wide ITS Goal(s):	Increase Safety/Enhance Traveler Mobility/ Innovative Use of Technology/Encourage Private Investment
User Service Objective(s):	Reduce Delays/Identify-Secure Investment Partners/ Develop Incident Management Strategies/Increase Operational Capacity Strengthen Management of Commercial Vehicle Operations
Corridor Functional Area:	Safety-Warning/Commercial Vehicle Operations/ Traffic Management-Operations/Public-Private Partnerships
NPP User Service Bundle(s):	Emergency/Travel-Transportation Management/ Commercial Vehicle Operations/All Other Bundles

Purpose: To establish fully-equipped roadside pull-out areas throughout the I-70 West Corridor to remove obstructions from the travel lanes where further accident investigations can be conducted. To ensure the safety of accident investigation personnel and travelers involved in an incident while investigations are being conducted. To allow traffic flow to revert to normal operating conditions as soon as possible.

Correlation To Existing Plans/Programs: The CIMC, in its documentation for a Statewide Incident Management Program, recommended roadside accident investigation sites as part of the plan to reduce the upstream congestion that results from incident obstructions blocking through travel lanes.

Incident Investigation Sites are recommended as a medium-term activity for CDOT Region 1 as a part of an integrated regional transportation management system within the Smart Path Business Plan.

Operational/Organizational Relationships. The CDOT Engineering Regions would be responsible for site location, roadside pull-out design, and maintenance of facilities. The Regions and the ITOC would determine the best arrangement for operating and maintaining automatic and electronic devices. The Colorado State Patrol would share administrative, management, and planning functions with CDOT to develop pre-planned operational strategies. Capital, construction, and operating costs would be borne by CDOT and CSP.

Arrangements may be negotiated with telecommunications companies to donate communications devices. Some incentive, such as static sign advertising, would need to be offered to enlist their cooperation. Other cost-sharing strategies, similar to "adopt-a-highway" programs, could be implemented where local governments and other organizations invest personnel for maintenance and

security of the sites or cash contributions as sponsors of an individual site. CDOTs Public/Inter-Governmental Relations Division may want to administer or be involved in this program.

The need for incident investigation sites is currently more apparent within Region l's jurisdiction between Denver and Vail. Region 3 has not yet justified a current need or desire for implementation of this project. Although traffic-related accidents are commonly the sole purpose for providing investigation sites, natural disasters (such as rock and mud slides and avalanche) are common in both regions. Incident investigation sites can serve other purposes--the obvious clearance location for traffic accidents could also be used as storage and command centers for clean-up operations when natural disasters obstruct roadway facilities and/or for routine maintenance activities.

Recommended Project Components. Site location is left to the discretion of the implementing CDOT Engineering Regions. Region 1 has proposed that interchange areas would be an ideal location because there is ample right-of-way and roadside improvements would, more than likely, be less costly. Other sites, where recurrent incidents are common, have been suggested in the data sheet for this project (see Early Action Projects Executive Summary companion document) and are mapped on Figure VII- 13. Existing pull-out areas can be ideal sites because they are already graded. Median-located sites have advantage in that they can serve bi-directional needs.

A graded pull-out area is not an application of advanced technologies. This project is intended to provide communications capabilities and electronic security devices to enhance the productivity of the personnel using the facility. Two-way cellular call boxes, automatic entrance/exit gates with blank-out "in-use" signage, and video surveillance and specialized lighting (for security) represent the advanced technology devices to make this an "intelligent" application.

Landscaping, berming, and/or walls are recommended to block views of the activities within the site from the roadway. This will reduce the "curiosity" slow-downs on the roadway facility when investigation and command control activities are in progress.

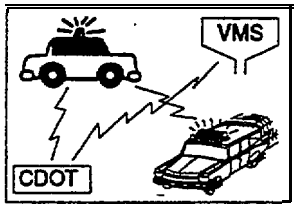
Project Implementation/Phasing Plan. When and why an incident investigation site is implemented is left to the discretion of the CDOT Engineering Regions. Each should consider the added value of having instrumented roadside posts to conduct activities other than specifically for incident investigation. Multiple-purpose sites can increase the productivity of operations and maintenance staff.

Incident investigation sites can also be integrated with other regional incident management and courtesy patrol programs to establish sites for obstruction removal and command operations. As each Region initiates one of these programs or early action recommendations, the functional correlation among the plans and programs should be analyzed to determine where complementary actions can be incorporated.

The implementation schedule illustrated on Figure VII-l 3 and noted in Table VII-10 recommends that the project development phase should begin in mid- 1996 so that deployment can start-up in mid-1998. The time limes indicated in Table VII-10 suggest approximate time frames to complete each phased activity. Start-up dates can be shifted to facilitate when the action is needed.

TABLE VII-10
INCIDENT INVESTIGATION SITES (EAPS W-I)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	*Management:* - Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	$25,000	54 months
	Administration: – Determine Outside Consultation Requirements - Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing	$15,000	12 months
	Planning: – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities - Identify and Allocate Project Funding – Incorporate Project Into STIP - Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance - Develop Project Evaluation Plan – Finalize Marketing Strategy	$30,000	18 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$10,000 per site	12 months
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$40,000 to $80,000 per site	30 months
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	$20,000 per site per annum	Monthly



Emergency Response Information System
(EAP SW-S/Region 3)

Transportation Problem/Need:	Road Closures/No Alternate Routes/ Ineffective Information Dissemination/ Commercial Vehicle Use of Corridor/ Lack of Personal Security
Corridor-Wide ITS Goal(s):	Enhance Traveler Mobility/Increase Safety/ Augment Communications-User Interface
User Service Objective(s):	Reduce Delays and Unnecessary Trip-Making/ Develop Incident Management Strategies/ Collect, Process, Disseminate Reliable Condition Data
Corridor Functional Area:	Traffic Management-Operations/ Commercial Vehicle Operations/ Traveler Information Systems/Safety-Warning Systems
NPP User Service Bundle(s):	Emergency/Travel Demand/Commercial Vehicle Management

Purpose: To provide travelers with en-route, real-time information regarding downstream conditions, including road closures, adverse weather, avalanches, and other natural catastrophes, well in advance of the event location so that alternate plans can be made to avoid the event or so that expectations for possible delays are understood.

Correlation To Existing Plans/Programs: The I-70 West Corridor Plan, presented to the Transportation Commission of Colorado by CDOT Region 1, indicates in its Public Awareness/ Education Plan that the Region (as well as others) should provide information regarding road and weather conditions to ski areas and cities and counties for dissemination to their respective customers, as well as directly to travelers via VMS.

Region 3 has written and intends to implement an Incident Management Plan by the first snowfall of the 1996 winter season. This plan designates alternate routing procedures and operations and maintenance responsibilities when weather, road, and traffic conditions cause obstructions and other incidents along I-70 and State Highways in the Region. The Region is investigating public/private partnership arrangements to facilitate operations and maintenance activities.

The Smart Path Business Plan identifies the project, Statewide Road and Weather Condition Information System. This project explicitly calls for the dissemination of incident, congestion, and roadway information to motorists throughout the State of Colorado via pavement sensor, weather

station, and VMS devices. This action was also identified by the ITS Program Office as a statewide, medium-term priority.

The C-Star Program project list includes ADVICE and DATASCAN which propose integrated VMS and sensor subsystems statewide for providing advance condition advisories and warnings to en-route travelers.

The Rural ATIS study recommends a field test that equips a probe vehicle with sensors to monitor road and weather conditions and transmit that data to roadside infrastructure (VMS, beacons). It also proposes the use of dynamic roadside signs that are remotely controlled and activated to provide traveler advisories.

Appendix C of Colorado's 20 Year Transportation Plan notes STIP programmed funds allocated as a regional priority to place signage on I-70 as part of the priority plan for State-significant corridors. Emergency Response Information Systems are identified as a priority for projects not on State-significant corridors (including SH 82). This project is not yet programmed in the STIP.

Operational/Organizational Relationships. CDOT Region 3 would assume all funding, operations, and maintenance responsibility for these subsystems. Public/private partnerships may be formed to offset operations and maintenance costs.

Recommended Project Components. Subsystem components would include permanent VMS: two at Dowds Junction, six in the Vail Valley, and four along SH 82 between Glenwood Springs and Aspen (programmed as part of the SH 82 widening project currently in the final design phase). Thirty-five additional smaller roadside or portable VMS would be installed Region wide. Signs would be interconnected to the Hanging Lake Tunnel regional TOC where condition data would be collected from existing sensor and detector infrastructure. Leased telephone lines would be used as the initial communications media between signs and the regional TOC until additional fiber optic cabling is installed.

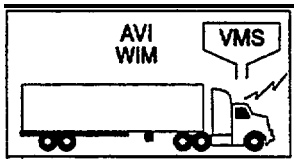
Region 3 could expand this emergency reporting network to include broadcasts to in-vehicle radios. The AM broadcast emergency interrupt capability within the Hanging Lake tunnels and the use of the Vail Super-HAR project components, once deployed, provide radio broadcast methodologies.

VMS, installed as a part of this project, could be used to support the Vail Super-HAR project, reducing some of the capital costs to encourage early start-up. Sensor, detector, HAR, and VMS infrastructure are part of Region 3's overall integration plan to disseminate real-time traveler information at key locations throughout the Region.

Interconnectivity to the CSP CAD system should be considered for future integration with this emergency response information system. CSP reports on incidents and emergency service provider dispatch can enable CDOT operations personnel to gain timely data to manage and advise on

potential traffic disruptions. Automated relay of this datafrom CSPs regional communications center to the Hanging Lake TOC will ensure real-time gathering, processing, and dissemination of information to the traveling public, as well as to operations and maintenance staff.

Project Implementation/Phasing Plan. The recommended implementation plan, tabulated and illustrated in Table VII-11 and on Figure VII-14 respectively, provides sufficient project development time to identify and secure design and capital and operating cost funds. Costs identified in Table VII-11 assume that all equipment will be purchased at the same time. Capital purchases and subsystem devices can be phased to implement the program over time as monies become available.



Dumont/Downieville Automated Port of Entry
(EAP CVO-2/CVO Division; Region 1)

Transportation Problem/Need:	Inefficient Management of Goods Movement/ Commercial Vehicle Use of the Corridor/ Localized Congestion
Corridor-Wide ITS Goal(s):	Enhance Traveler Mobility/Reinforce Economic Benefits
User Service Objective(s):	Strengthen Management-Oversight of Commercial Vehicles/ Monitor Commercial Vehicle Credentials/ Evaluate, Improve Current Processes and Regulations/ Increase Operational Capacity/Reduce Delays/ Develop Better Access
Corridor Functional Area:	Commercial Vehicle Operations/ Traffic Management-Operations
NPP User Service Bundle(s):	Commercial Vehicle Operations/Electronic Payment/ Travel Demand Management

Purpose: To automate the existing Dumont/Downieville Port Of Entry weigh and check station to allow commercial vehicles with the proper credentials and legal weights to bypass the station at highway speeds. This will, further, reduce commercial vehicle queuing onto local streets and interchange ramps, improving the efficiency of the station and reducing the individual commercial vehicle delays. Queue reductions will also alleviate traffic congestion and mitigate mobile source air and noise pollution associated with idling trucks. The ability to electronically monitor hazardous material transport and warn truck drivers about faulty equipment are added benefits of the recommended system.

TABLE VU-11
EMERGENCY RESPONSE INFORMATION SYSTEM (EAP SW-8)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	*Management:* – Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	$10,000	24 months
	Administration: – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordinate with Procurementi Purchasing	$5,000	10 months
	Planning: – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities - Identify and Allocate Project Funding – Incorporate Project Into STIP - Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$5,000	6 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$50,000	6 months
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$1,955,000	9 months
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	$30,000 per annum	monthly

Correlation To Existing Plans/Programs: CDOT, the Colorado Department of Revenue--Port of Entry Division, and the Federal Highway Administration (FHWA) are partners in the Model Automated Port of Entry at Trinidad, Colorado. The Trinidad POE uses ITS technologies such as Vehicle Identification (AVI), Automatic Vehicle Classification (AVC), and Weigh in Motion (WIM) to allow vehicles with proper credentials and weights to bypass the POE at highway speeds. The technology at this 'Model" POE is serving as a prototype for the deployment of other bypass systems throughout Colorado, including the proposal for the Dumont/Downieville POE.

The Smart Path Business Plan identifies the Automated POE (Durnont/Downieville) project. This project is intended to establish an automated POE system at the Dumont Downieville POE. The automated system would include AVI, AVC, and WIM, with information disseminated via VMS. Communications would be established between the Dumont/Downieville POE and other State POEs as well as with the Colorado Department of Revenue--Port of Entry Division.

The C-Star document, Strategic Plan for Intelligent Vehicle-Highway Systems in Colorado, identifies the AUTOPORT, DATATRUCK, and SECURE projects. AUTOPORT calls for the automation of all POEs and weigh stations in Colorado, to allow for legal vehicles to bypass the manual weigh and check stations. DATATRUCK proposes an integrated database to store motor carrier credentials and other physical details. SECURE calls for the implementation of a statewide system for monitoring and controlling hazardous materials movements. Such a system would track vehicles carrying hazardous materials and automatically implement response plans in the event of a hazardous material spill.

Colorado is a participant, with 13 other states, FHWA, and the motor carrier industry, in the HELP (Heavy Equipment License Plate), Inc. program. The consortium has developed and installed advanced technologies to improve commercial vehicle operations. Trucks from participating firms carry transponders to bypass POE's in participating states.

CDOT is working with ATAFs Western Regional Office to develop a fully-operational Geographic Information System (GIS) that will be used as a decision-support tool to monitor truck volumes and credentials, POE facilities, and hazardous materials transport along the Interstates and State Highways in Colorado. Map and database information can eventually be shared with POE operators.

CDOT is the administrative organization for the COVE Project, an institutional barriers study between 7 other states, the ATAF, and the Western Highway Institute (WHI) CDOT and the POE Division of the Department of Revenue are developing a CVO Business Plan to incorporate the commercial vehicle related activities performed by CDOT, the POE Division, and other public agencies. This will provide guidelines for CDOT and POE responsibilities with respect to the operation of the Dumont/Downieville automated POE.

CDOT, the Colorado Transportation Institute (CTI), ATAF, and FHWA studied the Effects of Geometric Characteristics of Interchanges on Truck Safety. The published results are relevant to

the design of the AVI and WIM systems to be installed as a part of the Dumont-Downieville POE automation.

Colorado was awarded funding to perform a field operational test to develop, test, and evaluate an Electronic One-Stop Shopping expert system module. Other states, universities, consultants, and the WHI are participating in this program. The resulting credential data system can be used at the Dumont-Downieville POE for electronic transmission of truck information to other sites and automatic pre-screening.

The I-70 West Transportation Needs Assessment investigated commercial vehicle activities with respect to accidents and hazardous materials transport. Recommendations in that plan included more strict monitoring and enforcement of state regulations for hazardous materials transport, truck driver training programs, and proper training in the handling of hazardous materials by CDOT maintenance crews. Automate monitoring of hazardous materials shipments had not yet become a vision in 1988.

The federally-funded Rural ATIS study proposes the use of transponder-equipped commercial vehicles as probes to transmit travel times and incidents/locations to roadside infrastructure. Commercial vehicles so equipped to bypass the Dumont-Downieville POE could be used in this type of value-added function to enhance other recommended early action projects that propose traveler advisory subsystems.

Appendix C of Colorado's 20 Year Transportation Plan lists regional priority funds that are programmed in the STIP for undetermined improvements along the I-70 West Corridor between the Jefferson/Clear Creek County line and Vail. This project could be funded from that allocation.

Operational/Organizational Relationships. The CDOT CVO Unit (under the ITS Program Office), Region 1, and the POE Division of the Department of Revenue would have joint responsibility for implementing this project. The roles and responsibilities for funding, programming, design, and deployment would be determined by the guidelines set forth in the Statewide CVO Business Plan.

Local businesses perceive that they will lose large amounts of revenue from the deployment of this truck bypass operation. An analysis of trucker use of Dumont-Downieville refueling and refreshment services was conducted to address this problem. The results indicated that there would be no appreciable loss of business. CDOT Region 1 should be responsible for relieving local business concerns.

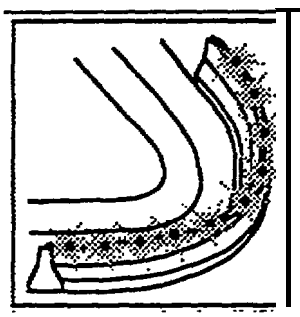
Recommended Project Components. Planning, design, and evaluation of the project would be a cooperative effort and could include the Colorado State Patrol as a partner in the evaluation process. Equipment would include the WIM and AVC subsystems to allow free-flow bypass of the weigh/check station and VMS to signal participating truckers that their respective credentials are current and accurate. Phase I (westbound) and Phase II (eastbound) roadway/roadside systems

would be similar. One set of data collection and processing equipment in the POE is required to handle both roadway subsystems.

A portable brake test subsystem is recommended as an added safety and warning measure for eastbound truckers as they enter the steeper grade and sharper curve segments of I-70. The value-added subsystem has good potential to prevent some of the recurrent downstream incidents that create motorist delays, particularly during inclement weather.

Project Implementation/Phasing Plan. The project implementation and phasing plan recommends that Phase I (westbound) be deployed first followed by Phase II (eastbound) approximately 9 months later. Initial planning and design tasks have been accomplished so that Phase I deployment can conceivably occur in the 3rd quarter of 1996. Start-up can be "slipped" to accommodate allocation of funds.

Table VII- 12 and Figure VII- 15 indicate ideal time frames for deploying this project.



Advanced Technology Roadway Delineation
(EAP SW-4/Corridor-Wide)

Transportation Problem/Need:	Poorly Delineated/Maintained Travel Ways Lack of Personal Travel Security
Corridor-Wide ITS Goal(s):	Increase Safety
User Service Objective(s):	Reduce Accident Frequency, Severity
Corridor Functional Area:	Safely-Warning Systems
NPP User Service Bundle(s):	Emergency Management

Purpose: To effectively define outer boundaries (inside and outside shoulders) of the roadway, particularly under reduced visibility conditions caused by adverse weather and during daily low light/dark periods.

Correlation To Existing Plans/Programs: The Dowds Junction area is currently equipped with a median-barrier lighted guidance tube. The evaluation of its effectiveness and performance, although, not documented, will provide important information regarding the maintenance of similar systems.

TABLE VII-12
DUMONT//DOWNIEVILLE AUTOMATED PORT OF ENTRY (EAP CVO-2)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	*Management:* – Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures - Monitor/Coordinate Project Progress	$25,000	48 months
	Administration: – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing	$5,000	6 months
	Planning: – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP – Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$10,000	12 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$50,000 per phase	6 months per phase
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$755,000 Phase I $800,000 Phase II	12 months per phase
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	$60,000 per annum	monthly

The I-70 West Corridor Plan, presented to the Transportation Commission of Colorado by CDOT Region 1, identifies a Coordination and Communications Plan, stating an urgent need for lighted delineation on Georgetown Hill.

The Minnesota Department of Transportation (MnDOT) has effectively used lighted delineation technology in construction work zones on the freeway system in Minneapolis. Their success stories are relevant to future applications of similar systems throughout the I-70 West Corridor.

The C-Star Strategic Plan proposes the PERCEIVE project that would investigate the suitability of vision enhancement technologies. The Smart Path Business Plan does not acknowledge this project.

I-70 West Advanced Technology Roadway Delineation is included in Appendix C of Colorado's 20 Year Transportation Plan as a priority, non-programmed project in State-significant corridors.

Operational/Organizational Relationships. The CDOT Engineering Regions would be responsible for the development, design, deployment, operations, and maintenance of lighted guidance tube applications along segments of the I-70 West Corridor within their respective jurisdictions.

Recommended Project Components. The 3M-manufactured lighted guidance tube is recommended for application in the I-70 West Corridor because it is the most tested and frequently specified. Material defect and equipment support is readily available.

Mono-directional lighting is recommended for outside shoulder applications and, where bi-directional roadways are separated by wide medians and/or elevations, for inside shoulder applications. Bidirectional lighting is recommended where bi-directional lanes are separated only by a median barrier.

A power source is required every 2,000 feet for mono-directional and 1,000 feet for bi-directional applications. Fifty-watt lamps are spaced in the reflective tubing material at 100-foot intervals.

Lighted guidance tube systems are portable so that installation of one unit can occur at many locations where construction zone or other non-recurrent, differing time needs can be met with one system and where a power source is available.

Tubes do require cleaning, particularly in the environment throughout the I-70 West Corridor. In addition to regular maintenance, tube surfaces must be wiped free of snow and road dirt to retain their visibility. This means that :on-demand" type maintenance must be performed during and after heavy snow storms and travel periods (where numerous vehicles kick-up debris onto the tube).

Institutional/Maintenance Issues. CDOT Region 3 is working with 3M to make adjustments to the existing lighted guidance tube application installed in the Dowds Junction area. As noted

previously, substantial maintenance activity is required to keep the tube free of accumulated outer surface debris (that degrades the effectiveness of the lighted roadway delineation) and to remove piled-on roadway snow after plowing operations (that covers the tubes completely).

The "lessons learned" by Region 3 regarding these maintenance issues must be passed on to other ITS implementors throughout Colorado (particularly CDOT Region 1 since they have a strong desire to install a similar system in various locations along the I-70 West Corridor within their jurisdiction). This will ensure that similar operations and maintenance "mistakes" are not repeated for future deployments of lighted guidance systems.

Project Implementation/Phasing Plan. The recommended implementation schedule assumes that this project is not so much a priority of the operating agency but that it has good potential to attain high customer satisfaction if maintained properly. Region 3's deployment of the system at Dowds Junction has received mixed reviews. Region l's immediate need for vision enhancement of the roadway around Georgetown Hill provides an opportunity for that region to field test an application. The recommended schedule for this specific site can be accelerated as appropriate.

Table VII-13 and Figure VII-16 describe the costs, schedule, and recommended locations for this advanced technology application.

Advanced Ice Detection/Warning System
(EAP DCA-7/Region 3; Corridor-Wide)

Transportation Problem/Need:	Recurring Incidents at Known Locations/ Lack of Personal Travel Security/ Ineffective Information Dissemination/ Road Closures
Corridor-Wide ITS Goal(s):	Increase Safety/Enhance Traveler Mobility/ Augment Communications-User Interface
User Service Objective(s):	Reduce Delays/Increase Operational Capacity Reduce Accident Frequency-Severity/ Disseminate Reliable Condition Data
Corridor Functional Area:	Safety- Warning Systems/ Traveler Information Systems/ Traffic Management-Operations
NPP User Service Bundle(s):	Emergency Management/ Travel and Transportation Management

TABLE VII-13
AD VANCED TECHNOLOGY ROADWAY DELINEATION (EAPS W-4)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	*Management:* – Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	$5,000 per application[1]	6 months[2]
	Administration: – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing	$5,000 per application[1]	6 months[2]
	Planning: – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP – Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$5,000 per application[1]	12 months[2]
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$5,000 to $10,000 per application	6 months[2]
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$60,000 to $70,000 per application	18 months[2]
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	$6,000 per installation per annum	monthly and on demand

[1] one or more locations may be included in one application
[2] timelines suggest activity for multiple applications

Purpose: To provide travelers with real-time advance advisories and warnings regarding downstream icy road conditions via roadside infrastructure. To increase the current spectrum of pavement sensors and weather stations that can be additionally used for preventative maintenance at preferential icing locations.

Correlation To Existing Plans/Programs: CDOT Region 3 has installed ice detection and related traveler advisory systems (VMS) at various locations along the I-70 West Corridor (Glenwood Canyon and Dowds Junction) and has plans to implement several others (Vail area and along SH 82). The implementation and dramatic success of these systems (efficiencies in operations and maintenance as well as public approval) indicates the Region's desire to eventually instrument the entire corridor and other well-traveled facilities within their jurisdiction. It also illustrates the success of this early deployment planning study whereby, as the planning and analysis occurred, several projects such as this advanced into the deployment stage.

The I-70 West Corridor Plan, presented to the Transportation Commission of Colorado by CDOT Region 1, identifies, in its Public Awareness/Education Plan the need for dissemination of road and weather conditions to ski areas and cities and counties throughout the I-70 West Corridor for dissemination to their customers as well as dissemination of this information directly to travelers via VMS.

The Smart Path Business Plan recommends two projects related to advanced ice detection within the I-70 West Corridor: Ice Detection System (Tenmile Canyon/Vail Pass); and Statewide Road and Weather Condition Information System. The Ice Detection System (Tenmile Canyon/Vail Pass) calls for roadway pavement sensors to be installed on I-70 from Wheeler Junction (SH 91) to Dowds Junction (SH 24). The project identifies the Eisenhower TMC as having primary responsibility for data collection, processing, and dissemination to maintenance crews and travelers. The Hanging Lake TMC is also tasked with the responsibility of information dissemination. The Smart Path Statewide Road and Weather Condition Information System proposes installation of roadway pavement sensors for maintenance and traveler advisory uses.

The C-Star Strategic Plan identifies the MESSENGER and ADVICE projects to provide statewide broadcasting and VMS systems, respectively, that disseminate road and weather conditions data. These dissemination systems are critical to the success of an advanced ice detection warning system.

The Rural ATIS study documentation proposes maintenance vehicle automated detection systems where on-board transceivers would be able collect condition information from roadway sensors. This might be particularly applicable to snow plows that would be able to detect and report potential icing under snowpack on the travel ways. Those sensors would automatically activate warning signs or flashers in the immediate vicinity upstream of the plow operations.

This project is identified in Appendix D of Colorado's 20 Year Transportation Plan as a non-programmed priority.

Operational/Organizational Relationships. Each Engineering Region would be responsible for the development, design deployment, operations, and maintenance of their respective ice detection subsystems. As regional TOCs and the C-TMC/iTOC are interconnected through the IT1 Network, information will be shared so that regional and statewide reporting of I-70 West Corridor conditions can be accomplished.

Institutional Issues. Existing pavement sensor devices are part of a proprietary system where CDOT cannot collect raw data. This may become an institutional barrier as the each region expands its ITS services to include data sharing with other regions and other organizations. Use of proprietary systems demands sole source procurements (contrary to State regulations).

Proprietary systems also become technical barriers as they preclude integration of subsystems into the open architecture recommended for the I-70 West Corridor ITS. The CDOT Regions and the ITS Program Office need to "put their heads together" to brainstorm a solution to this problem. As new projects, such as additional ice detection system are brought on line, serious consideration must be given as to who's equipment and software will be purchased. Software development that meets the standards of the statewide and corridor-wide ITS is much more attractive than not being able to integrate a variety of proprietary systems into the ITI Network.

CDOT Region 3's planned VMS installations (15 new signs have been purchased and are stored for near-term placement) have overlapping functionality with ice detection/warning and emergency response information system uses (EAP SW-8). Region wide integration of both must be considered and carried-out to ensure coordination and connectivity between systems.

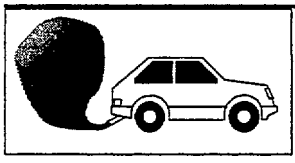
Recommended Project Components. Pavement sensors, weather stations, and VMS are the key field components for each subsystem. These require communication links for data retrieval from sensors and information dissemination to the VMS. Software integration (existing applications and future programming) will be necessary for interoperability between existing and future devices. The software will process the data, with area-specific algorithms, to select appropriate sign messages. Region 3 currently has a set of operational dialogs and algorithms in place that perform data processing functions for the Hanging Lake tunnel systems. These may be adaptable for future sensing/advising installations. Region 3 may want to consider purchase of additional computer processing workstations to isolate ice detection systems from other tunnel control functions. Staffing needs to be considered as more subsystems are brought on line, particularly since 24 hour operation is desired.

Project Implementation/Phasing Plan. The implementation schedule for this project includes ample project development time to address the potential institutional and technical issues associated with current subsystems deployed within the I-70 West Corridor and statewide.

Preliminary cost estimates, documented in Table VII- 14, are combined for 18 sensors required for the Region 3 system. If an additional 3 sensors are needed for another segment of the I-70 West

Corridor (by Region 3 or Region l), it would be appropriate to divide 18 into $5 15,000 and multiply that number by 3 to develop a conceptual cost estimate to deploy those 3 new sensors.

Figure VII-l 7 identifies the location of Region 3's proposed installations that lie within the I-70 West Corridor study area. The implementation schedule recommends a 1997 project start date so that institutional and technical issues can be resolved.



Mobile Emissions Testing Stations
(EAP EEI-S/Corridor-Wide)

Transportation Problem/Need:	Environmental Impacts
Corridor-Wide ITS Goal(s):	Improve Environmental Quality
User Service Objective(s):	Reduce Vehicle Emissions
Corridor Functional Area:	Environmental/Economic Impact
NPP User Service Bundle(s):	Emissions Testing and Mitigation

Purpose: To determine the level of vehicle emission pollutants within the I-70 West Corridor that exceed legal limits and provide a program to reduce the violations so that ambient air quality is acceptable.

Correlation To Existing Plans/Programs: The Research Unit of the CDOT ITS Program Office is currently conducting research and developing an operational test for an Emissions Reduction project. Carbon monoxide levels emitted by passing vehicles will be measured by a roadside unit. Motorists will be advised, via VMS, with real-time information on how their vehicle is operating. This operational test is intended to be the prototype for this project.

The Smart Path Business Plan identifies a Voluntary Emissions Reduction Operational Test. This project identifies the installation of an active infrared roadside emissions sensor working in conjunction with a VMS to relay vehicular emissions readings to passing motorists. Highway Advisory Radio (HAR), telephone hotlines, and brochures will provide motorists with additional information regarding vehicle emissions. The project calls for evaluation of the system through surveys and measurement of emission levels at the site over time. This is the same program as that identified as being conducted by CDOT.

This project is slated in Colorado's 20 Year Transportation Plan Appendix E as one of Region l's long-range needs. It is currently not programmed in the STIP.

Operational/Organizational Relationships. This program requires intra-agency and private sector partnering. The Engineering Regions will be responsible for selecting and making improvements

TABLE VII-14
ADVANCED ICE DETECTION/WARNING SYSTEM (EAP DCA-7)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development	*Management:* - Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	$10,000	30 months
	Administration: – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing	$5,000	4 months
	Planning: – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP – Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$20,000	6 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$25,000	6 months
Deployment	Advertisement/Bid Construction/Installation Testing/Training/Start-Up/Evaluation Marketing Strategy Implementation	$515,000	18 months
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	$30,000 per annum	monthly

at specific deployment locations within the I-70 West Corridor. The ITS Program Office, at the discretion of the Regions, may elect to operate the program for compilation of statewide statistics.

The CSP will be responsible for violation enforcement. The Department of Revenue would assess and collect fees for violations. CDOT and the Department of Revenue will need to develop a cooperative plan on how those ticket revenues will be spent. CDOT may want those monies to reinvest in the system for other parts of the state if it is highly successful.

CDOT's Public/Inter-Governmental Relations Division will need to work closely with the Regions to develop an effective public relations program. Violators may be very vocal, voicing their complaints directly to the Region's staff. Regional staff members do not need a new system that imposes additional work to respond to those complaints.

Academia (University of Denver--Professor Don Stedman) has developed the prototype system. A manufacturer will be needed as additional units are required. The prototype developer will more than likely want royalties from the mass production and sale of emissions detection units.

The selected manufacturer will need to charge enough per unit to make a profit. Capital costs must be kept to a minimum to make deployment of numerous units viable to CDOT.

Recommended Project Components. Phase I system deployment would include the emissions detection unit and a VMS to provide pollutant advisories. Station locations would require some level of improvement to adequately site and provide a secure environment for the units.

A potential cost reduction strategy would be to piggy-back this project onto the Incident Investigation Site project. An area within the incident investigation site could 'house" the emission detection station.

Power (solar or transmission line) could be provided for both uses. Security surveillance and lighting for the investigation site could also be used for the detection station equipment.

Phase II proposes enhancement of the system to automate violation recordation and fining. The use of a video surveillance camera might serve both the incident investigation site security needs and the license plate "picture-taking" needs of the emissions detection system upgrades.

Where it is determined that investigation and emissions detection sites are to be collocated, the appropriate camera that serves the functional requirements of the detection system should be procured. Although this is "overkill" for the incident investigation site, money is saved by eliminating the purchase of a general surveillance camera solely for security purposes.

Implementation of Phase II supposes that current Colorado law can and will be changed. This phase of the system raises privacy issues that will have to be debated in legislative session.

Project Implementation/Phasing Plan. Implementation of this project is dependent on the success of the operational test being conducted in Denver. The recommended project start-up in mid-1998 allows time to see if the operational test is a success.

A 9-month planning phase allows time to address the cooperative requirements and institutional arrangements among participating agencies and organizations. During Phase I planning, project implementors need to begin the legislative process that addresses the privacy issue.

Table VII-l 5 and Figure VII-l 8 define the schedule, cost, and location details for the project.

EARLY-ACTION PROJECT PRIORITIZATION

Although it is the intent of the Corridor Master Plan recommendations to initiate and complete all Early Action projects within a 5-year time frame, staffing, funding, and partnering limitations may prohibit accomplishing such an aggressive plan. To focus limited resources on immediate, necessary actions, Table VII-17 suggests which projects should have priority. Early Action projects not started within the recommended time frame should receive high priority for medium-term project initiation.

MEDIUM TERM PROJECT INITIATIVES

Medium-term ITS projects, identified in this implementation plan, are those that should be given strong consideration for initiation, design, and/or deployment within the next 10 years. These have been designated by the Statewide ITS Implementation Team as secondary priority projects and are denoted by Engineering Region or Statewide ITS Program Office initiation. Additional projects are recommended for consideration.

Medium-term projects are less detailed because of the potential for change. Summaries are provided that briefly describe the project, identify which current transportation problems can be resolved and/or which user need can be addressed; what benefits can be provided; approximate capital, operating, and maintenance costs; and recognize potential participating partners.

Since there are numerous medium-term projects that can be implemented, the Engineering Regions and the ITS Program Office should carefully review and evaluate each project, at least annually, to decide if they are still applicable and appropriate to current and future needs and changing requirements. This process should also include other projects identified in the Early Action Projects Appendix as well as those recommended within this Corridor Master Plan.

CDOT Engineering Regions, the ITS Program Office, the Statewide ITS Implementation Team, the I-70 West Corridor Coalition, and any other interested and involved party need to stay abreast of national ITS initiatives and private sector advancements. New technologies are continually emerging--new projects can be formulated where old ones become obsolete.

TABLE VII-15
MOBILE EMISSIONS TESTING Stations (EAP EEI-5)
IMPLEMENTATION PLAN

TASK/RELATED ACTIVITIES		PRELIMINARY COST ESTIMATE	TIME LINE
Project Development–	*Management:* Assign Project Leader and Staff – Establish Responsibilities for Work, Coordination, Review, and Approvals – Finalize Procurement Procedures – Monitor/Coordinate Project Progress	$15,000	30 months
	Administration: – Public Relations – Determine Outside Consultation Requirements – Execute MOU's With Other Entities – Coordinate with Procurement/ Purchasing	$20,000	12 months
	Planning: – Refine Work Scope, Costs, Products, and Services – Contact, Coordinate, and Contract Cooperating Entities – Identify and Allocate Project Funding – Incorporate Project Into STIP – Develop Project Operations Plan for Staffing, Training, Operations, and Maintenance – Develop Project Evaluation Plan – Finalize Marketing Strategy	$50,000	18 months
Design	FIR/FOR Reviews/Approvals Design Report(s) Construction/Installation Plans Construction/Equipment Cost Estimates Specifications/Special Provisions	$50,000	10 months
Deployment	Advertisement/Bid Construction/Installation Testing/Training&art-Up/Evaluation Marketing Strategy Implementation	$385,000	12 months
Operations/ Maintenance	Staffing Operating Timetable Maintenance Schedule	$55,000 per annum	monthly

TABLE VII-16
EARLY ACTOIN PROJECT PRIORITIZATION

Corridor- Wide	
1	Voice/Data Communications Upgrades
2	Call Box System
3	Hot Spot Courtesy Patrols
4	Incident Investigation Sites
5	Advanced Technology Roadway Delineation
6	High-Capacity Data Transmission Links
7	Mobile Emissions Testing Stations
Region 1	
1	Eisenhower Tunnel Control Center Upgrades
2	Dumont/Downieville Automated Port of Entry
3	Summit Stage Transfer Center APTS/ATIS Operational Test
4	Automated Reversible Lane Program
5	Georgetown Area Gusty Wind Sensor/Variable Message Sign System
6	Preplanned Incident Action Plans
7	Other Advanced Ice Detection/Warning Systems
Region 3	
1	Hanging Lake Tunnel Control Center Upgrades
2	Advanced Ice Detection/Warning Systems
3	Emergency Response Information System
4	Preplanned Incident Action Plans
5	Vail Super HAR/VMS Program

The following synopsis recommends medium-term projects that meet the goals and objectives of the I- 70 Rural IVHS study vision:

Data Collection/Processing/Dissemination:
- Advanced Sensor Technology Applications (State-Wide),
- Tenmile Canyon/Vail Pass Icy Road Sensor/VMS System (Region l),
- Avalanche Detection and Warning System (Regions 1 & 3), and
- Glenwood Canyon Excessive Speed Warning System (Region 3);

Traveler Services Information:
- Traveler Information Systems Expansion:
  + Idaho Springs Intelligent Rest Area (Region 1),
  + Other Rest Stop/Information Center Traveler Service Systems (Region 3),
  + Eisenhower Tunnel Motorist Information System (Region l),
  + Vail Pass Rest Area ATIS Upgrades (Region l),
  + Glenwood Canyon Rest Areas (Grizzly Creek, Hanging Lake, No Name) ATIS Upgrades (Region 3),
  + Denver West Intelligent Rest Area/Transit Center (Regions 1 and 6), and
  + POE Traveler Information Centers (Region 3);
- Internet/World Wide Web Traveler Information Page (Corridor-Wide);
- CCTV Exchange Partnerships (Statewide ITS Implementation);
- Resort Area Real-Time Condition Broadcasts (Regions 1 & 3); and
- Front Range Trailblazer System (Region 6);

Electronic Payment Services:
- One-Stop Shopping Commercial Vehicle Automated Credential Processing (State-Wide); and

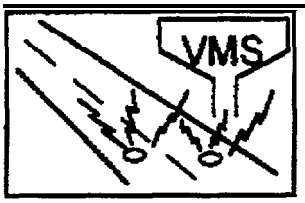
Safety and Warning Systems:
- In-Vehicle Cellular/GPS Mayday System (State-Wide).

Figure VII-19 locates medium-term project recommendations within the I-70 West Corridor.

The following medium-term project descriptions summarize subsystem characteristics, the problem resolution, potential user benefits, an approximate subsystem cost, and potential participating partners. Again, each description is meant to allow whatever flexibility is required to develop the recommended project functions or forego the project altogether for a more timely and advantageous project.

All recommended projects conform to the vision for ITS in Colorado as demonstrated by the C-Star Strategic Plan, the Smart Path Business Plan, the C-TMC Model Deployment initiatives, and Colorado's 20 Year Transportation Plan (which is developed through input from the Engineering Regions responsible for the I-70 West Corridor and the ITS Program Office and the TPRs impacted by I-70 West Corridor travel).

– Data Collection/Processing/Dissemination:



Advanced Sensor Technology Applications (State-Wide)

Transportation Problem/Need:	Ineffective Information Dissemination/ Recurring Incidents at Known Locations
Corridor-Wide ITS Goal(s):	Increase Safety/Enhance Traveler Mobility/ Augment Communications/User Interface
User Service Objective(s):	Reduce Delays, Accident Frequency, and Severity Gather, Process, and Disseminate Reliable Condition Data
Corridor Functional Area:	Safety-Warning Systems/ Traveler Information Systems/ Traffic Management-Operations
NPP User Service Bundle(s):	Emergency Management/ Travel-Transportation Management

Subsystem Characteristics. Building on the evaluation of early action projects that detect road, weather, and traffic condition data, process it, and disseminate it to the traveling public and service providers, this medium-term action implements environmental and roadway hazard devices in additional segments of the I-70 West Corridor to reach the ultimate long-term goal of a continuously monitored and protected facility.

As technologies emerge and additional vendors manufacture products, numerous new opportunities to enhance the capabilities and functions of icy road sensor systems. As communications systems are deployed, conditions will be produced for providing interconnect between each subsystem and between each of the operating traffic management centers.

Potential User Benefit: Continuous improvement in operational capacity; informed travelers as better decision-makers; greater utilization of existing capacity; traveler awareness, security, and safety; and a satisfied public.

Approximate Cost: $200,000 to $500,000 per application

Potential Participants: CDOT, CSP, local governments, trucking industry, private information service providers, telecommunications companies, local businesses and industries.

Tenmile Canyon/Vail Pass Icy Road Sensor/VMS System (Region 1)

Transportation Problem/Need:	Recurring Incidents at Known Locations/ Lack of Personal Travel Security/ Ineffective Information Dissemination/ Road Closures
Corridor-Wide ITS Goal(s):	Increase Safety/Enhance Traveler Mobility/ Augment Communications-User Interface
User Service Objective(s):	Reduce Delays/Increase Operational Capacity Reduce Accident Frequency-Severity/ Disseminate Reliable Condition Data
Corridor Functional Area:	Safety-Warning Systems/Traveler Information Systems/ Traffic Management-Operations
NPP User Service Bundle(s):	Emergency Management/ Travel and Transportation Management

Subsystem Characteristics. The roadway pavement would be instrumented with surface sensors to measure surface and subsurface temperatures and determine surface conditions for dew, frost, ice, snow, black ice, degree of wetness/dryness, and chemical composition. A software algorithm would translate this data into advisories for maintenance crews to mobilize to apply chemical de-icing compounds before the surface becomes a hazard to motorists.

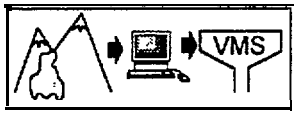
Weather identifier and visibility (WIVIS) sensors would also be installed to measure precipitation, visibility, and other atmospheric conditions. Software algorithms would predict potential weather patterns. In addition to providing CDOT with appropriate data and management information, the information would be relayed automatically to the travelers via VMS to provide advisories.

Devices would be installed where necessary to provide comprehensive surface condition coverage from Wheeler Junction (SH 91) to the Eagle/Summit County border. The Eisenhower TOC would have primary responsibility, feeding information to Region 3's Hanging Lake TOC.

Potential User Benefit: Traveler security and safety; customer satisfaction; increased operational efficiency; improved operations and maintenance performance.

Approximate Cost: $300,000

Potential Participants: CDOT Region 1; CDOT ITOC/C-TMC; Private Information Service Providers.



Avalanche Detection and Warning System (Regions 1 & 3)

Transportation Problem/Need:	Recurring Incidents at Known Locations/ Lack of Personal Travel Security/ Ineffective Information Dissemination
Corridor-Wide ITS Goal(s):	Increase Safety/ Innovative Use of Emerging Technologies/ Augment Communications-User Interface
User Service Objective(s):	Reduce Delays, Accident Frequency and Severity/ Reduce Emergency Response Times/ Develop Incident Management Strategies/ Disseminate Reliable Condition Data
Corridor Functional Area:	Emergency Response/Safety-Warning Systems
NPP User Service Bundle(s):	Emergency/Travel-Transportation Management

Subsystem Characteristics. Avalanche detection sensors and warning systems would be installed at known high-probability locations. Upon detection by the sensors of snowpack movement or shifts, a warning would be transmitted to the regional TOC. The operator would dispatch response teams to the potential slide area to implement traffic controls and begin obstruction removal operations.

The operator would also initiate broadcasts and announcements via HAR, to travelers in the area, and via automated communications systems to local media to advise of potential road closures or potential hazard locations so informed decisions would be made regarding, trip starts and/or delays. Where permanent VMS are appropriately in advance of a slide area, special messages would be relayed automatically to these signs to provide additional traveler advisory and warning information.

Where impending danger of a slide traversing roadway rights-of-way exists, advance warnings would be posted automatically on associated VMS to advise travelers of the danger and what action to take (stop, pull-off, proceed with caution).

Potential User Benefit: Traveler safety; advance warning of impending danger; early mobilization of response crews; early implementation of traffic controls.

Approximate Cost: $200,000 Per Site

Potential Participants: CDOT, CSP, Academia, Avalanche Sensor Manufacturers, Local Media.

Glenwood Canyon Excessive Speed Warning System (Region 3)

Transportation Problem/Need:	Driving Inexperience-Excessive Speeds/ Ineffective Information Dissemination
Corridor-Wide ITS Goal(s):	Increase Safety/ Augment Communications-User Interface
User Service Objective(s):	Reduce Accident Frequency and Severity/ Develop Incident Management Strategies/ Gather, Process, and Disseminate Reliable Condition Data
Corridor Functional Area:	Safety-Warning Systems/ Traveler Information Systems
NPP User Service Bundle(s):	Emergency/Travel-Transportation Management

Subsystem Characteristics. Often, motorists and commercial vehicle operators travel at speeds 10 to 20 miles per hour in excess of the posted limits. In many cases, individual drivers are not aware that they are speeding. In others, they are unfamiliar with the roadway and enter dangerous areas at speeds far above their ability to control their vehicle. The resulting run-off-road accidents, spin-outs, and jack-knifes not only endanger the perpetrator, but also other unsuspecting travelers in the vicinity.

Using radar and VMS technologies, detectors would be permanently stationed along the roadside in known high speed areas. As vehicles crossed the line of detection, speed would be clocked. If that speed exceeds the posted limit by more than 5 miles per hour, the speed would be automatically transmitted to and posted on a VMS, advising the driver of the excessive speed. The system could be expanded so that, when the safe speed is below the posted speed (e.g. during icy road conditions), the speed limit compliance parameters would be adjusted accordingly.

A second set of detection devices could be installed to check the violator for speed limit compliance. When appropriate, the Colorado State Patrol could man these areas and ticket violators for not heeding the warning. Surveillance cameras could be installed with the second set of detectors to record any warnings that were not followed. Vehicle identification would allow ticketing of the offense by mail if State regulations are passed to allow this procedure. A legislative campaign would need to be initiated to modify privacy laws.

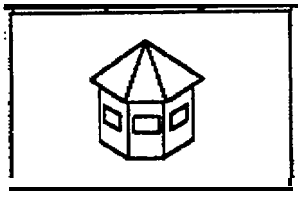
Region 3 has several variable speed signs installed in Glenwood Canyon that are activated from the Hanging Lake control center when conditions are known to be hazardous. These are not currently connected to any field devices or automated programming functions. This project is intended to enhance the functionality of existing infrastructure (such as the variable speed signs) and expand on existing systems to meet this particular problem within the Canyon.

Potential User Benefit: Traveler security and safety; reduction in frequency and severity of accidents; efficient use of enforcement and maintenance resources.

Approximate Cost: $60,000 Per Installation

Potential Participants: CDOT, CSP, Legislators.

- Traveler Services Information:



Traveler Information System Expansion (Regions 1,3, & 6)

Transportation Problem/Need:	Ineffective Information Dissemination/ Limited Confidence in State Government Services/ Lack of Coordination/Cooperation Environmental Impacts
Corridor-Wide ITS Goal(s):	Reinforce Economic and Social Benefits of Transportation/ Augment Communications-User Interface/ Improve Environmental Quality
User Service Objective(s):	Disseminate Reliable Travel-Tourist Data/ Create and Support Cooperative Relationships/ Capture Economic Benefits
Corridor Functional Area:	Traveler Information Systems/ Education-Training/ Environmental/Economic Impact
NPP User Service Bundle(s):	Travel-Transportation Management

Subsystem Characteristics. New and upgraded rest area and traveler information center facilities would continue to provide travelers with a safe refuge from traffic and weather related back-ups. In addition to the construction of new facilities and upgrades of existing facilities to meet ADA requirements, a kiosk-based traveler information service will be a major feature in each location. These computerized systems would be interconnected to the Eisenhower and Hanging Lake TOCs and the C-TMC. Each touch-screen computer information center would receive up-to-the-minute traveler information and advisories. The system would also have local, regional, and statewide tourist information and details on accommodations and services in the immediate area, within the northwest region, and for selected areas statewide.

Each rest area and information center should also be designed and/or upgraded to provide ample, "intelligent" restroom facilities (automatic flushing toilets, water faucet controls, and lighting systems). So that historic data can be captured for future analysis of rest area/information center usage, each facility should be equipped with automatic counters at parking lot entrances and exits and on pedestrian doorways to record traffic volumes (vehicles and pedestrians) and what portions of the facility were used.

Locations designated for development and upgrade include Idaho Springs Intelligent Rest Area (Region 1); Other Rest Stop/Information Center Traveler Service Systems [Fruita, Grand Junction, Rifle, Glenwood Springs, Eagle, Edward, and Vail] (Region 3); Eisenhower Tunnel Motorist Information System (Region 1); Vail Pass Rest Area ATIS Upgrades (Region 1); Glenwood Canyon Rest Area (Grizzly Creek, Hanging Lake, No Name) ATIS Upgrades (Region 3); Denver West Intelligent Rest Area/Transit Center (Regions 1 and 6), and POE Traveler Information Centers (Region 3).

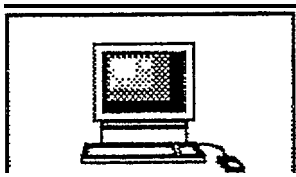
The Denver West facility is a substitute name for the now defunct Hogback Multi-Modal Transfer Center Operational Test. A comprehensive location study was performed after vocal Genesee-area special interest groups rejected the plan, insinuating that the project would disrupt their current quality of life. The I-70/SH 26/US 40 interchange remains the ideal site to capture carpoolers and vanpoolers who continue to congregate at this location. It is also a popular starting point for bicyclists and pedestrians adventuring into the foothills for a ride or hike. The original concept can be modified to promote a "rest area" environment that may be more amenable to Genesee residents.

POE Traveler Information Centers would provide touch screen information kiosks similar to those installed in rest areas/stops and information centers. Information will vary to meet commercial vehicle operator needs. In addition to road, weather, and traffic condition reports, trucker-specific information such as where to buy chains; state-wide truck stop locations and services; and downstream POEs types (weigh/check versus automated) and status (open or closed) would be provided. This captive audience has many informational needs that can be catered to, generating good relations between the State and interstate commerce activities.

Potential User Benefit: In some locations, stimulates the local economy; creates state/local cooperation; provides safe refuge for travelers; provides a medium to inform travelers; improves Colorado's image; sets the stage for public/private partner opportunities.

Approximate Cost: $200,000 to $1,500,000 Per Site

Potential Participants: CDOT, Colorado Department of Revenue, CMCA, ATAF, Local Governments, Local Businesses and Residents, Local Volunteers, Regional Business Sponsors, Commercial Vehicle Operators, Chambers of Commerce.



Internet/World Wide Web Traveler Information Page (Corridor-Wide)

Transportation Problem/Need:	Ineffective Information Dissemination/ Congestion/Road Closures/No Alternate Routes
Corridor-Wide ITS Goal(s):	Enhance Traveler Mobility/ Augment Communications-User Interface/ Promote Transit Usage-Improve Transit Service
User Service Objective(s):	Reduce Delays-Unnecessary Trip-Making/ Educate All Stakeholders/Disseminate Reliable Condition Data/ Reduce Auto-Truck Demand/Increase Operational Capacity
Corridor Functional Area:	Traveler Information Systems/ Public Transportation-Alternative Modes/ Education-Training/Traffic Management-Operations
NPP User Service Bundle(s):	Travel-Transportation/Travel Demand Management/ Public Transportation Onerations

Subsystem Characteristics. An increasing number of State DOT's are developing Home Pages on the Internet/World Wide Web (Net/Web) that include automated mapping of real-time traffic information for use by anyone with access to the service. Users can dial up and preview a transportation system map that shows actual link congestion on major facilities, allowing pre-trip planning capabilities for route selection and trip start.

CDOT has recently established a Home Page on the Net/Web and is developing information for general access. Building on the concept, an I-70 West Corridor transportation system map on CDOTs Home Page would be dependent on the extent that the I-70 facility is instrumented so that actual real-time data could be automatically linked to the map.

Map limits for the I-70 West Corridor should encompass DIA on the east and extend to, at a minimum, Grand Junction on the west (the Utah border would be preferred). Feeder routes that serve other communities, resorts, and recreational areas, as they are instrumented, would be of importance to users (SH 82 to Aspen, SH 13 1 to Steamboat Springs, US 24 to Leadville, SH 9 south to Breckenridge and north to Kremmling and Steamboat Springs, US 40 to Winter Park, and US 6 and SH 119 to Black Hawk and Central City are key examples). CDOT's GIS would make an excellent base map/database system to develop the final display.

Traffic information data must be displayed in "terms" that are beneficial to the average traveler. Many current systems display color-coded bandwidths showing varying levels of speed or congestion on major segments of a facility. Much care in planning and design of the displays will be important to convey information in a readily recognizable format--not in traffic engineering terminology. Flow of facility segments in terms of speed (5 mph increments) is probably the most understandable.

Other features should be included in the service to provide a comprehensive real-time database of relevant information. Point and click information buttons that provide up-to-date airline schedules, shuttle service providers and schedules, operating ski areas and casinos and their respective business hours, pavement conditions (icy, snowpacked, wet, dry), and incidents and their stages of clean-up, and road closures and their causes (avalanche, over-turned truck) offer information that will help individual travelers make informed decisions on when and how to make their trip into and out of the high country. There is a good potential to link National Oceanic and Atmospheric Administration (NOAA)/National Weather Service (NWS) information to the localized condition data for weather forecast dissemination. Links to other government and information provider Home Pages can also be established to give users a comprehensive "look" at travel conditions throughout the I-70 West Corridor and adjacent regions.

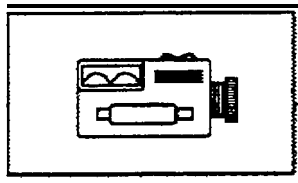
CDOT may want to consider "selling" sponsorships to offset the cost of maintaining the information. Local organizations and business could pay a monthly fee in return for a "brought to you by..." advertising spot. Advertising could consist of a "calling card" motif similar to that used by trade publications that provide space for business-card reprints.

It is recommended that such a service be put on-line only when enough of the I-70 West facility is instrumented so that enough meaningful data is provided. A partial or incomplete display will only induce negative feedback and perception regarding the usefulness of the service. The intent is to provide a service that has high user acclaim.

Potential User Benefit: Widespread access to actual condition data; individual trip pre-planning capabilities; well-informed travelers making better trip-making decisions; high customer satisfaction; better use of transit; less congestion; potential reduction in delays and incidents.

Approximate Cost: up to $500,000 to develop
up to $50,000 per year to update and maintain
$10/month plus access time for individual users

Potential Participants: CDOT (ITS Program Office, Divisioin of Transportation Development (DTD) GIS Unit, Regional TOCs, iTOC & C-TMC, Public/Inter-Governmental Relations Division), local governments, NOAA/NWS, DIA and airlines, ski resorts, casinos, local information providers (such as Chambers of Commerce and the media), local organizations and business as sponsors.



CCTV Exchange Partnerships (Statewide ITS Implementation)

Transportation Problem/Need:	Ineffective Information Dissemination/ Lack of Coordination/Cooperation/ Congestion/Road Closures/No Alternate Routes/ Limited Financial Resources
Corridor-Wide ITS Goal(s):	Enhance Traveler Mobility/ Augment Communications-User Interface/ Innovative Use of Technology/ Encourage High Public-Policy Level Acceptance/ Encourage Public-Private Investments
User Service Objective(s):	Reduce Delays/Increase Operational Capacity/ Disseminate Reliable Condition Data/ Improve Current Processes-Regulations/ Secure Investment Partners/Leverage Funding Sources
Corridor Functional Area:	Traveler Information Systems/ Institutional Issues/Education-Training/ Public-Private Partnerships/ Traffic Management-Operations
NPP User Service Bundle(s):	Travel-Transportation/Travel Demand Management

Subsystem Characteristics. CDOT and Denver metropolitan area television stations have been negotiating ways to instrument the I-70 West Facility between Denver and Vail to provide live "video cam" reports of facility conditions during news and special reports. CDOT would like to access the surveillance camera data to develop travel time and volume information.

Because the functional requirements of camera components are vastly different, the type of surveillance camera needed for traffic data development would be much more sophisticated than that needed for live action broadcasts. A cost-sharing arrangement for equipment procurement must be negotiated.

The passage of HB 1267 (the Public-Private Partnership bill), although originally developed and legalized for fiber communications applications, can probably be interpreted to allow installation of private-sector-owned surveillance cameras. CDOT would negotiate how it would access camera data--perhaps in exchange for use of the rights-of-way.

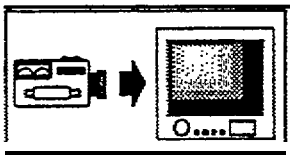
Camera location will be another element to negotiate. Each television station involved will want higher priority over the others so that each can presumably provide a unique service to its viewers. CDOT will want an integrated system that provides continual, non-redundant coverage of the corridor.

A value-added utility to this project would be CDOTs ability to feed the live broadcasts to ski resort lodges, casinos, and traveler information kiosks at rest areas and information centers. The television stations may reject this idea since they may want exclusive use of the footage.

Potential User Benefit: Widespread broadcast of real-time condition information; effective public-private partnerships; data to complete other ITS projects (i.e., the Net/Web Home Page Travel Information Map); customer satisfaction; pre-trip planning capabilities; more informed customers making better trip-making decisions.

Approximate Cost: $200,000 per installation

Potential Participants: CDOT, Television Stations



Resort Area Real-Time Condition Broadcasts (Regions 1 & 3)

Transportation Problem/Need:	Ineffective Information Dissemination/ Lack of Coordination/Cooperation/ Congestion/Road Closures/No Alternate Routes/ Limited Financial Resources
Corridor-Wide ITS Goal(s):	Enhance Traveler Mobility/ Augment Communications-User Interface/ Innovative Use of Technology/ Encourage High Public-Policy Level Acceptance/ Encourage Public-Private Investments
User Service Objective(s):	Reduce Delays/Increase Operational Capacity/ Disseminate Reliable Condition Data/ Improve Current Processes-Regulations/ Secure Investment Partners/Leverage Funding Sources
Corridor Functional Area:	Traveler Information Systems/Institutional Issues/ Education-Training/Public-Private Partnerships/ Traffic Management-Operations
NPP User Service Bundle(s):	Travel-Transportation/Travel Demand Management

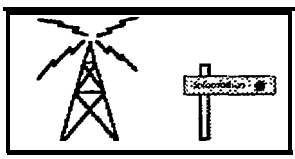
Subsystem Characteristics. Using video surveillance systems installed at the Eisenhower Tunnel and other locations along the I-70 West Corridor, live footage of actual travel conditions would be broadcast to monitors located in resort lodges, casinos, hotel common areas and/or lounges, and POE facilities. Trip-makers, preparing to make a return trip from a resort/recreational vacation, could make the determination when to start their trip, based on their viewing of real-time traffic and weather conditions. Truckers could monitor downstream conditions from broadcasts at POEs, truck/weigh stations, and truck stops to decide if adverse travel conditions warrant a lay-over.

The live footage could be broadcast using television/cable station transmitters. System installation, maintenance, and operations could be supported by the broadcast companies and resort and hotel operators, allowing establishment of public/private partnerships.

Potential User Benefit: Widespread broadcast of real-time travel information; better informed trip-makers; traveler comfort, security, and convenience; reduction in peak period volumes resulting in less congestion and delay; more effective use of operations and maintenance resources; data to complete other ITS projects (i.e., Net/Web Home Page Transportation Information Service).

Approximate Cost: $10,000 to $25,000 per location, assuming surveillance cameras are in place.

Potential Participants: CDOT, Colorado Department of Revenue (Port of Entry Division), Ski Resorts and Casinos, Local Businesses, Local Television/ Cable Stations, Commercial Truck Stops.



Front Range Trailblazer System (Region 6)

Transportation Problem/Need:	Ineffective Information Dissemination/ No Alternate Routes
Corridor-Wide ITS Goal(s):	Enhance Traveler Mobility/Increase Safety/ Augment Communications-User Interface/ Encourage High Public & Policy-Level Acceptance/ Use Existing Advanced Technologies in Innovative Ways
User Service Objective(s):	Disseminate Reliable Travel-Tourist Data/ Reduce Delays and Accident Frequencies
Corridor Functional Area:	Traveler Information Systems
NPP User Service Bundle(s):	Travel-Transportation Management

Subsystem Characteristics: Over one-half of the recreational traffic along the I-70 West Corridor is generated by Front Range area residents taking advantage of the winter and summer outdoor resources available for one- to two-day weekend excursions. Most of the customers who frequent the gaming areas in Black Hawk and Central City originate from the Front Range area as well. These trip-makers access recreational and gaming activity areas in the Rocky Mountains, not only via I-70, but from other State Highway routes that serve the high country.

US 285 is a popular route to Summit County ski resorts and hunting/fishing areas. Southern Front Range and southwest metropolitan area residents often use C-470 as a part of their route to the mountains. Likewise, south suburban residents use US 285. SH 93 from the north, SH 58 and US 6 from the east, and C-470 from the south are common routes to access SH 119 into Black Hawk and Central City.

A system of electronic trailblazers would be installed on major Interstate and State Highway routes along the Front Range and within the Denver metropolitan area to advise travelers of alternate routes that can be taken into the mountains. Trailblazers would be installed at key locations along C-470, US 285, I-70 (west metropolitan), US 6, SH 58, and SH 93 to advise travelers about appropriate routes as they approach decision points to gain entrance to the mountains.

The system of trailblazers along the Front Range and metropolitan area routes would be linked to the CDOT Region 6 and Colorado Traffic Management Center information systems for automatic activation. These trailblazers would recommend the best route for the prevailing conditions. Trailblazers would also be placed at regular intervals along each route to provide wayfinding guidance. For example, if traffic is particularly heavy near Eisenhower Tunnel, the trailblazers might state "Use US 285% the route identifier and "To US 285" as the wayfinder.

This system would be deployed dependent on the adequate extent of sensing and detecting devices installed throughout the I-70 West Corridor. It is critical that adequate information can be gathered and processed so that accurate routing information can be provided via the trailblazers. Data collected from field devices by the regional TOCs and the C-TMC would be distributed to the Region 6 TOC in raw formats so that software algorithms, specific to this data dissemination system, could process and relay appropriate information.

Communicating the data can be accomplished along several media. Region 6 will have the responsibility to decide which is the most effective (from cost and reliability standpoints). These can include fiber optic cabling (if and when the roadside infrastructure will have access to conduit), radio transmission, cellular telephone, and the State microwave system. Other more feasible or desirable communications methods may become apparent as the system is developed and designed.

This project also offers cost-sharing opportunities with local businesses and organizations through sponsorships similar to the "adopt-a-highway" program. For a monthly fee, CDOT could provide

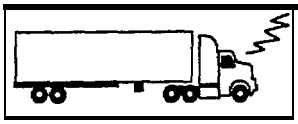
a static "this trailblazer sponsored by..." feature on the sign housing. This incentive would be dependent on state and federal laws regarding advertising within public rights-of-way.

Potential User Benefit: Well-informed travelers making better trip-making decisions; high customer satisfaction; effective public-private partnerships; increased traveler mobility.

Approximate Cost: $10,000 per installation; $50,000 software/system integration.

Potential Participants: CDOT Region 6, CDOT ITS Program Office, Colorado Division of Telecommunications, Trailblazer Vendors, Ski Resorts, Casino Owners, Local Businesses.

- Electronic Payment Services:



One-Stop Shopping Commercial Vehicle Automated Credential Processing (State-Wide)

Transportation Problem/Need:	Inefficient Management of Goods Movement/ Commercial Vehicle Use of Corridor
Corridor-Wide ITS Goal(s):	Enhance Traveler Mobility/ Reinforce Economic Benefits of Transportation
User Service Objective(s):	Strengthen Management-Oversight of CVO/ Monitor Hazardous Materials Transport-OverHeight/Weight Trucks/ Improve Current Processes-Regulations
Corridor Functional Area:	Commercial Vehicle Operations
NPP User Service Bundle(s):	Commercial Vehicle Operations

Subsystem Characteristics. This project would implement the Expert System Module, Truck Information Module, and Credentials Data System, developed as products of the Electronic One-Stop Shopping IVHS Field Operational Test Program, at the Dumont-Downieville Automated POE and other check/weigh stations and ports-of-entry serving the I-70 West Corridor.

The Expert System Module will analyze truck credential applications to confirm that Colorado CVO requirements are met. It will generate all necessary credentials as the commercial vehicle enters the State. The Dumont-Downieville Automated POE processor will have electronic access to the credential database to confirm that data collected "on site" matches.

The Truck Information Module will allow commercial vehicle operators to prescreen and electronically file their credential applications with the Department of Revenue. This information would be available electronically at the Dumont-Downieville Automated POE for checking and

matching credentials to data collected "on-site." Commodity routing requirements, travel data, and general regulatory provisions would be available in the POE processor for electronic transmission to in-vehicle units as they bypass the station.

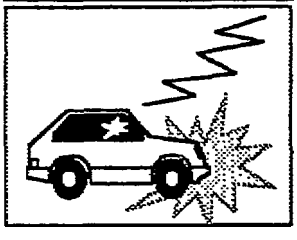
The Credentials Data System will be available at the Dumont-Downieville POE to facilitate the transfer of the Expert System and Truck Information Module data.

Potential User Benefit: Reduction of POE and trucker time and costs; streamlining of administrative processes; rapid turn-around of credential confirmation; consistency and uniformity in evaluating credentials; extended access and availability of credential data and requirements; interstate networking.

Approximate Cost: $20,000 Per Site

Potential Participants: CDOT ITS Program Office CVO Unit, Department of Revenue Port of Entry Division, Dumont-Downieville Automated POE Staff, Affiliated Truckers, Other State CVO/POE Divisions.

- Safety and Warning Systems:



In-Vehicle Cellular/GPS MAYDAY System (State-Wide)

Transportation Problem/Need:	Lack of Personal Travel Security
Corridor-Wide ITS Goal(s):	Increase Safety
User Service Objective(s):	Reduce Emergency Response Times
Corridor Functional Area:	Emergency Response
NPP User Service Bundle(s):	Emergency Management

Subsystem Characteristics. Using the systems developed for the Colorado MAYDAY Project and the Colorado State Patrol (CSP) computer-aided dispatch system (CAD), this project would deploy the technologies corridor-wide. Stranded, isolated, or injured motorists, equipped with in-vehicle global positioning system (GPS) and cellular telephone devices, would push a button to activate a "call-for-help." The system would electronically place a call over the cellular telephone to the CSP CAD, providing location information from the GPS unit, displayed in near real-time on a digital

map. A dispatch operator and the CAD would dispatch the appropriate emergency response unit to the scene.

Each in-vehicle unit would have a unique identifier that corresponds to a database of information about the vehicle and vehicle operator. Medical data about the operator, stored in the database, would allow the dispatcher to pass along special instructions to the emergency response unit. The cellular telephone number of the user would allow the dispatcher to confirm, to the caller, that the call was received and help is on the way. Vehicle information would allow the dispatcher to provide that data to the responding unit, so that appropriate tools, equipment, and supplies can be transported to the scene.

Potential User Benefit: Traveler security in times of need; improved public perception of CDOT and CSP; more efficient and effective emergency response.

Approximate Cost:
$75,000--System Design/Deployment
$10,000 to $20,000 Per Annum--System Update/Maintenance
$100,000 Per Annum--System Operations
$1000 Each--System Users

Potential Participants: CDOT iTOC/C-TMC; CSP; Emergency Response Providers; System Users.

LONG-TERM PROJECT DEPLOYMENT

Long-term ITS projects, applicable to the I-70 West Corridor, are those that can be considered beyond a 10 year horizon. A listing is provided regarding the kinds of ITS and multi-modal transportation system developments and initiatives that CDOT Regions and the ITS Program Office should monitor annually. As new ideas and technologies emerge, they should be examined for their ability to satisfy current and future transportation needs within the Corridor. Long-term suggestions within the Implementation Plan are visionary and require more detailed assessment as time goes on and paradigms shift.

In-vehicle subsystems and devices will more than likely be developed and marketed by the private sector. Because condition information and roadside transmitting devices may be required, operating agencies will need to be aware of the implications regarding the development and sale of such advanced technologies.

The Automated Highway System (AHS) concept development is rapidly advancing at the national level and can conceivably result in transition applications across the country within the long-range time frame. The private sector is currently developing the in-vehicle components that will require electronic roadway infrastructure to operate in the fully-automated mode. Along rural and intercity corridors, the public sector (particularly State DOT's) will, more than likely, be the leading and

responsible automated roadway operators, or will be a significant partner with the private sector if state's allow privatization of certain transportation-related operations.

CDOT needs to stay abreast of the advancements in this arena during the next 10 years. The system concepts suggest a highly viable solution to most I-70 West Corridor problems if funding for the roadway elements can be secured. Colorado should endeavor to position itself as a test bed for AHS implementation--the I-70 West Corridor is the prime corridor within the state to in which to make such investments.

Overall benefits that significantly reduce accidents and road condition delays (collision avoidance, longitudinal and lateral vehicle control), increase travel times (sensors and detectors to add longitudinal capacity), and reduce environmental impacts (electric powered vehicles) can satisfy the concerns of all stakeholders. The resort, economic development, and commercial industries can attract more customers to achieve their profit-oriented goals.

Universal Traveler Information Programs will more than likely be the most prominent and fastest moving set of ITS technologies to emerge. Following the significant advancements of the 1990s information age (and the electronic super-information highway), most people in the United States will be connected via various personal electronic devices. The passing into a new century will usher in dramatic advancements in artificial intelligence for expert systems where human intervention will be of less concern to ensure reliable data processing and exchange.

Once expensive options on vehicles, navigation and route guidance devices, pavement sensors, and other information gathering devices will become standard features. CDOT and its ITS partners must be ready to deploy appropriate roadside infrastructure and increase the capacity of the TMCs to operate on the vast amounts of information that will make travel decisions happen within the "wink of an eye."

The private sector will be mass marketing the general public to buy new gadgets and they will succeed. CDOT and its transportation operations partners need to keep up and surpass the market so they can personally and professionally respond to the changing communications that affect the transportation environment.

We the people have adjusted to the perception that driving wherever and whenever we like is an inalienable right. The physical capacity of the laud cannot handle the our growing numbers and our growing travel requirements. Beyond ten years, we the people will begin to recognize that, if we want to maintain the level of freedom to which we have become accustomed, we are going to have to pay for that flexibility. Road Use Controls will allow us to automatically debit our in-vehicle smart cards as we enter and exit restricted use facilities so that we don't have to worry about whether we have any change in our pockets.

CDOT and its transportation partners need to learn how to deal with new found "riches." If public agencies continue to operate transportation systems, they need to develop programs and policies for reinvesting the toll box revenues back into the transportation system.

Comprehensive Roadway Instrumentation is a likely result beyond 2000 so that we know everything there is to know about the facilities across which we are traveling. Not only will I-70 and the other Interstates have pavement sensors, surveillance cameras, and roadside beacons placed every 1/2 mile, so, too, will SH 9 between Breckemidge and Kremmling, SH 119 between I-70 and Black Hawk, US 24 from I-70 to Colorado Springs, and SH 82 from Glenwood Springs to Aspen.

CDOT and its transportation partners will be bombarded with tons of data--both useful and useless. Programs and processes need to be designed to appropriately and effectively use the data for future planning, design, construction, operations, and maintenance activities.

ITS technology holds the greatest promise for mass transit operators to attract those masses from their cars into a fixed route, fixed schedule system. Advanced Public Transportation Systems will equip the mass transit vehicles with the necessary components to appeal to our sensibilities of convenience, comfort, privacy, reliability, and flexibility.

Transit operators must be ready for the influx of new customers, able to expand their operations and services to complete in the global marketplace. Private operators are more efficient in their business because they need to turn a profit. Public agencies are encouraged to learn from the private sector.

Integration of ITS Technologies with Other Major Transportation Investment Strategies is paramount for needed improvements to occur. Limited financial resources already strain relationships and compel aggressive competition for what little money there is. Until engineers and scientists invent Jetson-like air-borne contraptions (and woe to all traffic engineers when they have to regulate traffic in 3-D) or Star Trek transporters, public involvement, environmental impact and other necessary planning strategies will also consume the last piece of pie.

Piggy-backing ITS applications onto other transportation improvement projects will breed new technological solutions, buy-in the conventionalists, and change the way the transportation business is done.

Everyone gets nervous about their personal security whenever they're on the road. Advances in Safety and Emergency Response Systems will automate administrative functions so that response crews can quickly do what they are trained to do--help. Roadside and in-vehicle systems will protect us from ourselves, reducing the potential for unexpected collisions because we've momentarily forgotten our primary function while in our car and on the road--driving.

CDOT needs to develop partnerships with enforcement and emergency service providers to streamline redundant activities. Since the primary objective is to provide for the health, safety, and

welfare of the traveling public, these partnerships and the advancement of technological services accomplish much to attain goal.

Road Maintenance and Management Systems will create more productive and capable crews. These individuals know more about transportation than most. Providing them with electronic tools to operate and maintain the transportation system will cultivate creativity and innovation for inventing new electronic tools to speed up processes and maintain safe travel ways.

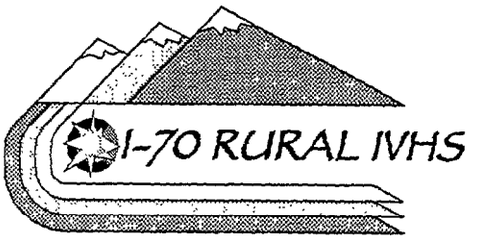
CDOT planners and engineers need to collaboratively partner with their operations and maintenance counterparts so that systems planning and design responds to operational and maintenance requirements. An integrated and open process accomplishes the same functionality as an integrated open system.

The ITS vision requires imagination and ingenuity. The ITS vision is steadfastly becoming reality. ITS reality will eventually become commonplace and expected. For now, the following known ITS technologies have potential for deployment in the I-70 West Corridor in the long-range time frame (beyond 10 years):

- in-vehicle sensor, navigation, and guidance systems:
  + on-vehicle/roadside beacon edge-of-lane delimiters,
  + route navigation and guidance devices,
  + infra-red vision enhancement devices,
  + private vehicles as automated probes, and
  + congestion prediction;
- automated highway system elements (automated vehicle control systems):
  + in-vehicle position sensor (following, lane changes) warnings,
  + automated collision avoidance (braking and/or steering), and
  + adaptive cruise control;
- universal traveler information program:
  + personal/portable traveler information devices,
  + super-information stations at traveler stops (continual real-time video broadcasts, traffic data, road and weather condition data, traveler services and event data);
  + in-vehicle radio data systems, and
  + real-time dissemination of airline and transit service data to information centers, in-vehicle devices, and personal portable devices;
- road use controls:
  + ramp and/or mainline toll plazas (full-time or peak period),
  + peak period use restrictions (commercial and/or private vehicles), and automated special use lanes (HOV, trucks, transit);
- comprehensive roadway instrumentation (detectors, CCTV, VIDS):
  + throughout the I-70 west corridor, and
  + along state highways connecting to I-70;

- advanced public transportation systems:
  - coordinated GPS/AVL of all transit operators (public and private),
  - corridor-wide integrated fare systems (smart cards), and
  - real-time/interactive ride matching/car pooling connections;
- integration of ITS technologies with other major transportation investment strategies:
  - multi-modal transfer centers (commuter/passenger/high-speed rail, light rail transit, bus, bicycle, pedestrian information/electronic fare collection interfaces),
  - automated intermodal centers (freight transfer for truck/rail/air modes), and
  - intelligent bicycle/pedestrian systems;
- safety/emergency response systems:
  - comprehensive 2-way MAYDAY emergency and stranded motorist assistance,
  - electronic flare call for help,
  - automated at-grade railroad crossing warning system (in-vehicle),
  - driver impairment detection and warning (in-vehicle), and
  - animal/vehicular warning system; and
- road maintenance and management systems:
  - in-vehicle weather/pavement condition sensors,

Imagination, ingenuity, and time will tell us what else the future of transportation along the I-70 West Corridor (and throughout the State of Colorado) holds!



CORRIDOR

MASTER PLAN

SECTION VIII

BUSINESS PLAN/ MARKETING STRATEGY SUMMARY

SECTION VIII BUSINESS PLAN AND MARKETING STRATEGY SUMMARY

Scope: Identify private sector participation opportunities for implementing IVHS technology as well as seek commitments for joint participation in implementation phases.

Prepare a marketing strategy that will provide CDOT with a framework for completing the overall goals outlined in the plan.

Develop a Business Plan which prioritizes the short-term and long-term vision of the IVHS plan for this corridor and takes advantage ofprivate sector funding opportunities, First priority will be given to those items which benefit traveler safety.

Deliverables: *Business Plan*
Marketing Strategy

OBJECTIVES

- *Provide Direction for Implementation*
- *Identify Funding Sources*
- *Create a Marketing Strategy*
- *Outline internal Program Execution*
- *Describe the Benefits to Stakeholders*

PROCESS

- *Draw From Nationwide Examples*
- *Field Test Strategies*
- *Modify Process to Local Requirements*
- *Design Business and Marketing Elements Based on What Learned*
- *Apply to Early Action Projects*

SOURCES

- *Travelers*
- *Local Residents and Businesses*
- *Prospective Funding Partners*
- *Legislators*
- *CDOT Staff*
- *Local Governments*

The Business Plan is a guidance document for implementing the I-70 West Corridor ITS program. A business plan is necessary to establish and prioritize the ITS vision for the I-70 West Corridor. Since ITS technology is relatively new in the eyes of most stakeholders, it is appropriate to provide direction' to those stakeholders on how the vision can be carried out. It is has proven difficult to foster change within the organizations that have responsibility for implementing new planning paradigms. The integration of advanced technology concepts into traditional transportation planning and improvement programs has, and will continue, to require a distinct and consistent effort from within.

While the objectives of the Business Plan are process-oriented; the milestones of success are measurable by:

- providing specific direction for CDOT to implement an integrated ITS Program for the I-70 West Corridor;
- identifying prospective sources of funding for priority ITS programs and projects;
- creating a marketing strategy that broadens awareness of ITS benefits;
- outlining how CDOT can execute the objectives of the I-70 West Corridor ITS Program internally; and

- describing how the benefits of the ITS Program can be communicated effectively to the traveling public, local governments, prospective funding partners, and local residents and businesses.

The Business Plan is specific and practical. It has a strong financial component. The Business Plan draws from other illustrative examples throughout the country. Portions of the Plan were subjected to a "field test" by taking the next implementation steps and using the process and results to refine the Plan.

The Business Plan builds on the accomplishments of the CDOT ITS Program Office with respect to the initiative that stepped beyond traditional mores and brought the ITS vision to Colorado. This dramatic, and sometimes courageous effort, has put Colorado in the spotlight as one of the front-running states in implementing a strong statewide ITS program.

CDOT embarked on this aggressive ITS initiative in the early 1990s by identifying how advanced technology applications could effectively respond to and solve the State's deteriorating transportation system. Since that time, several steps have been taken:

- initiation of several organizational changes to allow deployment of ITS technology efficiently and creatively;
- completion of an ITS vision for the state--C-Star;
- organization of a statewide ITS Implementation Team who developed the Smart Path Business Plan which carries the C-Star vision into an active implementation plan;
- funding of five operational tests of ITS technology;
- amendment of Colorado legislation to facilitate incident response and partnerships with private sector parties. The public/private partnering initiatives led to legislation allowing the telecommunications industry to install fiber in highway rights-of-way;
- initiated six additional ITS projects, which are in the planning stages; and
- identified 80+ feasible ITS projects for implementation in the I-70 West Corridor.

The Business Plan concentrates on the following components:

Colorado ITS Program Overview. The CDOT ITS program in given perspective by explaining activities to date, describing planned early action programs, and providing the uninitiated with a perspective of how ITS fits into the transportation industry. It includes:

- activities accomplished;
- planned programs; and
- ITS-- in context within the transportation industry.

Target Markets. The Business Plan is market-driven based on target markets, pertinent market trends, and strategic opportunities to achieve them. Target markets include:

- travelers;
- residents & businesses;
- prospective funding partners;
- state legislators;
- CDOT staff; and
- local governments.

Decision-Making Processes. Various funding approval processes can impact the deployment of ITS programs, including:

- federal funding;
- state funding;
- working with the private sector; and
- critical paths for approvals.

Marketing Strategy. The Marketing Strategy is designed to increase "customer" awareness and deliver a message. It targets internally (within CDOT) and externally. Private sector marketing strategies typically include activities such as advertising, public relations, and direct-mail. To these activities, this Marketing Strategy adds workshops, working with the news media, telecommunications, and other activities. The Marketing Strategy recommends:

- plan overviews;
- strategic marketing programs;
- public relations programs;
- print and electronic media outlets;
- workshops;
- written materials; and
- advertising.

Finance Plan. Likely financing partners and their respective attributes influence:

- how to package programs for acceptance by financing partners;
- sources of revenue from federal, state, local and private sources; and
- techniques pertinent to financing ITS projects.

Projects that are considered as the backbone of the I-70 West Corridor ITS will underlie the success of all projects. Several Early Action Projects are considered ready-to-go since the technology is in place and they are not contingent on any action other than direct implementation. Other sets of projects represent required combinations to achieve success.

The Finance Plan includes:

- financial packaging for results;
- likely financing partners, such as:

  + product vendors,
  + private non-profit institutions,
  + national trade & lobby associations,
  + local business community, and
  + federal, state, and local governments;
- funding arrangements; and
- likely funding partners for early action (short-term) projects.

Case Studies. Case studies were conducted as "field tests" to sample the implementation potential for early action ITS projects that are in the planning stages.

Next Steps.Specific steps that CDOT can undertake to further the I-70 West Corridor ITS Program are identified including staffing, funding, marketing, legislative initiatives, and other action recommendations.