EARLY ACTION PLAN

Intelligent Vehicle-Highway Systems
Denver Metro Area

Project IVH-MP 9108(1)

for the
COLORADO DEPARTMENT
OF TRANSPORTATION

C-STAR

November 1992

by:
CENTENNIAL ENGINEERING, INC.
CASTLE ROCK CONSULTANT' S
BALLOFFET AND ASSOCIATES, INC.

IVHS Study for the Denver Metro Area

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Page

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LIST OF ACRONYMS / ABBREVIATIONS

AAA	American Automobile Association
APTS	Advanced Public Transportation Systems
ATIS	Advanced Traveler Information Systems
ATMS	Advanced Traffic Management Systems
AVCS	Advanced Vehicle Control Systems
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
CCTV	Closed Circuit Television
CDOT	Colorado Department of Transportation
CIMC	Colorado Incident Management Coalition
CSP	Colorado State Patrol
CTI	Colorado Transportation Institute
CVO	Commercial Vehicle Operations
DAB	Digital Audio Broadcasting
DRCOG	Denver Regional Council of Governments
EON	Enhanced Other Networks
FHWA	Federal Highway Administration
FMCS	Fleet Management and Control Systems
FTA	Federal Transit Administration
GPS	Global Positioning System
HAR	Highway Advisory Radio
HOV	High Occupancy Vehicle
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
IVHS	Intelligent Vehicle Highway Systems
MAC	Metro Area Connection (Light Rail)
MOVA	Modernized Optimized Vehicle Actuation
OPAC	Optimized Policies for Adaptive Control
RDS	Radio Data System
RTD	Regional Transportation District
SCATS	Sydney Coordinated Adaptive Traffic System
SCOOT	Split, Cycle, and Offset Optimization Technique
TMC	Traffic Message Channel
TOC	Traffic Operations Center
TP/TA	Traffic Program/Traffic Announcement
TSM	Transportation Systems Management
VMS	Variable Message Signs
VMT	Vehicle Miles Traveled

1.0 OVERVIEW

1.1 Introduction

This report presents an outline of the recommended Early Action Plan for the initial development and deployment of Intelligent Vehicle-Highway Systems (IVHS) in the Denver Metropolitan Area. It includes several of those activities identified as appropriate for short-term implementation as detailed in the IVHS Strategic Plan. As such, this document is subordinate to the Strategic Plan and is intended as a short-term planning guide for the Colorado Department of Transportation (CDOT). Statements of problem identifications, goals and objectives have therefore been excluded here.

The Strategic Plan recommends the broad direction the Denver Metro IVHS program should follow, lists items which should be accomplished and identifies those activities which are promising and potentially effective in the Denver area. The Plan separates these activities into short-term (present until 1995), medium-term (1995-2000) and long-term time frames. The purpose of the Early Action Plan is to discuss and prioritize the short-term activities. Detailed evaluations of all the activities are provided in the IVHS Master Plan.

The highest priority item for IVHS Early Action is for CDOT to design and implement a Traffic Operations Center (TOC). The reasons behind this recommendation are varied but fall into three general categories:

- A TOC provides a focal point for the Denver area's IVHS-related activities, including data collection, information dissemination, traffic management and incident response. Provision of these activities under one roof will help to reduce area-wide delays, preserve air quality, increase safety, and form a platform for the implementation of future IVHS activities.

- Funding for the design of a TOC is available. The Federal Highway Administration (FHWA) is currently embarking on a program to promote the development of TOC's in the 75 largest metropolitan areas in the United States, and FHWA officials have indicated support for such a facility in the Denver area. CDOT has submitted a proposal to FHWA for funding the design of such a facility, which has recently been approved.

- A TOC provides opportunities for multi-jurisdictional dialogue and cooperation, education and research, and partnerships with the private sector which will form critical branches of the Denver area's IVHS program in the medium- to long-term.

Optimistically, the TOC could be constructed by late 1994. In order to maximize the initial effectiveness of the permanent facility, CDOT is considering the implementation of an interim TOC in late 1992 or early 1993. Current regional programs will be key elements of both facilities.

1.2 Current Regional Programs

CDOT and other agencies in the region have implemented a number of traffic control techniques and demand management programs to address regional transportation problems. These activities, which will be interfaced with and incorporated into the Denver area IVHS program, include the following:

- CDOT monitors and operates a network of freeway ramp meters at 28 locations, primarily in the east and south portions of the Denver area along I-25 and I-225. These control entry to the freeway system. Real-time traffic count information from the ramp meters is currently available and is shared with the private sector in a tabular format. CDOT is in the process of upgrading the ramp metering system computer to obtain greater control and monitoring flexibility. Improved software will allow graphical displays of freeway speeds.

- The Denver area freeways include a network of CDOT ice-detection sensors. Information received from the sensors is used to assist in scheduling and dispatching of highway maintenance vehicles during the winter. CDOT is also participating in a Federally-funded research project involving the development of new environmental sensor systems.

- CDOT currently maintains three telephone hotlines which the public can access to obtain information about weather-related or construction related roadway conditions. One is for statewide roadway conditions, another is for roads within two hours of Denver, and the third is for construction activities in the I-25 corridor. Hotline messages are kept as up-to-date as possible, however at any given time the information described could be several hours old.

- CDOT also maintains low power Highway Advisory Radio (HAR) installations located on interstate freeways on the fringes of the Denver area. They provide motorists with information about construction activities and road closures. Although this information is updated a few times per day, again, at any given time the information may be several hours old.

- CDOT is participating with the Regional Transportation District (RTD) in the construction of a two-lane reversible Bus/High Occupancy Vehicle (HOV) facility in the North I-25 Corridor between 70th Avenue and 20th Street. When completed in 1994, the bus/HOV facility will include a state-of-the-art traffic management system with an extensive network of loop detectors, closed circuit television (CCTV) monitoring, variable message signs (VMS), and computer-aided command and control capabilities. CDOT will be responsible for the control and operations of this system. RTD will have the system monitoring functions tied into their dispatch center, although this information will be available to CDOT as well. Use of the VMS will he limited to the bus/HOV lanes, but the loop and CCTV systems have the capability to monitor mainline traffic. Construction of the bus/HOV lanes will encourage the use of transit and ridesharing programs and relieve congestion on North I-25.

- CDOT initiated the formation of the Colorado Incident Management Coalition (CIMC) in 1991. Among the topics being investigated by Coalition subgroups are the use of cellular telephones to report incidents, 800 MHz communications between agencies, the initiation of a program of courtesy patrols along I-25 and a small portion of I-70, legal and interjurisdictional issues, incident command/control and facilitation of emergency services. A broad range of agencies and private interests have participated in this effort, and the CIMC has already made important progress toward increased cooperation and dialogue between multiple agencies and jurisdictions. The CIMC has issued a final report outlining 26 potential activities, Recommendations of the Colorado Incident Management Coalition, September 1992. Many of these proposals coincide with potential IVHS activities and have been utilized in preparing this Strategic Plan. For example, several of the CIMC recommendations depend upon the implementation of a Traffic Operations Center, one of the proposed IVHS activities detailed in Chapter 5. The CIMC hosted a follow-up conference in September, 1992 to summarize the group's activities in the first year of operation, and will continue its coordination efforts into the future. Leadership of the program will be transferted to the Denver Regional Council of Governments (DRCOG).

- RTD is currently working to implement a Global Positioning System (GPS) for a satellite-based automatic vehicle location (AVL) and computer aided dispatch system for its bus fleet. The existing communications system will be greatly enhanced through implementation of the GPS. RTD will use the system to monitor the existing bus fleet and trains when the Denver area light rail system (MAC) becomes operational. RTD is hopeful of ultimately providing real-time transit scheduling information to its Park-n-Ride facilities and other locations.

- Ride Arrangers, the commuter assistance program operated by DRCOG, offers a number of alternative transportation services in the Denver area. Initiatives include employer incentive arrangements to promote transit, assistance in the formation of carpools and vanpools, and a guaranteed ride home program.

- DRCOG coordinates a regional traffic signal timing program to improve traffic signal timings across jurisdictional boundaries.

- CDOT participates in the multi-state ENTERPRISE program for IVHS research, development, and implementation. The ENTERPRISE program could result in technology advancements with opportunities for practical use in the Denver area.

- Through its involvement in ENTERPRISE, Colorado has developed the C-Star program for statewide research, development, and deployment of IVHS technologies. This envisions a series of IVHS operational centers or IVHS hubs, distributed throughout the state. These will serve as focal points for required traffic and fleet management and traveler information services. The C-Star plan identified the Denver area as a key region for early IVHS demonstration and deployment.

- DRCOG has studied Denver regional mobility as it relates to the overall Regional Transportation Plan. These efforts will continue as DRCOG will soon initiate efforts to develop a Denver regional congestion management plan. Planners will complete a comprehensive evaluation of congested freeway and arterial segments and develop strategies and priorities to address congestion problems. The goal is to create an approved congestion management system for the Denver area in accordance with the requirements of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).

- The C-Star strategic plan recommends the establishment of a facility for high technology research in transportation in the State of Colorado. The Colorado Transportation Institute (CTI) has been outlined in a proposal and will likely be established within 12 months. The CTI could direct or undertake some IVHS research and development activities. The CTI would also provide access to valuable facilities such as laboratories and equipment for testing new IVHS approaches.[1]

The IVHS Early Action program will seek to build on these current and proposed efforts to the maximum extent possible. This will help to maximize gains realized from each project, minimize overlap within the total initiative, and create a firm basis on which to fast-track success. These existing programs provide many opportunities for implementing IVHS technologies.

1.3 Early Action Plan Components

IVHS activities most appropriate for early implementation incorporate the regional efforts described above and provide the basis for future expansions in high technology areas as they become available. Several of the activities identified in the Strategic Plan were designated as short-term projects because they best fit these requirements. Potential short-term activities identified in the Strategic Plan are as follows:

TRAFFIC OPERATIONS CENTER ACTIVITIES

- Activity 5.1.1 - Interim/Permanent Traffic Operations Center.
- Activity 5.3.1 - TOC Data Base Integration.

FIELD ACTIVITIES

- Activity 5.2.1 - Collect Real-Time Traffic Volume/Speed Information.
- Activity 5.5.1 - Temporary Communications in Key Locations.
- Activity 5.5.2 - Permanent Communications Network.
- Activity 5.7.1 - Expand Freeway Ramp Metering.

[1]Castle Rock Consultants. The C-Star Program. Intelligent Vehicle Highway Systems in Colorado, Draft Strategic Plan, September 10, 1992.

TRAVELER INFORMATION SYSTEMS ACTIVITIES

- Activity 5.6.1 - Enhance HAR.
- Activity 5.6.2 - Variable Message Signs.
- Activity 5.6.4 - Teletext/Cable TV Information Systems.
- Activity 5.6.6 - Audiotcx Information Systems.

INCIDENT MANAGEMENT ACTIVITIES

- Activity 5.2.3 - Dial-In Data Collection.
- Activity 5.4.1 - Incident Dctcction and Managcmcnt.
- Activity 5.4.2 - Coopcrativc Exchange System with TV/Radio.
- Activity 5.4.3 - Public and Private Dispatch Systems.
- Activity 5.4.4 - Preplanned Incident Diversion Routing.

OPERATIONAL TEST CORRIDOR ACTIVITIES

- Activity 5.1.2 - Demonstration Corridor
- Activity 5.7.2 - Advanced Isolatcd/Simulated Signal Coordination.
- Activity 5.7.3 - Rcvcrsiblc Lanes.

MANAGEMENT ACTIVITIES

- Activity 5.8.1 - Rideshare Matching/Management System.
- Activity 5.8.6 - CDOT/RTD/DRCOG Partnership.
- Activity 5.9.1 - Program Management/Coordination
- Activity 5.9.2 - Marketing and User Acceptance Surveys.
- Activity 5.9.3 - Participation in Standardization.
- Activity 5.9.5 - Public/Private Partnerships.

While not all of these activities can bc achieved in the short-term due to time and financial constraints, they present a menu of options for CDOT to consider. Scvcral of these activities could be implcmcntcd simultaneously along with a Traffic Operations Center or a demonstration corridor project, for cxamplc. The activities arc discussed in further detail in subsequent chapters of this document and in the IVHS Strategic Plan and Master Plan.

2.0 TRAFFIC OPERATIONS CENTER (TOC)

2.1 Introduction

The project team recommends that initial IVHS efforts be concentrated toward the design, construction and implementation of a TOC. Establishing a TOC is central to several elements of the Denver area IVHS program. Its importance will continue beyond the short-term phase and well into the future when the TOC expands its role in supporting and controlling available and emerging IVHS technologies over these time periods.

The TOC will be a multi-jurisdictional, multi-agency facility. Space will be provided for Colorado Department of Transportation (CDOT) and Colorado State Patrol (CSP) personnel, as well as for public/private sector staff including traffic engineers from cities and counties in the Denver area, the media, enforcement agencies and fire/emergency medical response organizations. The TOC has the potential to be an important platform from which to improve dialogue and cooperation between Denver area jurisdictions and agencies. It also provides opportunities to establish educational and research programs as well as partnerships with the private sector.

Earlier in 1992, the Federal Highway Administration (FHWA) announced it was embarking on a program to establish TOCs in the largest 75 urban areas in the United States. Discussions between CDOT and FHWA revealed that funding is available now for the design of such a facility in 1992-93. Consequently, CDOT has secured this funding and implementation of a Denver area TOC could occur by late 1994.

Between now and late 1994, CDOT will likely implement an interim TOC to begin organizing the existing field systems, such as ramp metering, ice detection, telephone hotlines, and Highway Advisory Radio (HAR), into a group of systems operated from a single location. Implementation of activities subsidiary to the TOC, such as construction and enhancement of the communications system, could begin almost immediately, especially following the implementation of an interim TOC, and extend into the late 1990's and beyond.

The TOC will serve to unite the existing and soon to be realized efforts described above, as well as provide a basis for medium- and long-term IVHS efforts as described in the Strategic Plan. The facility will be an information clearing house, with data-sharing capabilities for other jurisdictions as well as a center for the dissemination of information to the public. Many of the CIMC's 26 recommendations become feasible faster with the presence of an operational TOC.

2.2 TOC Purpose

The TOC will serve multiple purposes. These include the following:

- The TOC will be a focal point for multi-agency and public/private sector traffic management efforts. Operators will be able to monitor and control traffic flows

on area freeways and ultimately influence traffic flows on the arterial street network.

- The TOC will serve as a foundation for short, medium- and long-term IVHS activities in the Denver area. These include Advanced Traveler Information Systems (ATIS), Advanced Public Transportation Systems (APTS), Fleet Management Control Systems (FMCS), Advanced Vehicle Control Systems (AVCS), Advanced Traffic Management Systems (ATMS), demand management systems and the data collection and information dissemination functions associated with these systems.

- The TOC will be a regional incident detection and response center. Coordination of local incident management initiatives will take place under one roof. TOC capabilities will include automated and manual detection of incidents, initiation of response plans including transmission of advisory messages to the appropriate agencies, and the provision of "war room" capabilities for major emergencies which impact traffic and require coordination between multiple agencies, as well as accurate press releases. The TOC will also be the coordination center for a cellular call-in system to report accidents and the Denver area courtesy patrol program.

- The TOC will communicate with travelers at home, in-vehicle, and from remote locations such as office building lobbies or shopping centers. Information to be available will include current conditions, weather updates, advance notice of congested areas or construction zones, potential routing options and transit schedules and status. The TOC will generate traffic messages for telephone hotlines, HAR, variable message signs (VMS), and other communications media as well as maintain the appropriate data bases for traveler enquiry services.

- The TOC will provide a location for high technology research in cooperation with local colleges and universities, the Colorado Transportation Institute (CTI) FHWA or other agencies interested in transportation research.

- The TOC will function as the source for a public awareness and education program to inform travelers about the purposes, benefits and activities of the TOC and IVHS in general.

Conceptual planning for the TOC will include these factors as they relate to the Denver area's IVHS-related data collection and information dissemination efforts. One important TOC function will be to unite existing Denver area traffic management technologies and demand management efforts under one roof, while remaining flexible enough to incorporate future expansions and enhancements in IVHS.

The implementation of a TOC is crucial to many of the Denver area's proposed IVHS and incident management initiatives. The TOC will provide a focal point for these activities in traffic and incident management, thereby supporting the operation of an integrated transportation information system. The amount of data base integration and sheer volume

of incoming data will require a state-of-the-art computer system for system facilitation and management.

2.3 TOC Features

The TOC building will have space available for traffic operations, maintenance and enforcement functions.

Space will be provided for CDOT personnel from Regions 1, 6 and Staff representatives from CDOT Headquarters. Additional space will be available for public/private sector staff including traffic engineers from cities or counties in the Denver area, local enforcement and fire/emergency medical response organizations. This multi-jurisdictional representation will allow for multiple use of traffic information, incident management coordination, and freeway/arterial traffic operations control and monitoring. Building areas will also be provided for the media, including traffic reporting services, and for visitors to tour the facility without disrupting operations. Restrooms, kitchen facilities, offices, conference rooms, storage areas and reception area will all be included in the building.

The TOC building will be shared by the Colorado State Patrol (CSP), which already coordinates many activities with CDOT. The presence of both agencies within the same facility will help in coordinating incident responses and dispatching of maintenance vehicles during inclement weather. CSP is currently in the process of consolidating their dispatch operations in northeast Colorado. Existing CSP dispatch facilities in Limon, Hot Sulfur Springs, Greeley and Sterling will be consolidated with the Denver area dispatch unit and located in the TOC.

Ongoing activities in IVHS and incident management will be incorporated into the TOC as they are implemented, however, a number of features should be operational on the first day that the permanent TOC opens, or shortly thereafter. An interim TOC would likely facilitate the capability to have these features in place. These include communications, monitoring, control, and administrative functions as follows:

- State-of-the-art communications system including connection of the center to the respective field elements, linking of the TOC with other communication and operation centers (such as the I-70 operations centers at the Eisenhower Tunnel and in Glenwood Canyon), and provisions for future expansion. The communications system will be a critical component of all short, medium, and long-term IVHS efforts.

- Expanded and upgraded ramp metering system, providing real-time traffic data and graphical displays to the TOC. Traffic data from other pavement loops installed along the freeway system in conjunction with recent resurfacing projects will be included as soon as communications links are established.

- Incorporation of the North I-25 Traffic Management System including its command/control, CCTV and VMS systems.

- Provision of TOC-generated weather, roadway, and traffic data to traffic reporting services, radio and TV stations, and other appropriate agencies.

- Continuation of the telephone hotline program and HAR services to provide information on road conditions, weather, and freeway construction activities with potential enhancements to introduce TOC-supported real-time data updates.

- Incorporation of the Denver area ice-monitoring system and Region 1 weather and avalanche databases into improved maintenance scheduling and dispatching operations for Regions 1 and 6.

- Communications facilities to assist in coordination between jurisdictions, such as the 800 MHz trunked radio system recommended by the CIMC. Initial plans call for two pairs of 800 MHz channels to be implemented; one for use by public safety agencies and the other as a motorist aid channel for dissemination of information to the public. The TOC will act as a central operations point to provide information to the media.

- Integration of a cellular telephone call-in system to assist in reporting and verification of incidents as proposed by the CIMC.

- Incorporation of existing CCTV systems in or near the Denver region, such as the system deployed by one local broadcast television station.

- Incorporation of existing VMS displays in or near the Denver area, particularly those belonging to CDOT Region 1.

- Coordination of the courtesy patrol program the CIMC has initiated for I-25 and a portion of I-70.

- A freeway wok permit system for all construction, maintenance, and utility work with a daily distribution of the approved lists.

. A Data Base Integration System to assist in computerized data processing on a real-time basis.

2.4 TOC Advanced Features

Over time, CDOT will be able to expand its ATMS coverage and communications systems over greater portions of the Denver area freeway and arterial systems. Concurrently with this future expansion, medium- and long-term IVHS initiatives will be examined for inclusion into the TOC. The TOC may include the following advanced IVHS features:

- An Advanced Traveler Information System which will incorporate data obtained from the loop detectors to produce a freeway speed/congestion electronic map for

use by the media and public in areas such as building lobbies or on cable television for pre-trip planning.

- A TOC Expert System which will ultimately ease the responsibilities of the TOC operators by providing automated support capabilities.

- A Radio Data System (RDS) using a Traffic Message Channel (TMC).

- A system to provide coordination with transit/paratransit providers, such as audiotex and/or videotex.

- A computer-aided dispatch system with Geographic Information System capabilities for CDOT Region 1 and 6 highway maintenance and engineering vehicles, the CSP and linkage to all area fire and police agencies, and other communication and operations centers. This feature could include an interface with the RTD GPS system.

- Continued coordination of a system to accommodate cellular call-ins for incident reporting and verification.

- Continued incorporation of incident management activities including the courtesy patrol program with the goal of establishing a comprehensive incident management program including detection, verification, public and media information, coordination of appropriate responses, scene management and clearances.

- Provision for inclusion of freeway/arterial, other arterial, or grid traffic signal systems which may be implemented on the State Highway System, potentially including adaptive, air-quality responsive or fourth generation systems.

- Provision for interfacing city traffic signal systems with other city systems or with freeway systems made possible through improved multi-jurisdictional cooperation efforts.

- Computer and communication capabilities to accommodate the initial in-vehicle systems to be implemented in the Denver area.

Prioritization of medium- and longer range IVHS activities are discussed in more detail in the IVHS Master Plan.

2.5 TOC Multi-Agency Aspect

Within the Denver area, there are a number of agencies and organizations concerned with traffic and incident management. A goal of the TOC development effort is to look at them not as individual agencies, but as members of a team with common objectives. Traditionally, these groups work relatively independently in trying to solve similar problems affecting their particular jurisdictions. With implementation of an interface

through the TOC, these agencies should be able to coordinate their individual efforts in a more comprehensive manner beneficial to all involved parties and the highway network as a whole.

A variety of organizations, both public and private, may ultimately be involved in operating, coordinating with or using data collected at the TOC. In the initial stages of operation, potential participants could include:

- CDOT Region Six.
- CDOT Region One.
- CDOT Headquarters.
- Colorado State Patrol (CSP).
- City and County of Denver Traffic Engineering Department.
- Regional Transportation District (RTD).
- Denver Regional Council of Governments (DRCOG).
- Denver area police agencies.
- Denver area fire departments.
- Commercial traffic reporting services.
- Media (radio and cable TV).
- Emergency services such as paramedics, etc.
- Private towing companies.
- Colorado Incident Management Coalition (CIMC).

Some of these groups, such as CDOT and CSP, would maintain a permanent staff presence in the TOC. Others may provide staff on an as-needed basis, or could coordinate or interface with the permanent TOC operations. As the Denver area TOC system expands, agencies such as the police, fire and traffic engineering departments in additional communities may become involved. Potential areas for consideration include the following cities and counties:

- Arvada
- Aurora
- Broomfield
- Cherry Hills Village
- Commerce City
- Englewood
- Federal Heights
- Golden
- Greenwood Village
- Lakewood
- Littleton
- Northglenn
- Sheridan
- Thornton
- Westminster
- Wheat Ridge
- Adams County

- Arapahoe County
- Douglas county
- Jefferson County

The exact system boundaries for the region controlled or monitored by the TOC are not yet determined. The previous listings are therefore a preliminary illustration of the program's potential extension and impact. As the TOC and its interfaces to other groups become operational, the appropriate participant agencies and organizations will become more evident.

CDOT will introduce the TOC to the Denver area transportation community upon opening of the new building and intends to institute a policy of information sharing from the first day of implementation. It is hoped that the various agencies will see the benefits of increased data sharing, communications and dialogue, and begin to form a base of local support for the activities of the TOC.

2.6 Interim TOC

CDOT is considering the implementation of an interim TOC facility in late 1992 or early 1993. The purposes of such a facility would be largely the same as for the permanent TOC with four added advantages:

- CDOT would have a testing ground in which to learn the best methods and techniques in running a TOC prior to the opening of the permanent facility.

- The CIMC has completed its first year of work and made recommendations. Implementation of an interim TOC would give CDOT a running start at establishing incident management teams, priorities and strategies prior to opening the permanent TOC. Related activities such as the establishment of the cellular call-in and 800 MHz communications systems, establishment of corridor management teams, and the coordination of the courtesy patrol program, could be implemented almost immediately.

- CDOT could immediately begin investigating ways to upgrade the HAR and hotline systems to provide near real-time information.

- CDOT would have a platform from which to initiate and build interjurisdictional relationships which would carry into the future.

The interim facility would likely be in a rented space and centrally located in the Denver area. CDOT is officially committed to implementation of the interim TOC however funding sources for the implementation and operation of the facility have not been pinpointed.

3.0 FIELD ENHANCEMENTS

3.1 Introduction

Some improvements will by necessity need to be made to existing field equipment and systems to make them more compatible with the anticipated TOC systems and to update various systems capabilities to state-of-the-art levels. CDOT has already initiated this process through its project to update the current ramp metering computer hardware and software. This process will also include the establishment of real-time communication links between the TOC and the field elements, which include controllers, cameras, and detectors.

3.2 Communications

Communications technologies have advanced rapidly within the past few years. State-of-the-art link-to-link communications are today achieved predominantly through the use of fiber optics. The advantages of fiber optics technology include speed, capacity, signal clarity and immunity from various types of interference such as electrical inductance, lighming, vibration, moisture, static electricity, and automobile ignitions. The new communications system to be installed from the TOC to the field elements should rely heavily on fiber optics as a medium.

Fiber optics have been used in traffic control applications in the Denver area for several years, specifically in traffic signal systems in the cities of Denver and Wheat Ridge. To date, the communications performances of these systems have been excellent. Plans for the North I-25 Traffic Management System include fiber optic connections between the central computer and the various command, control, monitoring, and data collection elements.

The type of fiber optic cable recommended for traffic control purposes is a similar cable to that used in widespread installations by telephone companies across the country. Installation of a buried fiber optic communications network along the Denver area freeways may provide opportunities for a public/private partnership in the form of joint use or leasing arrangements, or financial participation in construction activities from private telecommunications providers.

A trend has also been developing in the past several years toward a more distributed approach to traffic control. Placement of more logic and control functions at the roadside not only reduces demands upon the central computer, but reduces communications costs, as not every piece of field equipment needs a direct connection to the central computer.

Implementation of IVHS elements will increase communication requirements from the existing situation several times over. The compartmentalization of various data collection, monitoring, and control functions will result in a net cost savings in the long run because communications improvements may constitute the single largest cost of implementing a Denver-wide IVHS system in the next 20 years.

The high costs associated with installing communications conduit along many miles of freeway system dictate that growth of the ultimate fiber optic network will be segment by segment as funding becomes available. In the short-term, however, fiber optic links may only exist along the north I-25 corridor and along freeway segments adjacent to the TOC. Near term efforts to incorporate various field elements into the TOC, such as the existing ramp metering system, will likely be via existing copper wire links and telephone lines. The older communications elements will be gradually phased out as the fiber optic system is expanded.

Communication links to remote centers or jurisdictions will likely be by a combination of telephone, microwave, and radio in the short-term. Satellite communications may be a possibility for these types of communications in the medium- to long-term.

3.3 Monitoring Elements and Data Collection

The TOC will utilize several elements of field hardware to accomplish freeway and arterial monitoring functions. The most common of these elements will probably be loop detectors, at least in the short-term. Other methods which may become financially or technically viable may be added in the medium- or long-term time frames. These methods might include microwave, radar, video, or infrared detection. Information from the detectors will be used to determine congestion levels along segments of the metro freeway and arterial systems and to detect the possibility of an incident.

CDOT has a large network of loop detectors already in place along the existing freeway system. This is because, in addition to the loops placed for the ramp metering system, CDOT has also been installing loop detectors along the freeways during recent overlay projects, primarily along I-25. At present, no control equipment has been installed at the latter locations to tabulate the traffic count information. CDOT will probably install the appropriate control equipment to bring these loop systems on line in the short-term due to the desire to generate a color-coded speed/congestion map of the freeway system in conjunction with the interim TOC.

Closed circuit television (CCTV) cameras will also be used for monitoring. CCTV can be used to confirm reported incidents, and can also be used in the same manner as a detector to count vehicles. With the initial implementation of CCTV technology in the north I-25 corridor, CDOT may prefer to begin expanding its monitoring capabilities in the CCTV area as opposed to adding more loops. CCTV provides a safety benefit not found in the maintenance-intensive loop detectors in that CDOT would not need to close freeway lanes to perform maintenance on or to replace a video camera.

In the initial stages of the IVHS program, the communications system will be limited due to financial constraints of building a large network in the short-term. CDOT should consider installing additional field hardware, such as CCTV cameras, at critical bottlenecks or accident locations with temporary communication links from the field to the TOC. This activity should be undertaken by CDOT as one of the early projects to be done in concurrence with the interim TOC.

Several Denver area television stations have installed CCTV cameras at fixed locations to view traffic conditions along the freeway. CDOT will likely pursue the development of public/private partnerships with the TV stations to obtain access to these video feeds, providing an additional expansion of the CCTV coverage areas in the short-term.

4.0 TRAVELER INFORMATION SYSTEMS

4.1 Highway Advisory Radio (HAR)

Implementation of a TOC will allow almost immediate improvements to traveler information systems. HAR allows CDOT to broadcast recorded messages at low power levels to the traveler by virtue of a wire placed underground adjacent to the roadway. Much of CDOT's existing HAR is located in outlying areas to advise truckers and other interstate travelers of conditions and roadway construction in Denver. With the TOC, this information can be transmitted to the public in a much more efficient and closer to real time manner because incident notification will be much faster and the capability to change HAR messages will be much more convenient. The system can also provide the potential for live audio traffic bulletins during peak periods or in light of incidents or inclement weather. In order to improve the effectiveness of HAR, CDOT should consider expansion of the HAR into the core Denver area, installing HAR signs with flashers to alert the traveling public of critical times to tune to the appropriate frequency on their car radios. CDOT is currently investigating legalities and methods of extending the existing HAR facilities into the urbanized portion of the Denver area freeway system.

4.2 Road Condition/Closure System

CDOT currently maintains two telephone hotlines dealing with road conditions statewide and within two hours of Denver, as well as one construction hotline detailing road closures and anticipated delays during construction periods. After TOC implementation, CDOT will have the opportunity to update the hotline information in a much more efficient and closer to real time manner, thereby providing better information to the public.

4.3 Speed/Congestion Map

CDOT is currently developing the software necessary to compile information from the ramp metering system and convert it to a graphical format. This will be done as part of upcoming improvements to the ramp metering computer system and operational software. Since CDOT has such a large number of unconnected detector loops already in place, priority in implementing a communications network should be given to installing controllers for these loops and linking to them. This will expand coverage of the speed/congestion map to freeway segments outside of the currently metered areas. The map will serve a twofold purpose. The first would be as a visual aid for the TOC operators to monitor freeway operations and identify problem areas quickly. The second function would be as an information base for transmittal to the public. The public could receive this information through dedicated monitors installed in the lobbies of large office buildings or other high-pedestrian locations. The information could also be transmitted on a dedicated cable television channel which would allow travelers to preplan their trips to a certain extent prior to leaving.

4.4 Other Information Systems

The Strategic Plan identified several information systems with potential to have noticeable benefits in the short-ten. These include teletext and cable television information systems, videotex information systems, audiotex information systems, and the use of variable message signs.

Teletext and cable television systems would make use of graphics such as the speed/congestion map to relay traffic information to the public in real time. The service would offer a number of pages of traffic information, selectable by area or information type. A picture insert window will also be used to show live broadcast pictures of major incidents from TOC-controlled cameras. Videotex systems provide information to the public from remote computer and video terminals located in office buildings and activity centers. Two private companies have already expressed interest in participating in these projects, presenting a good opportunity for a public/private partnership.

Audiotex services supply information by telephone. The user is able to use touch-tone keys to move between menus and select the appropriate information. The activity will be primarily focused on transit services, building upon RTD's existing information system, soon to be enhanced by implementation of the GPS system.

4.5 Variable Message Signs (VMS)

Variable message signs offer an on-street technique to give motorists real-time information in advance of key decision points along freeways, or prior to reaching congested points along the route but can be expensive due to their structural and electronic requirements. Their use should be integrated with other information dissemination techniques. CDOT should evaluate the effectiveness of the VMS signs to be installed as part of the North I-25 Bus/HOV project and continue to evaluate the need for such signs in critical locations as the communications system is expanded. Other potential uses of VMS could include variable speed limit signs and lane use control signs. CDOT Region 1 has an existing system of VMS to assist travelers moving in and out of the mountains west of Denver. In the short-term, Region 1 will likely shift control operations for the VMS system to the TOC.

5.0 INCIDENT MANAGEMENT PROPOSALS

5.1 Coordination with Law Enforcement and Fire Protection Agencies

The CIMC is currently working to increase the communications capabilities between enforcement and response agencies, municipalities, and the public. One proposal includes two common 800 MHz channels to facilitate these communications. One channel will be for agency use only and the second will be a Motorist Aid Channel for shared traffic information used by agencies and the public. Agreements have already been worked out between CDOT and the City and County of Denver, for CDOT to purchase and the City to maintain two of Denver's repeaters on Mt. Morrison to facilitate the effort. It is anticipated that use of the 800 MHz channel will improve verification and response times to major incidents in the Denver area. The TOC will again provide the focal point for use of this channel as it relates to incident management. With the CSP moving into the TOC, coordination between agencies can only be improved beyond these levels.

5.2 Incident Reporting

In the short-term, detector, and CCTV coverage of the freeway system will be limited. Utilizing a cellular telephone call-in system will provide improved levels of incident detection and verification. The cellular call-in reporting of incidents has a proven track record of success in other cities and is a second area being explored by the CIMC. Accidents and emergencies will still be reported through the *911 system, however, roadway conditions will be reported through a second number, possibly *77. The CIMC is currently evaluating the manpower requirements such a system would demand upon the CSP, Denver Police Department, and TOC staffs. CDOT and CSP would likely need extra call takers in the TOC devoted exclusively to fielding these calls, in order to keep other operators free to deal with control, enforcement, and monitoring issues. In order to improve system effectiveness, the program should include a freeway signing plan to encourage motorist participation and also a roadway reference system with mile markers installed at l/l0 mile intervals to allow motorists to more accurately report their location. To prevent overloading of the existing *911 system, the dial-in system should be introduced after the implementation of the TOC.

The incident reporting system should continue to make use of information supplied by airborne news media crews, law enforcement patrols and Public Works employees, possibly augmented by RTD bus drivers.

5.3 Incident Detection and Verification

In the short-term, incident detection should become a much more reliable process. The 800 MHz communication channels and cellular call-in systems will greatly increase the flow and volume of incident reporting. Computer systems to be installed with the TOC will assist this effort by supplying a level of automated incident detection. Human detection and verification will be improved by the speed map discussed earlier, allowing

operators to identify potential problem areas at a glance, as well as the potential to verify an incident through CCTV cameras.

CDOT will likely make extensive use of CCTV technology to assist in the verification process once a possible incident has been identified. CDOT should consider expanding the I-25 North CCTV coverage to a more comprehensive area. A segmental increase in cameras as funding becomes available may be the best method to extend the coverage areas. In the short-term, CDOT should initially install some CCTV cameras at high accident or heavily congested locations.

5.4 Courtesy Patrol Coordination

The CIMC successfully implemented a courtesy patrol program for the I-25 corridor and a small portion of I-70 through the Mousetrap area beginning on August 31, 1992. The courtesy patrols perform such functions as assisting with minor automobile repairs, providing gasoline, removing disabled vehicles off the freeway when possible or to the shoulders, and performing as good will ambassadors toward the public. The initial program is a pilot venture and will be evaluated during the initial six month operations period. CSP operates the patrol, using vehicles with push bumpers, along the portion of I-25 from Colfax Avenue north to 84th Avenue, including the I-70 segment between Federal Boulevard and Washington Street. The local branch of the American Automobile Association (AAA) operates the patrol south of Colfax to County Line Road using tow trucks. CDOT anticipates that courtesy patrol operations will eventually be coordinated out of the TOC.

6.0 FLEET MANAGEMENT SYSTEMS

Implementation of the TOC will enable CDOT to improve its maintenance dispatching capabilities. Current Region 6 dispatching efforts are executed from the CSP dispatching center. During inclement weather, a Region 6 representative must travel to CSP headquarters in Lakewood to perform dispatching functions. Region 1, geographically spread from the Continental Divide to the Kansas state line, has much more complex and demanding dispatch requirements, in which vastly different weather conditions may exist on the plains, in the Denver area and in the mountains, and dispatching functions can be carried out from several different locations.

After the new TOC opens, CDOT should develop and implement an integrated maintenance fleet management system for Regions 1 and 6. This will aim to manage the use of these resources, particularly during extreme weather conditions when maintenance vehicles are required to keep the highway network operational. For this reason the system will include links with environmental sensor systems and the Region 1 weather and avalanche database to allow early warning of bad weather. In the TOC, dispatch consoles will be provided for both regions through CSP's upgraded 800 MHz tnmked radio system, which represents a tremendous short-term communications improvement over the status quo.

Longer term options might include dispatch of maintenance vehicles using specially designed operations control software and examining options for implementation of an AVL system. In this area, opportunities for increased cost-efficiency through integration with CSP or RTD facilities will be considered. Although it is not believed that an AVL system for maintenance vehicles only would be cost effective, it may be possible to reduce some of the cost by sharing an existing or proposed AVL system with another agency.

7.0 OPERATIONAL TEST CORRIDOR

An important early action activity will consist of planning and design to implement IVHS technologies, most likely a combination of ATMS treatments, in one or more demonstration corridors. At least one freeway or one arterial corridor will be considered for initial implementation. The project need not necessarily be constrained to a corridor application, but could also take the form of an area, consisting of a group of interchanges or an arterial grid network.

Criteria for selection of a demonstration project will include traffic volumes and levels of congestion; accident histories; costs and potential benefits; freeway versus arterial considerations; probability of operational and institutional success; ease of implementation; interface with incident management efforts; operational and maintenance requirements; communication and control requirements; and visibility to the general public.

The demonstration project will likely include several IVHS technologies. No candidate corridors have been identified at this time. Recommendations for demonstration projects will be made in a follow-up document to the Master Plan.

8.0 PROGRAM MANAGEMENT

The Strategic Plan identifies several management activities which should be initiated in the short-term to administer the Denver area IVHS program and provide a framework for future projects within the short-term, medium-term, and long-term planning horizons. These activities, intended to be completed primarily by the CDOT Region 6 and Headquarters staff, include the following tasks:

- Definition, management, coordination, evaluation, and review of technical projects.
- Updating program plans and policy objectives.
- Achieving public acceptance by developing marketing activities and distributing user acceptance surveys.
- Participation in standardization.
- Identification of partnerships with other agencies, such as RTD and DRCOG.
- Identification and pursuit of private partnerships for participation in the Denver area's IVHS program.

Many of these tasks overlap. CDOT's primary management philosophy should be to actively encourage participation from the private sector whenever possible. This can most logically be done through creation of a marketing plan featuring initial contacts then following through with presentations to the local business community as part of an educational process.

9.0 SUMMARY

Passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) has presented CDOT with enormous opportunities and challenges. Funding for IVHS implementation is specifically identified and FHWA is currently encouraging state agencies to develop these systems. The Denver area has a strong base of on-going projects and programs to build on. A TOC will provide a focal point for these activities and allow future implementation of expanded programs. In order to ensure the maximum effectiveness and utility of the TOC, it must be linked with data collection systems in the field. Links to travelers, the media, and other agencies must be established so that information is distributed in a timely manner to anyone needing it.

The TOC is the most critical activity for CDOT to pursue in the Early Action period. Perhaps the second most critical activity is the development of a mechanism by which to encourage participation of the private sector in future IVHS projects. Local computer, electronics, telecommunications and aerospace companies would seem to be logical choices for participation. Private partnerships could help CDOT develop some of the short-term IVHS projects in a more timely and cost-cffcctivc manner. These projects could include the TOC construction and/or operation, dcvclopmcnt of the permanent communications network, obtaining real-time traffic information from state-of-the-art field elements, and travel information dissemination of almost any type.

The IVHS Master Plan outlines specific projects in much greater detail, including lists of participants and their interrelationships, scheduling specifics, costs, priorities, and risks.