Colorado Transportation Management System (CTMS)

I-25 Truck Safety Improvements Project
(FY98 Earmark)

Local Evaluation Report

December 29, 2004

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All photos by CDOT except: 18 video image by City of Colorado Springs; 10, 13, 14, 17 by Centennial Engineering, Inc.

Executive Summary

The I-25 Truck Safety Improvements project (I-25 TSIP) is the result of a FY98 congressionally designated earmark to support improvements in transportation efficiency, promote safety, increase traffic flow, reduce emissions, improve traveler information, enhance alternate transportation modes, promote tourism and build on existing Intelligent Transportation Systems (ITS).

In spite of its name, the project was an all-encompassing statewide ITS deployment and integration package not limited to trucks and Commercial Vehicle Operations (CVO); nor was it limited in scope to the I-25 corridor.

The project included $9M in federal funding and $2.25M in matching state funds, yielding a project value of $11.25M.

With Federal Highway Administration (FHWA) concurrence, the project was initially divided into thirty (30) task orders to address ITS needs of the Colorado Department of Transportation (CDOT) in areas ranging from planning through detailed design and implementation. Specific activities included deploying field devices such as Dynamic Message Signs (DMS) and Highway Advisory Radio (HAR); automation of various Colorado trucking Ports of Entry (POE); improvements to internal subsystems including the traveler information web site ("Co-Trip") and multi-modal database; developing and deploying communications systems; and information exchange between CDOT and other agency partners. All task orders undertaken were done to address one or more pressing needs.
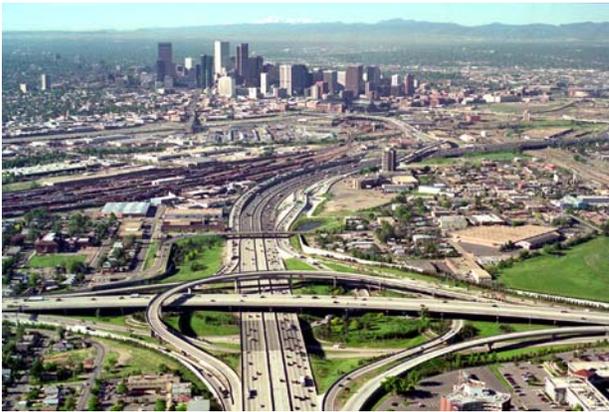

Photo 1 - I-25, central Denver at I-70 – looking south

Award of the I-25 Truck Safety Improvements Project (I-25 TSIP) funding allowed CDOT to augment previous ITS modules and subsystems and was an important building block for Colorado, providing critically needed systems integration and deployment. The funding allowed Colorado to increase the speed, accuracy and reliability of data collection and information dissemination systems, ultimately yielding a more powerful and utile statewide ITS.

CDOT believes the project is a resounding success. Prior to the I-25 Truck Safety Improvements, CDOT was infrastructure-poor and deficient in capability to collect, compile and disseminate information. Although an inter-agency partnership was in place, information exchange with partners had not been achieved. Statewide incident management initiatives were only beginning. A previous state-funded integration and deployment project had initiated detailed planning and design work but exhausted funding prior to implementing many of the desired elements. Finally, the overall CDOT ITS Program had achieved only modest funding levels and momentum from which it could easily rectify these shortcomings.

The I-25 TSIP provided the single mechanism needed to address previous ITS deficiencies, strengthen and expand inter-agency partnerships, bolster related initiatives like incident management, and generate significant ITS Program momentum. The project has been a catalyst to attract additional state and federal funding into Colorado, allowing CDOT to accelerate ITS deployment in the last five years on a scale unprecedented in the State. CDOT has taken advantage of project funding as well as the referenced momentum to develop order-of-magnitude improvements in: 1] number of field devices; 2] data collection and dissemination capability; 3] communications capability; 4] active interface with stakeholders; and 5] operations, maintenance and ITS program management.

The I-25 Truck Safety Improvements project is an ITS success story. Project goals and objectives were met. Deficiencies in infrastructure; functionality; automation; traveler information dissemination, commercial vehicle operations; data sharing; and amount, accuracy and timeliness of data were addressed in multiple task orders. CDOT believes achievement of the project goals and objectives on such a large scale makes the I-25 Truck Safety Improvements project a remarkable success story.

1. Introduction

In 1997, US Congress earmarked Fiscal Year 1998 (FY98) funds for selected projects identified to support improvements to transportation efficiency, promote safety, increase traffic flow, reduce emissions, improve traveler information, enhance alternate transportation modes, promote tourism and build on existing Intelligent Transportation Systems (ITS). A proposal submitted by the Colorado Department of Transportation (CDOT) was assessed and found to meet that profile. CDOT was subsequently awarded $9M in federal funds for the I-25 Truck Safety Improvements project. An additional $2.25M in matching state funds yielded a total project value of $11.25M.

Language in the Colorado Request for Congressional Inclusion outlined its I-25 Truck Safety Improvements project as an initiative to *"fund integration of ITS components in the Denver Area and on Interstate Highways serving Denver. It includes interconnection and expansion of the Denver and Colorado Springs traffic operations centers, improvement of incident management, congestion management improvements, deployment of rural traveler information and automation of ports-of-entry along the I-25 North American Free Trade Agreement (NAFTA) trade corridor."*

In the ensuing Partnership Agreement developed by CDOT and the Federal Highway Administration (FHWA), both entities reached concurrence on the work to be included. Project funds were initially allocated to thirty (30) task orders comprising a mix of deployment and integration. A base condition of the Partnership Agreement was that CDOT perform an evaluation of the project, hence this document presents the results of the final I-25 Truck Safety Improvements local evaluation.

Photo 2 - Urban congestion typical of I-25 Through Denver and Colorado Springs

1A Report Organization

Section 1 provides introductory material including a description of the requirements for inclusion in the local evaluation as defined in the Partnership Agreement and a list of abbreviations. Section 2 includes descriptions of the team, institutional involvement, project task orders and intended levels of integration. Sections 3 and 4 describe the evaluation plan and a summary of findings for the project – including two "elected activities" required by USDOT. Finally, Appendix A describes compliance of the I-25 Truck Safety Improvements with the FHWA Final Rule for projects of this type and Appendix B provides additional detailed task order information.

1B Local Evaluation - Reporting Requirements

The CDOT/FHWA Partnership Agreement requires the Local Evaluation Report encompass at a minimum the following discussions:

- Description of the work completed;
- Assessment of how well the project met goals and objectives; and
- The technical and institutional issues encountered completing the project.

ITS project evaluation guidelines prepared by USDOT require two of six additional "elective" evaluation activities be undertaken as part of the local evaluation report. Those are identified and included in this document. The balance of this report describes the overall project and individual task orders, highlights the requested areas and discusses how the elements of the project were or were not deemed successful.

1C Abbreviations

Abbreviations are used throughout this document. Table 1 provides a list of these and their definition.

Table 1 - Abbreviations

Abbreviation	Definition
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
ATR	Automated Traffic Recorder (count station)
AVI	Automated Vehicle Identification
C2C	Center-to-Center
C2F	Center-to-Field
CCD	City & County of Denver
CCTV	Closed Circuit Television
CDOT	Colorado Department of Transportation
Co-Trip	CDOT Road/Weather/Incident Information web site
CSP	Colorado State Patrol (currently co-located with CDOT ITS)
CSTOC	Colorado Springs Traffic Operations Center
CTMC	Colorado Transportation Management Center (CDOT statewide facility - Lakewood)
CTMS	Colorado Transportation Management System (current "umbrella" of projects)
CVEC	Commercial Vehicle Electronic Credentialing
CVISN	Commercial Vehicle Information Systems and Networks
CVO	Commercial Vehicle Operations
DIA	Denver International Airport
DMS	Dynamic Message Sign
DRCOG	Denver Regional Council of Governments (Denver Metropolitan Planning Organization)
EJT	Eisenhower-Johnson Tunnel (I-70 at Continental Divide about 50 miles west of Denver)
FHWA	Federal Highway Administration
HAR	Highway Advisory Radio
HELP	Heavy Vehicle Electronic License Plate
HLT	Hanging Lake Tunnel (I-70 east of Glenwood Springs)
I-25 TSIP	I-25 Truck Safety Improvements Project
IMP	Incident Management Plan (CDOT has IMP in place for segments of nine corridors)
ISP	Information Service Provider
ITS	Intelligent Transportation Systems
MM	Mile Marker
MPO	Metropolitan Planning Organization (DRCOG for Denver Area)
NITSA	National ITS Architecture
NTCIP	National Transportation Communications for ITS Protocol
POE	Port of Entry
RITSA	Regional ITS Architecture (Denver or Colorado Springs/Pueblo/Region 2 architectures)
RMDI	Colorado Revised Model Deployment Initiative (previous project)
RTD	Regional Transportation District (Denver)
SONET	Synchronized Optical Network
TIC	Traveler Information Center
T-REX	I-25 Southeast (Denver) Corridor Transportation Expansion Project
UCD	University of Colorado at Denver
USDOT	United States Department of Transportation
WIM	Weigh In Motion

Section 2 provides detailed background information through descriptions of the project management configuration, institutional involvement, task order breakdown and work descriptions and levels and types of integration.

2. I-25 Truck Safety Improvements Project Background

CDOT refers to its ongoing ITS development program as the Colorado Transportation Management System (CTMS). The CTMS dates from 1991 but efforts to move to large-scale deployment did not accelerate until 1996, when CDOT submitted a proposal to FHWA for the ITS Model Deployment Initiative.

Although the proposal was unsuccessful, the Colorado Transportation Commission decided to capitalize on internal and inter-agency momentum generated by the effort, allocating an initial $5.5M into Colorado ITS. That project, the Colorado Revised Model Deployment Initiative (RMDI), was the first large-scale ITS deployment and integration project undertaken by CDOT. RMDI began the architecture configuration and systems engineering process for future statewide ITS, deployed devices and became the first project under the CTMS umbrella. Award of the I-25 Truck Safety Improvements Project (I-25 TSIP) funds allowed CDOT to augment RMDI and was an important ITS building block for Colorado, providing critically needed integration and deployment. This funding allowed Colorado to increase the speed, accuracy and reliability of its data collection and information dissemination subsystems, ultimately yielding a more powerful and utile ITS.

Photo 3 – I-25 POE at Monument –
Non-automated operations northbound

Although RMDI had a specific focus on the Colorado Front Range, the I-25 TSIP is statewide – and not limited to CVO. Work was also not specific to I-25, but took place along statewide routes of significance in five of the six CDOT Regions. The I-25 TSIP comprised CDOT's second large-scale integration and deployment project.

2A Project Management

CDOT and its partners formed a team for the I-25 TSIP in the same configuration used in RMDI. In addition to CDOT and participating public entities, the original management team included two private sector groups: 1] the Systems Integrator ("Integrator"); and 2] the Program/Systems Manager ("Manager"). CDOT made a determination in RMDI that having access to two private teams provided a workable mechanism for review, feedback, advice and access to resources. Both parties contracted with CDOT following a competitive Request for Proposals and were teams of companies. The Integrator had responsibility for design and construction, procurement, software development and integration. The Manager provided technical oversight, completed portions of task orders, and otherwise assisted CDOT with the technical, administrative, management, coordination and reporting aspects of the project, including evaluation. The I-25 TSIP started in 1999 using this framework.

The Manager developed scopes of work, estimates and schedules for each task order. These were reviewed by a committee comprised of CDOT, FHWA, the Integrator, Manager and affected agencies. Upon approval by the referenced parties, task orders were activated by CDOT by providing the Integrator with written notice to proceed.

By mid-2000 due to reasons documented under separate cover, CDOT and the Integrator made a mutual determination to discontinue the Integrator's contract. CDOT developed plans for technical, schedule and cost recovery of the ongoing task orders. Due to technical, contractual and cost concerns balanced against scheduling constraints, CDOT made the following decisions:

- To finish selected task orders nearing completion using Integrator forces.
- To finish other open task orders using State forces.
- To start and finish not-yet-open task orders using State forces.

CDOT decided to continue the Manager's contract to provide technical and administrative assistance for the duration of the project.

The management team included the following individuals:

Role	Name	Phone
FHWA Oversight and Management	Rick Santos	(720) 963-3009
CDOT Program Manager	Frank Kinder	(303) 512-5820
CDOT Task Leader (Communications)	Bob Wycoff	(303) 512-5803
CDOT Task Leader (Integration/Web)	John Williams	(303) 512-5823
CDOT Task Leader (POE)	Dave Judy	(303) 512-5813
CDOT Task Leader (ATR/HAR)	Bruce Coltharp	(303) 512-5807
CDOT Task Leader (Planning)	Saeed Sobhi	(303) 512-5858
CDOT Task Leader (Operations)	Rod Mead	(303) 512-5822
CDOT Task Leader (DMS/CCTV)	Dick Stenger	(303) 512-5842
Manager Program Manager	Steve Sabinash	(303) 279-1984

2B Institutional Involvement

CDOT worked closely with internal and external stakeholders and partners throughout the I-25 TSIP. Stakeholders include the following individuals.

Organization	Name	Phone
CDOT Chief Engineer's Office	Peggy Catlin	(303) 757-9203
CDOT ITS Branch Manager	John Nelson	(303) 512-5838
CDOT Region 1	Ken DePinto	(303) 757-9122
CDOT Region 2	Terry Shippy	(719) 546-5492
CDOT Region 3	Jim Nall	(970) 248-7213
CDOT Region 4	Larry Haas	(970) 350-2143
CDOT Region 6	Ali Imansepahi	(303) 757-9511
Colorado Department of Revenue	Jerry Pierce	(303) 205-5684
Colorado State Patrol	Jim Lynn	(303) 239-4518
Colorado Tourism Board	F. Robert Lee	(303) 892-3850
Denver Regional Council of Governments	Steve Rudy	(303) 480-6747
Douglas County	Larry Corcoran	(303) 660-7490
City of Colorado Springs	John Merritt	(719) 661-6214
City of Fort Collins	W. Stanford	(970) 221-6630
City of Lakewood	Dave Baskett	(303) 987-7980
City & County of Denver Transportation	Bob Kochevar	(720) 865-3150
City & County of Denver Police	Ed Connors	(303) 640-2011
Denver International Airport (DIA)	Rick Busch	(303) 342-2200
Regional Transportation District (RTD)	Dave Shelley	(303) 299-2408
University of Colorado at Denver	Sarosh Khan	(303) 556-2724

Stakeholders were involved in all phases of work related to their jurisdictions. For example, the Stadium Parking Management task included frequent meetings and coordination between the CDOT management team, the City & County of Denver and CDOT Region 6. Such involvement began during scoping and continued throughout the work. Further discussion of institutional involvement and institutional issues is provided later in this document.

2C Task Order Breakdown and Work Descriptions

CDOT and FHWA began scope negotiation following award. The project was initially configured to include thirty (30) task orders. Certain task orders were later deleted, had their scope modified, or underwent funding transfer. Such changes were accomplished through amendments to the CDOT/FHWA Partnership Agreement, thereby obtaining approval of FHWA for such actions. Among the deleted task orders, three were initially cancelled but undertaken (and completed) by CDOT in separate projects. These included:

- Task Order #12 – Incident Management Plan (IMP) I-25 Denver to Colorado Springs – developed separately by CDOT Region 1 and complete as of this date.

- Task Order #13 - I-25 Ramp Metering Denver – constructed separately by CDOT Region 6 as part of the I-25 Southeast Corridor Transportation Expansion (T-REX) project. Temporary meters are in place for all ramps between MM 195 and MM 203. Permanent meters will be installed according to the master I-25 construction schedule – slated for completion by 2006. Region 6 is also continuing a program to expand ramp metering coverage along additional routes of regional significance such as US-6 and C470.

- Task Order #15 – Commercial Vehicle Electronic Credentialing (CVEC) – developed separately by the CDOT ITS Branch using state funding and complete as of this date.

Portions of two task orders were postponed altogether. These included:

- Task Order #6C – Automated Traffic Recorder (ATR) Integration – postponed until a later project pending further development of the CDOT "core" system.

- Task Order #23 (Colorado Springs Traffic Signal Interface) – postponed in-progress due to inability of the Integrator, CDOT, City and signal system vendor to agree on pricing for the first integration – between the City signal and freeway management systems. Early Task Order #23 work to develop the interface between the CTMC and Colorado Springs Traffic Operations Center (CSTOC) was undertaken, resulting in Operational Concepts and Requirements, communications system deployment and work station exchange to allow each party access to the other's data. Activities undertaken as part of cancelled Task Order #23 are discussed as part of the evaluation of Task Order #7 (I-25 Interconnect, CTMC to Colorado Springs).

The project was ultimately configured as shown in Table 2. Project funds allocated to each and a brief work description are included. More detailed descriptions follow.

Table 2 - Project Detail

No.	Task Order Name	Value	Brief Description
1	I-25 Truck Safety Reimbursement, Region 1	$ 1,200,000	Reimburse Region 1 for ITS elements of truck climbing lane project south of Denver.
2	POE Automation, I-25 Monument, Region 2	$ 414,258	Install AVI/WIM (most AVI state-funded).
2A	POE Enhancements	$ 48,000	Enhance web for CVO data. Install POE computers.
3	POE Automation, I-25 Fort Collins, Region 4	$ 480,538	Install AVI/WIM (most AVI state-funded).
4	POE Automation, I-70 Limon, Region 1	$ 407,453	Install AVI/WIM (most AVI state-funded).
5	CTMC Operations	$ 681,964	CTMC ops, management and support personnel.
6	*ATMS/ATIS Integration ($ 1,231,659)*	*N/A*	*See Task Orders 6A, 6B, 6C, 6D, 6E, 6M.*
6A	ATMS/ATIS – Communications	$ 60,000	Statewide communications system architecture.
6B	ATMS/ATIS - NTCIP DMS Driver	$ 57,000	Software for NTCIP-compliant DMS driver.
6C	ATMS/ATIS - ATR Integration	$ 0	DELETED. Deferred to later project.
6D	ATMS/ATIS - Web Integration	$ 449,751	Primary task to develop/enhance Co-Trip web site.
6E	ATMS/ATIS - Denver Fiber Ring	$ 454,268	End equipment for Denver high-speed ring network.
6M	ATMS/ATIS Integration – Miscellaneous	$ 210,640	Database enhancements, hardware, software.
7	I-25 Interconnect, CTMC – Colorado Springs	$ 627,000	Work sta. swap; install T1 (temp) & fiber (perm).
8	I-25 HAR, Region 4	$ 56,596	Install HAR.
9	I-25 DMS, Colorado Springs, Region 2	$ 1,190,496	DMS and support structures.
10	I-25 DMS, Region 4	$ 750,000	DMS and structures (augmented with state funding).
11	I-25 ATR/WIM, Region 4	$ 84,417	Install ATR/WIM (count/weigh stations).
12	I-25 IMP, Denver – Colorado Springs, Reg. 1	$ 0	DELETED. Completed as part of separate project.
13	I-25 Ramp Metering, Denver, Region 6	$ 0	DELETED. Part of separate project.
14	1-800 Road Weather Information Line	$ 150,000	Interim 1-800 road/weather call-in (Y2K compliant).
15	CVO Electronic Credentialing (CVEC)	$ 0	DELETED. Completed as part of separate project.
16	I-70 Hanging Lake Tunnel Integration, Reg. 3	$ 288,000	Requirements for new system; upgrade video.
17	Denver Area Speed Map, Region 6	$ 200,000	Develop speed map.
18	I-25 Stadium Parking Mgmt., Denver, Region 6	$ 300,000	Equipment to manage I-25 for stadium events.
19	Denver Area Traffic Signal Interface	$ 250,000	Develop C2C interface with City of Lakewood.
20	Message Paging Interface	$ 150,000	Paging alerts for incident response personnel.
21	CCTV, Regions 1 and 6	$ 500,000	CCTV software, switchers, cameras, mounting.
22	Colorado Springs Area Speed Map, Region 2	$ 200,000	Develop speed map.
23	Colorado Springs Traffic Signal Interface	$ 0	DELETED. Deferred to later project.
24	Statewide Speed Map	$ 200,000	Develop speed map.
25	Weather Systems Integration	$ 100,000	Compile/organize weather data and port to web site.
26	Low-Speed Communications	$ 820,599	Communications end equipment.
27	Traveler Information Center (TIC)	$ 400,000	ISP test project – augmented with state funding.
28	Public Information & Incentive Leverage	$ 14,130	CDOT-selected public relations activities.
29	Transit Data Integration / Kiosks	$ 100,000	Kiosks for transit centers & rest areas.
30	Start-Up Tasks	$ 354,890	Various interfaces; architecture training.
	TOTAL	**$ 11,250,000**	

2C.1 Task Order Details
The following descriptions provide detail about the task orders undertaken as part of the I-25 TSIP.

Task Order #1: I-25 Truck Safety Reimbursement, Region 1
This project reimbursed Region 1 for ITS and truck safety elements in Project IM 0252-038 (truck climb lanes MM-187 to MM-194 south of Denver). Items deployed included interconnect conduit/cable, DMS, ATR, WIM, weather station and call boxes. Work was completed under separate contract by CDOT Region 1. Task order value was $1,200.000

Task Order #2: Port-of-Entry (POE) Automation I-25 at Monument, Region 2
This project installed WIM and AVI sensors on I-25 and hardware/software to allow automated commercial vehicle bypass for PrePass subscribers (if vehicle credentials in order). A portion of the AVI work was state-funded. Work was completed by the Integrator. Task order value was $414,258.

Task Order #2A: POE Enhancements
This sub-task comprised: upgrading the web site to incorporate trucker-specific information; and providing the ports with automated access to this data. In addition, Closed Circuit Television (CCTV) cameras were installed at selected ports to allow the operator to view POE ramps. Work was completed by CDOT. Task order value was $48,000.

Task Order #3: POE Automation I-25 at Fort Collins, Region 4
This project installed WIM and AVI sensors on I-25 and hardware/software at the port to allow automated commercial vehicle bypass for PrePass subscribers (if vehicle credentials in order). A portion of the AVI work was state-funded. Work was completed by the Integrator. Task order value was $480,538.

Task Order #4: POE Automation I-70 at Limon, Region 1
This project installed WIM and AVI sensors on I-70 and hardware/software at the port to allow automated commercial vehicle bypass for PrePass subscribers (if vehicle credentials in order). A portion of the AVI work was state-funded. Work was completed by the Integrator. Task order value was $407,453.

Task Order #5: CTMC Operations
This task provided CTMC technical/administrative staff support. Federal participation ended following the 4th quarter 1999 and was continued with state funding. Personnel were provided through the Integrator. Task order value was $681,964.

Task Order #6: ATMS and ATIS Integration
This project was the primary architecture compliance and systems integration activity for the I-25 Truck Safety Improvements. The project was split into sub-tasks for easier coordination and tracking. Work was completed by CDOT except where indicated. Total task order value was $1,231,659.

Photo 4 - Task Order #5 – CTMC operations room staff

Task Order #6A: Communications Systems Architecture
This project developed architecture and standard design for statewide communications subsystems including high- and low-speed tiers. Work was completed under separate contract through CDOT Region 6. Sub-task value (contribution) was $60,000 with additional funding by Region 6.

Task Order #6B: National Transportation Communications for ITS (NTCIP) Compliant DMS Driver
This project developed a software device driver to allow communication with new NTCIP-compliant DMS being implemented as part of the separate Region 6 HOV Lane Expansion project on US-36. Work was completed by the Manager under separate contract to CDOT Region 6. Sub-task value was $57,000.

Task Order #6C: ATR Integration
This project was postponed and deleted from the project pending further development of the CDOT central ATMS/ATIS.

Task Order #6D: Web Integration
This project provided an order-of-magnitude upgrade to the Co-Trip web site initially developed during RMDI. The site was expanded in capacity, speed, number of data options available and "look and feel." Work was completed by CDOT with the assistance of a separate contract. Sub-task value was $449,751.

Task Order #6E: Denver Metro Fiber Ring
This project procured and deployed end-hardware to establish an inter-agency high-speed fiber optic ring in the Denver area. Installation of the high-speed backbone was completed via separate contract. Agencies included in the ring (joined by others in later projects) were the City & County of Denver, City of Lakewood, Regional Transportation District (RTD), CDOT Headquarters, CDOT Region 6 and the CTMC. Work was completed by CDOT. Sub-task value was $454,268.

Task Order #6M: Miscellaneous Integration
This project provided software development for as-needed activities, primarily addressing the multi-modal database and web peripheral items. Work was completed by both Integrator and CDOT forces. Sub-task value was $210,640.

Task Order #7: I-25 Interconnect, CTMC to CSTOC
This project included a number of activities, some started under Task Order #23 prior to its cancellation. Completed Task #23 work included Operational Concepts, Requirements and an NTCIP planning document for the center-to-center (C2C) interface between the CTMC and CSTOC. Task #7 activities included installation of work stations at each facility as an interim means to exchange data, provision of interim T-1 communications, and contribution of the remaining funding balance of $400,000 toward field installation to deploy the 33 miles of fiber optic cable "missing" between the two centers. The remaining funding required for the 33 miles of cable and conduit was provided by the State. The Operational Concepts, System Requirements and NTCIP report were completed by the Manager. Fiber installation was through CDOT via separate contract. All other work was completed by CDOT. Task order value was $627,000.

Task Order #8: I-25 Highway Advisory Radio (HAR), Region 4
This task order deployed a new 10-watt HAR on I-25 between Denver and Fort Collins and also developed a shared use operating agreement with the City of Fort Collins for the joint use of their existing 40-watt HAR. Installation was initiated by the Integrator. Completion of the installation (including testing) and coordination with Fort Collins was completed by CDOT. Task order value was $56,596.

Task Order #9: I-25 Dynamic Message Signs (DMS), Colorado Springs, Region 2
This task purchased and installed about 20 master/slave DMS for installation on I-25 through Colorado Springs by City or Region forces. Installation was phased to coincide with reconstruction of I-25 through the City. Purchase was completed by the Integrator. Installation was completed by the City of Colorado Springs and/or CDOT Region 2. Task order value was $1,190,496.

Task Order #10: I-25 DMS, Region 4
This task order built 4 DMS and support structures on I-25 north of Denver. State funding was contributed to complete the fourth sign. Work was completed by the Integrator. Task order value was $750,000 not including approximately $157,000 in State funding.

Photo 5 - Task Order #10 – I-25 DMS in CDOT Region 4 – Location is northbound I-25 between Denver and Greeley

Task Order #11: I-25 ATR/WIM, Region 4
This task order installed automated count and weigh-in-motion stations in Region 4. The purpose was to identify levels of truck traffic using alternate routes to bypass the Fort Collins POE. Work was completed by the Integrator. Task order value was $84,417.

Task Order #12: I-25 Incident Management Plan, Denver to Colorado Springs, Region 1
This project was cancelled and completed under separate contract by Region 1.

Task Order #13: I-25 Ramp Metering, Denver, Region 6
This task was cancelled but is being deployed under the I-25 Southeast Corridor Transportation Expansion (T-REX) project. All temporary meters are in place from MM 195 to MM 203. Permanent meters will be phased in with the corridor reconstruction, slated for completion by 2006.

Task Order #14: 1-800 Road Weather Information Line
This project temporarily enhanced the CDOT road weather information line to improve capacity, service, allow toll-free calling, and provide Y2K compliance. Later, CDOT provided an order-of-magnitude upgrade to the system (with state funding) using the operational concepts and subsystem architecture developed under this task. Work was completed by the Integrator. Task order value was $200,000.

Task Order #15: Commercial Vehicle Electronic Credentialing (CVEC)
This project was cancelled and undertaken separately by CDOT. All "major" POE facilities in Colorado are currently automated for electronic credentialing (save for one location in one direction on I-70 – intentionally not automated due to steep mountainous grades immediately downstream and the desire to stop all trucks for safety reasons).

Task Order #16: Hanging Lake Tunnel (HLT) Integration, Region 3
HLT is on I-70 about 150 miles west of Denver. This project provided two elements of work. In the first, requirements were developed for an upgrade to the tunnel environmental and traffic control systems. Region 3 released a Request for Proposals for this work via outside contract and the resulting work is ongoing as of the date of this report. In the second phase, the video subsystems in the tunnel were upgraded to facilitate video data exchange between the CTMC and HLT. Phase 1 work was completed by the Integrator. Phase 2 was completed by CDOT. Task order value was $288,000.

Task Order #17: Denver Metro Area Speed Map
This project developed an automated map displaying (current) freeway speeds in the Denver area for use by system operators and for display on the web site. Work was completed by CDOT with assistance from the University of Colorado at Denver. Task order value was $200,000.

Task Order #18: I-25 Stadium Parking Management, Denver, Region 6
This project provided field elements to assist the City & County of Denver in developing traffic/parking control and monitoring for the new stadiums and other venues (Coors Field, Pepsi Center, Invesco Field, Six Flags Elitch Gardens) along I-25 in central Denver. The elements primarily consisted of communications and video equipment. Work was completed by CDOT. Task order value was $300,000.

Task Order #19: Denver Area Traffic Signal Interface
This project planned and designed a system-to system and center-to-center (C2C) interface between the CTMC and a selected Denver area system. The selected agency was the City of Lakewood. Activities included the development of Operational Concepts and Requirements for the interface, work station exchange, establishing physical communications and initial data exchange. Work was completed by CDOT and the Manager. Task order value was $250,000.

Task Order #20: Message Paging Interface
This task developed a paging system to notify CDOT and incident response personnel of road, weather and incident alerts. Work was completed by the Integrator. Task order value was $150,000.

Task Order #21: Closed Circuit Television (CCTV), Regions 1 & 6
This project installed cameras, mounting structures and communications to provide video data for the CTMC in the indicated Regions. Development and selection of a statewide video systems architecture, hardware vendor and software vendor was completed. Work was started by the Integrator and completed by CDOT. Task order value was $500,000.

Task Order #22: Colorado Springs Area Speed Map
This project developed an automated map displaying (current) freeway speeds in the Colorado Springs area for use by system operators and display on the Co-Trip and Colorado Springs web sites. Work was completed by CDOT with assistance from the University of Colorado at Denver. Task value was $200,000.

Photo 6 - CCTV installation

Task Order #23: Colorado Springs Traffic Signal Interface
This project was cancelled when the Integrator, CDOT and the City were unable to come to pricing agreement on a contract with the signal system vendor. Some activities were completed, including Operational Concepts and Requirements documentation for the interface and interim work station exchange to facilitate data sharing while the interface is under development. Referenced activities were completed by the Manager and/or CDOT. Remaining funds were transferred to Task Order #7. Completed Task Order #23 activities are discussed as part of the Task Order #7 evaluation. CDOT will revisit the remaining Task Order #23 activities as part of a future project.

Task Order #24: Statewide Speed Map
This project developed an automated speed map as a demonstration activity for a rural corridor. I-70 west of Denver was selected. The map uses data from vehicle probes and automated count stations to display current speeds on I-70 for use by operators and display on the Co-Trip web site. Work was completed by CDOT with assistance from the University of Colorado at Denver. Task order value was $200,000.

Task Order #25: Weather Systems Integration
This project compiled data from the statewide CDOT weather stations and made it available for public use via Co-Trip. More detailed data was made available on the CDOT-secure web for use by internal maintenance forces. Work was completed by CDOT. Task order value was $100,000.

Task Order #26: Low Speed Communications
This project developed architectures for low-speed communications networks (statewide) needed to allow data exchange between the CTMC and field devices over the high-speed fiber backbone. Work included installation of communications end-equipment at multiple locations. Work was completed by CDOT. Task order value was $820,599.

Task Order #27: Traveler Information Center (TIC)
This project was a test to determine the value of hosting a private Information Service Provider (ISP) in the CTMC and incorporating same into day-to-day operations. Upon exhaustion of federal funding, the test was continued using state funding but was ultimately discontinued. Work was completed by the Integrator. Task order value was $400,000, not including additional state funding of about $375,000.

Task Order #28: Public Information and Incentive Leveraging
This project was intended to augment the Integrator's proposed private match for the project. A limited amount of funding was used for the Fort Collins port of entry automation grand opening ceremonies. Work was completed by the Integrator. Task order value was $14,130.

Task Order #29: Transit Data Integration / Kiosks
The transit data integration element of the project was cancelled when a partner agency was unable to deliver one of the base elements. In any case, traveler information kiosks were deployed at a number of rest areas and transit stations. Work was completed by CDOT. Task order value was $100,000.

Task Order #30: Start-Up Tasks
This project completed a number of outstanding items remaining from the RMDI project. These included providing National ITS Architecture (NITSA) training, supporting development of the Denver Regional Architecture, completing the HAR interface, and completing the E-911 (incident reporting) interface with the Denver Police Department and Colorado State Patrol (CSP). The Integrator provided the architecture training and the remaining items were completed by CDOT. Task order value was $354,890.

Photo 7 - Task Order #25 compiled data from weather stations statewide for Dissemination to Colorado drivers and Co-Trip users

2D Levels/Types of Integration

The I-25 Truck Safety Improvements project yielded a mixture of deployment and integration. Those task orders focused on ITS <u>device deployment</u> included:

- Task Order #1: I-25 Truck Safety Reimbursement, Region 1.
- Task Order #2: POE Automation, I-25 at Monument, Region 2.
- Task Order #3: POE Automation, I-25 at Fort Collins, Region 4.
- Task Order #4: POE Automation, I-70 at Limon, Region 1.
- Task Order #8: I-25 HAR, Region 4.
- Task Order #9: I-25 DMS, Colorado Springs, Region 2.
- Task Order #10: I-25 DMS, Region 4.
- Task Order #11: I-25 ATR/WIM, Region 4.
- Task Order #18: I-25 Stadium Parking Management, Denver, Region 6.
- Task Order #21: CCTV, Regions 1 and 6.
- Task Order #29: Transit Data Integration / Kiosks (transit data integration component deferred).

Other task orders focused on <u>communications infrastructure deployment</u>. These included the following. Integration of communications elements also occurred as part of these tasks and is discussed separately.

- Task Order #6E: Denver Metro Fiber Ring.
- Task Order #7: I-25 Interconnect, CTMC to CSTOC.
- Task Order #26: Low Speed Communications.

Three task orders had <u>purposes other than deployment or integration</u>. These were:

- Task Order #5: CTMC Operations.
- Task Order #27: Traveler Information Center (TIC).
- Task Order #28: Public Information and Incentive Leveraging.

The remaining task orders were <u>integration activities</u> undertaken on several levels for multiple purposes and in various complexities. Because CDOT does not currently possess "umbrella" software to encompass all operating systems, much of the effort was devoted to defining architectures, improving subsystems, planning for future interfaces, and establishing limited data exchange with outside parties. Integration tasks are described below.

2D.1 System Architectures

Portions of four task orders were devoted to architecture development, one on a large scale, and three addressing subsystems.

- Task Order #6A: Communications Systems Architecture. This task developed communications systems architecture for deployment statewide (primarily for the first-tier, high speed communication level). Specific end hardware was selected for statewide deployment.

- Task Order #21: CCTV, Regions 1 and 6. CDOT established its "central" and remote video subsystem architectures as part of the work.

- Task Order #26: Low-Speed Communications. CDOT developed second- and third-tier architectures for low-speed communications to interface the CTMC with ITS subsystems statewide. The work was completed to identify alternative means to interface with the high-speed fiber optic backbone deployed under separate contract; and select a preferred alternative for configuration of the low-speed portion of the network.

- Task Order #30: Start Up Tasks. As part of this work, National ITS Architecture (NITSA) training was provided through FHWA.

During the project, two Regional ITS Architectures (RITSA) were developed outside the contract. The first was for the Denver area and the second for the Colorado Springs/Pueblo/CDOT Region 2 area. The latter was originally planned to consist of project architecture for the Gateway ITS deployment in Pueblo but was later expanded to include all of Region 2. Both were completed in 2002. Three additional RITSA are planned: one for the Fort Collins/Greeley/Region 4 area; one for the Grand Junction/Glenwood Springs/Region 3 area; and a third as a statewide architecture, primarily for rural deployments.

2D.2 Web Site Development

Portions of three task orders were devoted to enhancement of the CDOT (Co-Trip) web site.

- Task Order #2A: POE Enhancements. This sub-task developed a trucker-specific information category for Co-Trip as well as delivering the balance of the web information to POE operators.

- Task Order #6D: Web Integration. This task order provided an order-of-magnitude upgrade to the Co-Trip web site. The site now has much greater capacity and provides access to multiple areas of information including alerts, road/weather, current messaging on field devices including HAR and DMS, video snapshots, trucker information, current incidents, links to other CDOT (and external) sites and so on.

- Task Order #29: Transit Data Integration / Kiosks. Although the transit data component of this activity was deferred, CDOT deployed a number of kiosks as part of this task order. The kiosk information subsystem was developed as a web application using selected data pulled from the multi-modal database. CDOT considers the kiosk application to be a subset of the web system, hence its inclusion in this category.

Work in this area also combined information from existing functional modules into the CDOT multi-modal database and facilitated access to more utile and up-to-date information.

2D.3 Internal Systems Development

Portions (or all of) other task orders were devoted to development of new internal systems for the CTMC or the enhancement of existing ones.

- Task Order #6B: NTCIP Compliant DMS Driver. This task order developed a device driver for new DMS using the NTCIP protocol, ultimately allowing CTMC operators to communicate with these signs. The driver was configured to be capable of using fiber optic and dial-up communications.

- Task Order #6M: Miscellaneous Integration. The bulk of this task order consisted of software development to improve existing databases and operating systems in the CTMC. The database improvements were key sub-components of the web site enhancement activities. An NTCIP-compliant command/control module for legacy DMS was also obtained.

- Task Order #14: 1-800 Road Weather Information Line. The Integrator provided an interim upgrade to the 1-800 phone system to achieve Y2K compliance and increase capacity. CDOT is in the process of providing additional upgrades with state funds (using the architecture developed in this task order).
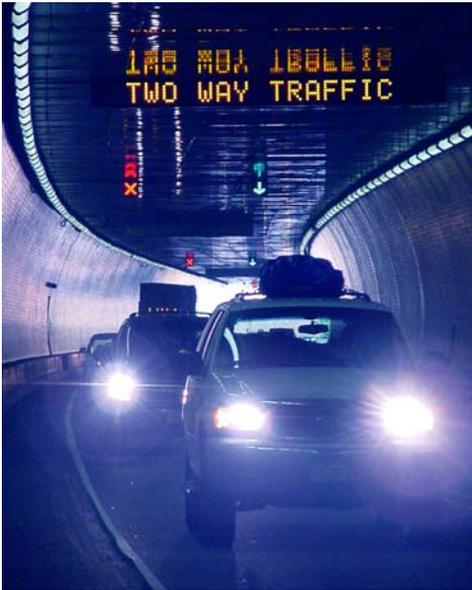

Photo 8 - Task Order #16 - Hanging Lake Tunnel

- Task Order #16: Hanging Lake Tunnel Integration, Region 3. The initial portion of this task order developed requirements for the new tunnel command and control software/system.

- Task Orders #17, #22 and #24: Speed Maps, Denver, Colorado Springs, Statewide. These task orders developed subsystems to collect data and display speed maps for CTMC operators and the web site.

- Task Order #20: Message Paging Interface. This task order allowed CDOT personnel to be notified of incidents in their areas of interest via paging devices. Specific personnel to be notified and their priority were as determined via nine (9) existing incident management plans (IMP) developed under separate contract.

- Task Order #25: Weather Systems Integration. CDOT collected weather station data, sorted and filtered the data and provided outputs in concise format to allow weather information displays for use by CTMC operators and for the web site. More detailed data was displayed on the CDOT-secure web site for use by maintenance forces.

- Task Order #30: Start-Up Tasks. This task order developed a Highway Advisory Radio (HAR) "central" control module for CTMC operators and allowed text of radio messages to be ported to the web. A second activity accessed the Computer Aided Dispatch (CAD) systems of the Colorado State Patrol (CSP) and Denver Police Department (DPD). Incoming data was filtered to identify traffic incident information, which was displayed on Co-Trip for CTMC operators and the traveling public.

2D.4 Communications Systems Integration

One task order was used to integrate and light a large fiber optic communications network to facilitate data exchange among multiple agencies. A second contributed to the installation of a new high-speed fiber optic backbone line. A third began deploying end equipment to facilitate center to field (C2F) communications.

- Task Order #6E: Denver Metropolitan Fiber Ring. This task order deployed end equipment to allow center-to-center (C2C) communications between the CTMC, CDOT Headquarters, CDOT Region 6, the Cities of Denver and Lakewood and the Regional Transportation District (RTD).

- Task Order #7: I-25 Interconnect, CTMC to CSTOC. A portion of this task order contributed funding toward the installation of a high-speed fiber optic line between the CTMC and CSTOC. The "missing" 33 miles of fiber were installed as part of this work, primarily using state funds.

- Task Order #26: Low-Speed Communications. This task order selectively deployed end equipment to allow center to field communications utilizing the State's high speed fiber optic backbone communications system.

2D.5 Outside Agency Data Exchange

Various activities were undertaken to allow data exchange between the CTMC and outside control centers. Again, due to the lack of umbrella software at the CTMC, further integration between centers was not pursued at this time.

- Task Order #6E: Denver Metro Fiber Ring. This task order deployed communications end equipment to light the Denver fiber backbone (installed under separate contract) and facilitate data exchange between CDOT and outside agency partners.

- Task Order #7: I-25 Interconnect, CTMC to CSTOC. Operational Concepts and Requirements were developed for a future center-to-center (C2C) interface between CTMC and the Colorado Springs Traffic Operations Center (CSTOC). In the interim, work station exchange was completed to allow each facility to access data of the other. Interim T-1 lines were implemented to facilitate video data exchange for display on each other's system and web sites. Finally, a portion of the task order funding was used to contribute to an otherwise state-funded initiative to install the remaining 33 miles of fiber optic cable to physically link the two centers.

- Task Order #16: I-70 Hanging Lake Tunnel (HLT) Integration, Region 3. Two activities were conducted. First, the Integrator developed Requirements for a system/software upgrade for the HLT control center. The Requirements were used by Region 3 to issue a Request for Proposals to complete the work. In the second activity, CDOT changed out internal and field video systems at HLT to match the architecture developed for deployment of the statewide video subsystem.

- Task Order #18: I-25 Stadium Parking Management, Denver, Region 6. This task consisted of deploying video and communications equipment to assist the City & County of Denver in monitoring I-25 and surrounding streets near the new stadium and entertainment venues along I-25. Work included provision of communications and video switching equipment to allow both parties to access data of the other.

- Task Order #19: Denver Area Traffic Signal Interface. The City of Lakewood was selected as the "Denver Area" interface to be pursued. Operational Concepts and Requirements were developed for a future C2C interface between the CTMC and the City. As an interim measure, a work station exchange was completed to allow each to access data of the other. Communications were established over fiber. Finally, a plan for additional integration in the future was developed.

- Task Order #27: Traveler Information Center. This task order was a test to establish an Information Service Provider (ISP) within the CTMC. The ISP established links to a number of outside parties and also provided travel information to the public via subscription. The test was not deemed a success.

A summary of the intended levels of integration for the task orders is provided in Table 3.

Table 3 – Intended Levels of Integration

#	TASK ORDER NAME	DEPLOY ITS DEVICES	COMMUNICATIONS INFRASTRUCTURE & INTEGRATION	SYSTEMS ARCHITECTURE	WEB	INTERNAL SYSTEMS	OUTSIDE DATA EXCHANGE	OTHER
1	I-25 Truck Safety Reimbursement	X						
2	POE I-25 Monument, Region 2	X						
2A	POE Enhancements	X			X		X	
3	POE I-25 Fort Collins, Region 4	X						
4	POE I-70 Limon, Region 1	X						
5	CTMC Operations							X
6A	Integration – Communications		X	X				
6B	Integration – NTCIP Driver					X		
6D	Integration – Web				X	X		
6E	Integration – Denver Ring		X				X	
6M	Integration – Miscellaneous				X	X		
7	I-25 I/C, CTMC-CSTOC		X				X	
8	I-25 HAR, Region 4	X						
9	I-25 DMS, Colorado Springs	X						
10	I-25 DMS, Region 4	X						
11	I-25 ATR/WIM, Region 4	X						
14	1-800 Road Weather Info Line			X		X		
16	I-70 Hanging Lake Tunnel					X	X	
17	Denver Area Speed Map					X		
18	Stadium Parking Management	X					X	
19	Denver Area Signal Interface						X	
20	Message Paging					X		
21	CCTV, Regions 1 and 6	X		X				
22	Colorado Springs Speed Map					X		
24	Statewide Speed Map					X		
25	Weather Systems Integration					X		
26	Low-Speed Communications		X	X				
27	TIC						X	X
28	Public Information & Incentive							X
29	Transit Data / Kiosks	X			X		X	
30	Start-Up Tasks			X		X		

Section 3 describes the evaluation plan for the project, including goals and objectives, hypotheses, measures of effectiveness, and a description of the additional elective activities.

3. Evaluation Plan

As described in the Local Evaluation Reporting Requirements, the following measures, <u>where applicable</u>, are to be quantitatively assessed as part of this report:

- Reduction of crashes;
- Reduction of fatalities;
- Increased throughput – people and goods;
- Reduction of congestion-related delay;
- Improved customer satisfaction;
- Savings in cost to the public and private sectors; and
- Energy and emissions impacts.

Technical levels of success for ITS projects are difficult to quantify in these categories - particularly for projects such as this one, which have significant traveler information and integration elements. This is because there is not a proven algorithm to relate measures such as crash reduction or emissions to ATIS devices such as HAR or DMS, or an ITS activity such as inter-agency data exchange.

Although FHWA and other states continue to collect data toward development of correlations between ITS devices and "hard" measures of effectiveness (MOE), work remains in a developmental stage. Concrete algorithms to relate such MOE to ATIS and ITS integration remain unavailable. Qualitative measures are easier to identify.
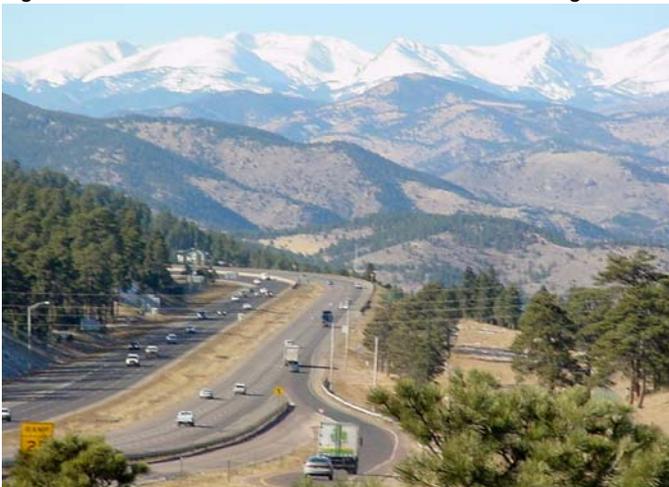
Photo 9 – Task Order #24 developed a speed map for I-70 – one of two Priority ITS corridors in Colorado – the other is I-25

Because the most of the tasks in the project are ATIS deployment and ITS integration, this project is one that will not directly yield "hard" measures of effectiveness in the categories listed. In fact, most of the "hard" numbers available as a project outcome are directly related to the POE task orders – in which throughput of goods, savings to the private sector and emissions impacts can be directly determined. For the remaining task orders, customer satisfaction with some of the devices can be estimated via surveys, however most of the project activities do not easily relate to the measures provided.

At the project outset, CDOT did not possess a high density of ITS devices. Similarly, from an operations perspective, there was only a marginal (in terms of capacity and information provided) web site, a lack of critical operational modules (for example weather station, HAR, CCTV and E-911) no integration between subsystems, and no inter-agency data exchange. The primary CDOT goal for the project was therefore twofold: 1] that CDOT address these deficiencies; and 2] that the project be an ITS "success story." Considering the subjectivity and other difficulties inherent in evaluating ITS integration projects, and given the desire for an ITS "success story," CDOT made the determination at an early stage to take an institutional approach to local evaluation.

In addition to the technical evaluation – measured by enhanced capabilities – devices (more data), additional functional modules (better data), integration between systems and improved inter-agency data exchange; and the "hard" data available for the POE task orders; the evaluation would also investigate financial, schedule, managerial and administrative performance.

In addition to the evaluation items discussed above, two additional elective activities were required to be part of the local evaluation. These are discussed in Section 3D to follow.

3A Goals and Objectives

In parallel with the I-25 Truck Safety Improvements project, CDOT initiated strategic planning efforts for the statewide deployment of ITS. As part of that effort, a number of high-level goals were identified for the CDOT ITS Program. These include the following:

- *Improve productivity.* Maximize productivity of the transportation system by using ITS to increase throughput of passengers and vehicles on the transportation system – effectively increasing capacity. Use ITS to continuously manage and fine tune operation of the transportation system in response to travel demand and in the event of incidents that interrupt normal operations.

- *Increase mobility*. Provide travel choices and increase travel efficiency through access to comprehensive, reliable, accurate and timely traveler information. Allow travelers to make informed decisions concerning their trip prior to and during travel. Enable travelers and businesses to efficiently choose travel time, mode and route based on real-time travel condition. This spreads volume among modes and over time, reduces costs of doing business and enhances quality of life.

- *Increase safety.* Enable faster response to incidents and reduce incidents through active traffic and incident management. Secondary benefits are realized from broadcasting alternate routes allowing travelers to avoid incidents and resulting congestion – such alternates developed as part of IMP. ITS technologies enhance safety of the traveling public by monitoring system operations, planning and managing transportation affected by special events, and providing travel related weather advisory information.

Photo 10 - I-25 mobility was constrained by T-REX – looking north in the "Narrows"

- *Enhance inter-modal connectivity and inter-jurisdictional coordination*. Promote and support seamless inter-modal transportation connectivity and Colorado ITS systems. Manage information as a resource that will enhance inter-modal connectivity between services provided by public and private transportation providers.

These program goals have the overall intent of developing a traveler information and traffic management system that allows integration and interface of existing legacy, as well as future systems, and one in which information is managed as an asset of value to transportation system users and transportation providers of all types.

The CDOT role is to provide statewide leadership by deploying enabling infrastructure, developing partnerships, establishing policies and procedures with stakeholders to ensure integration and seamless access to data, and by providing advocacy for those ITS investments that have a strong business case.

The I-25 TSIP supports the first and third program goal, while speaking directly to the second and fourth, as well as the overall statement of intent directly above.

Ultimately, the I-25 TSIP was developed with three specific goals in mind:

- Address Colorado ITS infrastructure deficiencies;
- Create an ITS success story in Colorado; and
- Develop a workable management structure to guide future ITS deployment.

Because the CDOT ITS strategic planning goals had yet to be developed at the project outset, these three goals were identified as an appropriate "target" for the I-25 TSIP. To that end, objectives were identified to help guide project development, including the following:

- Automate processes towards minimizing burdens on State staff;
- Provide enhanced functionality;
- Improve dissemination of traveler information;
- Improve CVO;
- Enhance availability of data for partner agencies;
- Enhance incident management capabilities; and
- Improve amount, accuracy and timeliness of data flows into and out of the system.

3B Hypotheses

Based on the project goals and objectives, CDOT was able to develop hypotheses upon which to build evaluation of the I-25 Truck Safety Improvements project. As might be anticipated, these focus tightly on elements of primary interest to CDOT staff within the ITS Program. These were as follows:

- Hypothesis 1. At the project conclusion, CDOT capabilities to collect, compile and disseminate traveler information statewide will be greatly enhanced. This is not limited to information dissemination with the general public but includes enhanced capabilities to exchange information with public agency partners.

- Hypothesis 2. At the project conclusion, CDOT capabilities to simplify commercial vehicle operations (CVO) at ports of entry (POE) in Colorado will be improved.

- Hypothesis 3. At the project conclusion, CDOT will have maintained and/or enhanced current ITS partnerships with other public agencies and developed new partnerships.

- Hypothesis 4. At the project conclusion, CDOT will have taken advantage of the synergies created by the project as a catalyst for statewide, widespread ITS deployment through other projects and funding sources, in effect using the I-25 Truck Safety Improvements project as a springboard from which to build an ITS "success story" in Colorado.

- Hypothesis 5. At the project conclusion, CDOT will be able to make a determination regarding the effectiveness of its management structure for the project and identify positive and negative lessons learned from the administrative and technical sides of the work.

The evaluation is thus based on a combination of CDOT-identified high-level goals, as well as the more microscopic goals and objectives identified for this project. Specific operational factors such as delay reduction or movement of goods will be provided as applicable but are not the major focus of the evaluation.

3C Measures of Effectiveness (MOE)

CDOT prepared a list of Measures of Effectiveness (MOE) based on the hypotheses to judge the success of the I-25 TSIP from a project-wide perspective as well as at the individual task order level. These were divided into four categories of evaluation with associated MOE as follows:

- Category 1 – Data and Infrastructure (Hypothesis 1). Goals and objectives to be addressed include: 1] addressing ITS infrastructure deficiencies; 2] automating processes toward minimizing burdens on CDOT staff; 3] provision of enhanced functionality; 4] improving dissemination of traveler information; 5] improving incident management capabilities and 6] improving amount, accuracy and timeliness of in/out data flow.

  The majority of the task orders fall into this category, whether via device deployment, integration, development of new subsystems or data processes, or a combination. The effects of these items are difficult to measure due to the information aspect of the majority of the improvements as opposed to traffic management or control.

  In any case, for all task orders, MOE include: 1] magnitude of the improvement; 2] why the improvement is important; 3] how the improvement enhanced data quality or flow; and 4] how the improvement enhanced functionality. In deployment projects, MOE also include items such as: 1] number; 2] type; 3] purpose; and 4] location. For integration and/or new subsystem task orders, MOE include: 1] functions provided; 2] purpose; and 3] subsequent reduction in CTMC (or other public employee) operator demands.

- • Category 2 – CVO (Hypothesis 2). Goals and objectives to be addressed include the improvement of CVO.

  Hard data is available in this category including: 1] throughput of people and goods; 2] reduction in congestion-related delay; 3] savings in cost to the private sector and 4] energy and emissions impacts. The projects also address the second item in Category 1 – namely automating processes toward minimizing burdens on state employees. All are used as MOE for the CVO-oriented projects.

- • Category 3 – Partnerships and Data Exchange (Hypothesis 3). Goals to be addressed include enhancing the availability of data for partners as well as preservation of existing partnerships and the creation of new ones.

  Measures in this category include: 1] whether existing partnerships were or were not maintained during the project; 2] number of new partnerships developed; and 3] types of cooperation achieved. In addition, since no physical data exchange existed prior to the project, a listing of the types and levels of data exchange achieved is an indication of project success. Many other potential evaluation criteria are subjective – such as the quality and perceived levels of cooperation however these are addressed herein in any case.

- • Category 4 – Intangibles (Hypotheses 4 and 5). Goals to be addressed include creation of an ITS success story and evaluation of the project management structure.

MOE regarding whether the project is an ITS success story are qualitative but primarily relate to how well the project met the goals and objectives outlined at the start. Although the second category is subjective as well, evaluation of how well the project met cost, scheduling and administrative milestones, as well as problems encountered provides an indication of levels of management success.

Photo 11 – I-70 DMS Message following the "Blizzard of 2003"

3D Additional Elective Activities

CDOT determined the following two elective activities (from the FHWA-suggested list for local evaluation) would also be part of this report:

- • Institutional issues associated with achieving cooperation among public sector agencies should be provided as well as documentation of how these were overcome. This includes work with previous partners such as the City & County of Denver (Transportation and Police), City of Colorado Springs, City of Lakewood and Colorado State Patrol and new partners including the Colorado Tourism Board, the City of Fort Collins and Douglas County.

- • A brief "Lessons Learned" report should also provided that describes the technical and institutional issues encountered by CDOT during the project. The description of the technical issues also includes a discussion of the problems and opportunities created by the CDOT/Integrator/Manager project management structure.

Both elective activities coincide well with the latter two project hypotheses identified in the previously and are described in detail herein.

Section 4 describes the project outcome and findings, including the results of the additional elective activities.

4. Evaluation Findings

CDOT believes the I-25 TSIP has been a resounding success. Prior to the I-25 TSIP, CDOT was infrastructure-poor and deficient in its capabilities to collect, compile and disseminate information. Although an inter-agency partnership was in place, information exchange with partners had not been achieved. Statewide incident management programs were only beginning. The previous RMDI project had initiated ITS planning and design work but exhausted its funding prior to implementing many of the desired elements. Finally, the overall CDOT ITS Program had achieved only modest funding levels and momentum from which it could easily rectify these shortcomings.

The I-25 TSIP provided the single mechanism needed to address previous ITS shortcomings and deficiencies, strengthen and expand inter-agency partnerships, bolster related initiatives like incident management, and generate significant ITS Program momentum. The project has been a catalyst to attract additional State and federal funding into Colorado ITS, allowing CDOT to accelerate ITS deployment in the last five years on scale unprecedented in the State. CDOT has taken advantage of project funding as well as the referenced momentum to develop order-of-magnitude improvements in (among others): 1] number of field devices; 2] data collection and dissemination capabilities; 3] communication capabilities; 4] active interface with partners and stakeholders; and 5] operations, maintenance and program management.

Photo 12 – Image from Task Order #21 camera location – I-25 at US-6 looking east

The I-25 Truck Safety Improvements project is an ITS success story. Although two task orders can be interpreted as unsuccessful and difficulties were encountered by CDOT in its day-to-day work with the Integrator, the end result is dramatically positive. The following sections illustrate how the project met the established goals and objectives, discuss the task orders and overall project in terms of the MOE, institutional issues encountered and lessons learned (the latter representing the two additional "elective" evaluation activities).

4A Project Outcome

A summary of how the project-specific goals and objectives were addressed by the individual task orders within the I-25 TSIP are listed in Table 4.

Table 4 – Project Goals and Objectives Met By Task Order

NO.	TasK ORDER NAME / Goals & Objectives MET? (RefeRENCE GOALS & OBJECTIVES list below table)	A	B	C	D	E	F	G	H	I	J
1	I-25 Truck Safety Reimbursement, Region1	Yes				Yes	Yes	Yes		Yes	Yes
2	POE Automation, I-25 Monument, Region 2	Yes			Yes	Yes	Yes	Yes			
2A	POE Enhancements				Yes	Yes	Yes	Yes	Yes		Yes
3	POE Automation, I-25 Fort Collins, Region 4	Yes			Yes	Yes	Yes	Yes			
4	POE Automation, I-70 Limon, Region 1	Yes			Yes	Yes	Yes	Yes			
5	CTMC Operations				Yes	Yes	Yes	Yes	Yes	Yes	Yes
6A	ATMS/ATIS Integration – Communications System				Yes	Yes			Yes	Yes	Yes
6B	ATMS/ATIS Integration – NTCIP DMS Driver					Yes	Yes				Yes
6D	ATMS/ATIS Integration – Web Integration				Yes	Yes	Yes		Yes		Yes
6E	ATMS/ATIS Integration – Denver Fiber Ring	Yes				Yes			Yes	Yes	Yes
6M	ATMS/ATIS Integration – Miscellaneous				Yes	Yes	Yes		Yes	Yes	Yes
7	I-25 Interconnect, CTMC – Colorado Springs	Yes				Yes	Yes		Yes	Yes	Yes
8	I-25 HAR, Region 4	Yes				Yes	Yes				Yes
9	I-25 DMS, Colorado Springs, Region 2	Yes				Yes	Yes				Yes
10	I-25 DMS, Region 4	Yes				Yes	Yes				Yes
11	I-25 ATR/WIM, Region 4	Yes				Yes		Yes			Yes
14	1-800 Road Weather Information Line				Yes	Yes	Yes				Yes

#	Task	A	B	C	D	E	F	G	H	I	J
16	I-70 Hanging Lake Tunnel Integration, Region 3	Yes			Yes	Yes			Yes	Yes	Yes
17	Denver Area Speed Map, Region 6					Yes	Yes				Yes
18	I-25 Stadium Parking Management, Denver, R-6	Yes			Yes	Yes	Yes		Yes	Yes	Yes
19	Denver Area Traffic Signal Interface					Yes	Yes		Yes		Yes
20	Message Paging Interface					Yes	Yes	Yes	Yes	Yes	Yes
21	CCTV, Regions 1 and 6	Yes			Yes	Yes	Yes			Yes	Yes
22	Colorado Springs Area Speed Map, Region 2					Yes	Yes	Yes	Yes		Yes
24	Statewide Speed Map, Region 1					Yes	Yes	Yes	Yes		Yes
25	Weather Systems Integration					Yes	Yes	Yes		Yes	Yes
26	Low-Speed Communications	Yes				Yes	Yes				Yes
27	Traveler Information Center (TIC)					Yes	Yes	Yes			Yes
28	Public Information & Incentive										
29	Transit Data Integration / Kiosks	Yes			Yes	Yes	Yes		Yes		
30	Start-Up Tasks	Yes			Yes	Yes	Yes		Yes	Yes	Yes
	OVERALL PROJECT	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Table 4 Goals and Objectives List (from Section 3A):
A - Address ITS infrastructure deficiencies.
B - Create an ITS "success story" in Colorado.
C – Develop workable management structures to guide future ITS deployment
D - Automate processes to minimize burdens on state employees.
E - Provide enhanced functionality
F - Improve dissemination of traveler information
G - Improve CVO
H - Enhance availability of data for partner agencies
I - Enhance incident management capabilities
J - Improve amount, accuracy and timeliness of data flows into and out of the system

All goals and objectives were met. Pre-project deficiencies in infrastructure; functionality; automation; traveler information dissemination; CVO; sharing of data; and amount, accuracy and timeliness of data were addressed by multiple task orders. CDOT believes meeting the project goals and objectives in the manner and magnitude achieved within this project makes the I-25 TSIP a remarkable ITS success story. Finally, CDOT believes the three tiered management approach using CDOT staff, an Integrator and a Manager is basically sound, although certain modifications to the structure (including more substantial CDOT involvement) will be made prior to acquisition of the services of the next Integrator – to be procured to assist in development of the "umbrella" ATMS/ATIS.

The following sections describe the results of the project within the context of the four evaluation categories developed through the goals, objectives and hypotheses.

4A.1 Evaluation Category 1 – Data and Infrastructure
Task orders in Category 1 are those that improved data flow – by deploying more devices, or by creating subsystems or data flows to improve data amount, accessibility, accuracy or timeliness. Although various task order elements overlap other evaluation categories those listed here were primarily intended to address deployment of ITS infrastructure or data. Category 1 tasks include the following, sorted by activity area:

DEPLOYMENT TASK ORDERS:
- Task Order #1 – I-25 Truck Safety Reimbursement, Region 1.
- Task Order #8 – I-25 HAR, Region 4.
- Task Order #9 – I-25 DMS, Colorado Springs, Region 2.
- Task Order #10 – I-25 DMS, Region 4.
- Task Order #11 – I-25 ATR/WIM, Region 4.
- Task Order #16 – Hanging Lake Tunnel Integration (requirements study phase followed by deployment phase).
- Task Order #18 – Stadium Parking Management, Denver, Region 6.
- Task Order #21 – CCTV, Regions 1 and 6 (architecture study phase followed by deployment phase).
- Task Order #29 – Transit Data Integration / Kiosks.

NEW/ENHANCED DATA COLLECTION/DISSEMINATION SUBSYSTEMS TASK ORDERS:
- Task Order #6B – NTCIP-Compliant DMS Driver.
- Task Order #6D – Web Integration.
- Task Order #14 – 1-800 Road Weather Information Line.
- Task Order #17, #22, #24 – Denver Area, Colorado Springs, Statewide Speed Maps.
- Task Order #20 – Message Paging Interface.
- Task Order #25 – Weather Systems Integration.
- Task Order #30 – Start-Up Tasks.

DATA FLOW ENHANCEMENT TASK ORDERS:
- Task Order #5 – CTMC Operations.
- Task Order #6A – Communications Subsystem Architecture.
- Task Order #6M – Miscellaneous Integration.
- Task Order #26 – Low-Speed Communications (included deployment of equipment as well).

The communications architecture and design activities are treated as a data flow system rather than an ITS subsystem, hence their categorization in the third group of Category 1.

4A.1.1 Evaluation Category 1 – Data and Infrastructure – Deployment
The bulk of the deployment activity for this project is in data collection devices (call boxes, weather stations, ATR, CCTV) or traveler information dissemination devices (DMS, HAR, kiosks) – items for which it is difficult to quantify success in terms of the FHWA-suggested MOE for traffic operations. Instead, the relative success of this group of task orders will be assessed qualitatively.

The first three columns of Table 5 shows field devices deployed as part of the I-25 Truck Safety Improvements project and their location by CDOT Region. The fourth and fifth columns depict number of devices in place prior to and following the project, and the sixth indicates the percentage growth in total number of devices over this period (additional devices were deployed outside the project using alternate federal or state funding sources). The intent of the sixth column is to illustrate overall increases in ITS deployment from project start to finish and how the I-25 Truck Safety Improvements acted as a catalyst to encourage overall ITS Program growth during the five year period.

Table 5 – ITS Device Deployment 2003

ITS DEVICE	#	LOCATION	# BEFORE	# 2003	GROWTH	COMMENT
Call Box	2	R-1	60	78	30%	Calls to CSP; maintenance by CTMC
Weather Sta	1	R-1	95	108	14%	36 Regions; 72 CTMC
DMS	24	R-2 and R-4	90	154	71%	Regions control 83; CTMC controls 71
ATR/WIM	6	R-1 and R-4	90	110	22%	All ATR (not all have WIM)
HAR	2	R-4	10	16	60%	Only CDOT-operated included in totals
CCTV	20	R-1, R-3, R-6	25	100	400%	Architecture led to large increase
Kiosks	7	R-1, R-3, R-4, R-6	0	7	-	Web browser concept
All Devices	**60**		**370**	**573**	**55%**	**Project led to 16% total growth.**

All deployment task orders met the project goal of "addressing ITS infrastructure deficiencies" and the objective to "provide enhanced functionality" – primarily through implementation by the concept that more devices lead to more data (or capability to disseminate) – hence more functionality. Most deployment task orders also met project objectives to "improve dissemination of traveler information," or to "improve the amount, accuracy and timeliness of data flow into and out of the system" - again, primarily through provision of additional collection or dissemination devices. The objective to "increase data availability for partner agencies" was met by Task Order #16 (between CTMC and Hanging Lake Tunnel), Task Order #18 (between CTMC and the City & County of Denver), and Task Order #29 (between the CTMC and the Colorado Tourism Board, Colorado Department of Revenue and the public). The remaining objectives were met by one or more of the deployment task orders.

Magnitude of Improvement
The project provided a 16% increase in the total number of ITS devices deployed in Colorado. More importantly, the project acted as a springboard for additional device deployment outside of this project using other federal or state funding. During the five year period of the project, CDOT was able to increase the total number of ITS devices statewide by 55%. Given Colorado's infrastructure-poor status before the project, the five-year improvement is substantial, important, and provides a much more solid platform from which to base future Program growth.

Functionality
Call box and weather station functionality was marginally increased through the deployment of additional field devices – yielding additional coverage in the field.

DMS capability was increased through the development of the NTCIP-compliant driver - used to communicate with new DMS deployed under a separate project and described separately under Task Order #6B. In addition, the deployment provided within this project resulted in markedly increased coverage along

I-25 both north and south of Denver, in particular along the approaches to regional decision points and areas noted for past incident frequency.

ATR capability was marginally increased through the deployment of additional devices. Note that original Task Order #6C to provide integration of ATR data at the CTMC was deferred until a later project.

HAR functionality was increased through development of the "central" HAR subsystem developed (and described) separately under Task Order #30. The new HAR devices deployed under this project gave CDOT continuous HAR coverage from Denver to the Wyoming border along I-25.

CCTV functionality was markedly increased through development of the subsystem architecture and identification of preferred hardware and software vendors. This activity allowed CDOT to change-out existing camera equipment and switchers to access many additional existing CDOT and outside-agency cameras. As a result, a tremendous increase in camera "accessibility" was achieved through the use of existing cameras previously deployed by the CDOT Regions and partner agencies.

Kiosks were not previously deployed in the Colorado. The original task order intent was that CDOT would use a subsystem architecture and software "front end" to be developed by a CDOT partner agency. When it became apparent that this activity was not being completed in a timely fashion, CDOT staff developed a substitute subsystem for kiosk deployment using a web browser. This meant that a separate subsystem for kiosks would not be developed at this time, but would instead take advantage of the capabilities of the web integration activities developed under Task Order #6D. Ultimately, kiosks were deployed at highway welcome centers (rest areas) with the cooperation of the Colorado Board of Tourism, POE facilities (reference also Task Order #2A), and selected locations in Denver for public relations purposes – most notably at the CDOT Headquarters building.

Management Structure

Task Order #1 was implemented by CDOT Region 1 under a separate contract. The ATR and DMS were constructed by the Integrator and its subcontractors. HAR construction was initiated by the Integrator and completed by CDOT. The remaining activities were initiated and completed by CDOT with construction (where necessary) provided by the ITS Maintenance contractor. In cases where construction was completed, coordination was initiated and conducted with the staff of the CDOT Region in question.

4A.1.2 – Evaluation Category 1 – Data and Infrastructure – New/Enhanced Data Collection/Dissemination Subsystems

Activity in this area included new subsystems for CCTV and kiosks as described in the previous section. Other new subsystems were developed as part of the I-25 Truck Safety Improvements including: 1] Speed maps; 2] Weather stations; and 3] E-911. Finally, modification or upgrade of existing systems was completed for the following: 1] DMS; 2] web; 3] 1-800 telephone call-in system; and 4] message paging. The latter three activities in particular provided time-saving benefit for operators at the CTMC. The majority of these activities were completed by CDOT staff. Table 6 provides a summary of this work.

Table 6 – New/Enhanced Data Collection/Dissemination Subsystems

SUBSYSTEM	WORK DESCRIPTION
CCTV	Developed statewide architecture; selected hardware and software vendors; deployed at numerous locations (by CDOT).
Kiosks	New web-browser subsystem based on previous web integration activity; deployed at select locations (by CDOT).
HAR	New "central" system architecture and deployment including capability to transfer data to web (by CDOT).
Speed Maps	New subsystem to incorporate data from vehicle probes and count stations; algorithms; and map (by CDOT and UCD).
Weather Stations	New subsystem to compile, organize and fuse weather station data and port to web sites (by CDOT).
E-911	New subsystem to compile enforcement incident data, filter and port useful data to web site (by CDOT).
DMS	New driver developed to communicate with DMS using NTCIP protocol (by Manager).
Web	Order-of-magnitude upgrade; significant increase in capacity, functionality and ability to link to subsystems (by CDOT).
1-800 Call-In	New architecture; increased capacity; provided Y2K compliance (by Integrator); later upgrades by CDOT.
Message Paging	New system architecture; increased capacity; allowed web interface (by Integrator); later upgrade using cellular (by CDOT).

All "data" task orders met the objectives to "provide enhanced functionality," to "improve dissemination of traveler information," and to "improve amount, accuracy and timeliness of data" – whether through improvements to flow, (alert paging via alternative means), provision of additional data (E-911 system), improvements to accessibility (via web and 1-800 systems) or improvements to data quality (weather systems). The objective to automate processes to reduce operator demands was met by multiple task orders but primarily achieved through the web integration activity – which provided the platform to tie

numerous activities together (and automate them) in light of the CTMC lack of an umbrella ATMS/ATIS. The remaining objectives were met by one or more of the "data" task orders.

Magnitude of Improvement
Although percentage improvements are not available for these activities, it is apparent that CDOT capability to collect, manage and disseminate data was markedly increased by the project. In all, four (4) existing subsystems were upgraded (DMS, Web, 1-800 and Message Paging), and six (6) new ones (CCTV, Kiosk, HAR, Speed Map, Weather Station and E-911) were created. The improvements benefit CDOT in the following areas: 1] the increase in the size and composition of the CDOT database makes CDOT a more attractive partner for data-exchange with outside agencies; 2] development of these subsystems facilitates adding new ITS field devices to the system with little of no negative impact to CTMC operators; 3] the systems have yielded more accurate and timely information to CTMC operators, and ultimately the public via Co-Trip and roadway dissemination devices; and 4] the systems have drastically increased data availability and CTMC functionality.

Functionality
CCTV capability was markedly increased through development of the subsystem architecture and identification of preferred hardware and software vendors. Prior to the project, CDOT capability in CCTV was limited to only a few cameras, in part because of the loss of control capability created by changes being made through the previous RMDI project. Development of the new architecture allowed CDOT to overcome that problem to access many additional CDOT and outside-agency cameras. Functionality of the "before" and "after" systems is almost non-comparable, as the capabilities presented by the new architecture are overwhelmingly superior.

The capability to deploy and operate kiosks was created through this project. This allowed CDOT to develop a means to exchange travel information with parties and locations that would otherwise have

difficulty accessing such data. For that reason, initial kiosk deployment is in highly rural areas, including the welcome centers at the Kansas, Nebraska and Utah borders; and at POE facilities, such that Colorado Department of Revenue officers can provide available information to truckers who stop at these facilities.

HAR functionality was significantly improved as well, as the new "central" system replaced what had become a highly unstable and unreliable system. The new system also provided a mechanism to allow data transfer to the web, allowing Co-Trip users point-and-click access the HAR information.

Photo 13 – Data dissemination occurs at the CTMC work station of a Public Information Officer (PIO)

Speed maps were identified before the project as a desirable subsystem, with primary application as a "quick" problem identification tool for use by the public and CTMC operators. The systems required development of the maps themselves including "look and feel," design and integration of vehicle probe data from a variety of sources, incorporation of traffic flow data from count stations/ATR, and incorporation of algorithms to determine appropriate speeds to post to the map displays.

CDOT ability to use data from its extensive network of weather stations was enhanced. Work included compiling, organizing and disseminating data (temperature, humidity, wind speed/direction, precipitation, and road surface condition) to Co-Trip. The activity yielded statewide coverage of road conditions and weather from local sites. Additional data not for public consumption (chemical on the road, anticipated time of surface freeze, etc.) was provided on the CDOT-secure web site for maintenance and incident response forces. To obtain additional and near real-time roadway condition and incident data, CDOT completed interfaces with the computer aided dispatch systems of two enforcement agencies: 1] Colorado State Patrol; and 2] the Denver Police Department. Obtained data (previously filtered to remove "sensitive" information) is filtered again at the CTMC to reduce the data buffer size, and sent to the Oracle database where
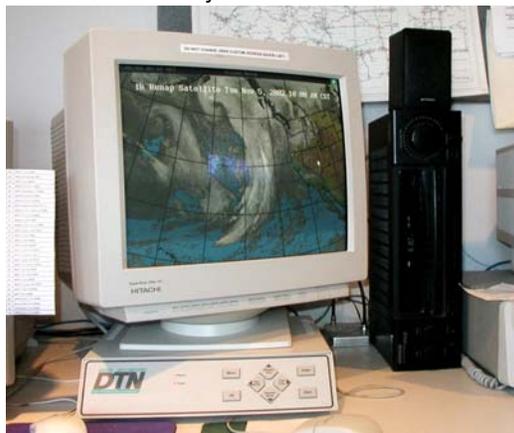
coordinates are assigned to assist the operator in locating the incident. Other data included in incident packets include: 1] time stamp; 2] location description; 3] incident open/closed; 4] type; 5] position (coordinates); and 6] description. Data is available to Co-Trip users and system operators.

DMS capability was marginally increased through development of the NTCIP-compliant driver – used to communicate with new DMS deployed under a separate project.

The I-25 Truck Safety Improvements project allowed CDOT to complete an order-of-magnitude upgrade to its previous web site.   The project increased capacity and notably increased amount and types of information offered. The site includes roadway status and alerts from the road/weather system, existing DMS and HAR messages, images from CCTV cameras deployed across Colorado, weather station information, a number of supplemental weather information choices including forecasts and satellite images, speed maps, construction information and incident information.

The 1-800 call-in system is also identified as the Interactive Voice Response (IVR) system by CDOT. Work included developing new system architecture and two interim activities - increasing capacity and achieving Y2K compliance.   Since that deployment, CDOT used the architecture developed in this project to further upgrade using state funding.   Although the current system capacity is 144 lines, the system is still somewhat undersized for large-scale snow events.

This project developed architecture for and implemented message paging. At present, this is an internal page out to notify CDOT staff of significant roadway events. The page is accomplished by an operator writing an internal e-mail to the page list which is sent automatically. The system was upgraded to allow limited paging for an Information Service Provider (ISP) providing subscription services to the public via cellular telephone.

Photo 14 – Supplemental weather information available to
CTMC operators and on Co-Trip –the image is a large Pacific storm

Management Structure
The 1-800 and Message Paging activities were completed by the Integrator although both were later enhanced further by CDOT. The DMS driver was developed by the Manager. Speed Maps were developed as a coordinated activity by CDOT and UCD.   Weather Station and Web integration activities were completed by CDOT.   The CCTV, Kiosk, HAR and E-911 activities were started by the Integrator and completed by CDOT. Integrator work on the early portions of these task orders is in part responsible for the majority of the disagreements with CDOT that ultimately led to dismissal of the Integrator.

4A.1.3 Evaluation Category 1 – Data and Infrastructure – Data Flow Enhancements
Task orders in this area are communications oriented. Work included integration activities to facilitate information flow between internal subsystems, improving operations within the CTMC, and communications system development and implementation to allow improvements to data flow system wide.   Because communications architectures were developed, and then followed by field device deployment to complete portions of various low-speed networks (and interface these to the high-speed fiber line network), these activities address the project goal of "addressing ITS infrastructure deficiencies." This group of task orders also successfully addresses the objectives to "enhance availability of data to partner agencies," to "enhance incident management capabilities," and to "improve dissemination of traveler information." In addition, the database work allowed automation of processes and enhanced functionality.

Magnitude of Improvement
The project provided for and improved data flows between the Oracle database and ITS subsystems. It also planned and developed communications systems for application statewide and developed processes and procedures in the CTMC to improve operations. Although difficult to quantify, this group of task orders provided significant "behind the scenes" improvements to allow enhanced data flow and improvements in the day-to-day operations of the CTMC.

Functionality

ITS operations were enhanced by developing policies and procedures for CDOT Public Information Officers (PIO) and operators working at the CTMC. Documents developed as part of this work included various operations, procedures and training manuals. The task order also funded day-to-day CTMC operations from the beginning of the task order through the fourth quarter of 1999.

The project contributed funding toward development of statewide communications architectures developed under separate contract by CDOT Region 6 as part of Task Order #6A. This activity developed the high-level, three-tiered architecture currently used by CDOT for ITS deployment statewide.

The I-25 TSIP provided detailed development of the ITS communications system architecture for the lower two communications tiers identified in the activity above. The identified architectures were then designed and deployed at numerous locations in Colorado – primarily those locations interfacing to the high-speed OC-48 communications network.

CDOT capability to provide efficient data flow between internal subsystems was enhanced. These activities focused on: 1] information flows between the Oracle database and existing (or new) ITS subsystems; and 2] organization or compilation of the information within the database to facilitate such flow.

Management Structure
Operations personnel and other administrative support staff were provided by the Integrator (this program has been continued via outside contract and state funding through the present). Development of the high-level communication system architecture was developed by CDOT Region 6 under a separate contract, following which the detailed low-speed architectures were developed by the CDOT ITS Branch. Low-speed communications equipment was deployed in many locations as a follow-on activity. All such furnish and installation was by CDOT or the CDOT ITS Maintenance Contractor.   Finally, development of the database to facilitate enhanced data flow was provided by both the Integrator and CDOT forces.

4A.2 Evaluation Category 2 – CVO
Task orders in Category 2 had an overall CVO intent and purpose, and three task orders were deemed to focus only on these areas. These were:

- Task Order #2 – POE Automation, I-25 Monument.
- Task Order #3 – POE Automation, I-25 Fort Collins.
- Task Order #4 – POE Automation, I-70 Limon.

Many task orders were CVO-related, but are classified separately for discussion due to additional purpose/function, or more appropriate classification in a separate category. Task Order #1 (I-25 Truck Safety Reimbursement) and Task Order #11 (I-25 ATR/WIM, Region 4) deployed field devices that were not necessarily CVO-specific, therefore those were classified as "Data and Infrastructure" activities for evaluation. Similarly, Task Order #2A (POE Web Enhancement) deployed field devices but primarily enhanced information flow between the CTMC and POE operators, therefore that work was classified as a "Partnership and Data Exchange Activity."

The POE automation activities not only addressed the project goals of "addressing ITS infrastructure deficiencies," but also objectives including "automating processes," "enhancing functionality," and "improving CVO."

Photo 15 – Truck passing AVI reader at automated POE

POE Automation included installation of WIM, AVI and associated computer and communications equipment required to allow electronic credentialing. Through additional state-funded task orders, the project also provided: 1] contribution toward AVI installation at the three locations; and 2] WIM, AVI and full automation capability at I-70 Loma, I-76 Fort Morgan, US-287 Lamar and US-160 Cortez.   Combined with two previously automated ports at I-25 Trinidad and I-70 Dumont westbound, all of Colorado's major POE (9

locations) are automated. Dumont eastbound is not currently automated because POE operators prefer to have all vehicles stop before beginning the long, mountainous downgrade to Denver.

Table 7 provides evaluation data collected from all nine automated POE. Combined results of the three projects completed as part of the I-25 Truck Safety Improvements projects are shown as a subtotal.

Table 7 – POE Automation Results (August 2004)

POE / MOE	TOTAL TRUCKS CLEARED	TOTAL AVI/WIM CLEARED	% TRUCKS BYPASSED	BYPASS INCREASE VS. 5/02	AVI/WIM dELAY [1] REDUCED (VEH-HR)	AVI/WIM FUEL [2] REDUCED (GALLONS)	aVi/WIM EMISSIONS [3] REDUCED (HC / CO) (#)	COST SAVINGS [4] (FUEL / TIME) ($)
I-25 Ft. Collins*	73,339	37,048	50.5%	33.2%	3,087	18,524	258 / 2,709	$37,000 / $185,200
I-25 Monument	86,554	29,595	34.2%	42.3%	2,466	14,797	206 / 2,164	$29,600 / $148,000
I-70 Limon	83,685	29,871	35.8%	43.9%	2,489	14,935	208 / 2,184	$29,900 / $149,300
Project Subtotal	*243,578*	*96,514*	*39.6%*	*39.2%*	*8,042*	*48,256*	*672 / 7,057*	*$96,500 / $482,500*
% of Total State	*53%*	*60%*	*-*	*-*	*60%*	*60%*	*60% / 60%*	*60% / 60%*
I-76 Ft. Morgan	61,023	17,422	28.5%	43.2%	1,451	8,711	121 / 1,273	$17,400 / $ 87,100
I-70 Dumont WB	30,402	13,903	45.7%	39.0%	1,159	6,951	97 / 1,017	$ 13,900 / $69,500
I-25 Trinidad	18,711	5,717	30.6%	75.2%	476	2,858	40 / 418	$ 5,700 / $28,600
I-70 Loma	41,100	11,820	28.8%	14.8%	985	5,910	82 / 865	$ 11,800 / $59,100
US-287 Lamar	47,208	12,134	25.7%	41.0%	1,011	6,067	84 / 887	$ 12,100 / $60,700
US-160 Cortez	19,274	4,805	24.9%	27.7%	400	2,402	34 / 351	$ 4,800 / $24,000
TOTAL ALL	**461,296**	**162,315**	**35.2%**	**38.2%**	**13,524**	**81,155**	**1,130/11,868**	**$162,200/$811,500**

All MOE compare non-automated to automated scenario in a typical month to determine: 1] reduction in delay (vehicle hours per month); 2] reduction in fuel consumption (gallons per month); 3] reduction in emissions (pounds of vehicular emissions reduced per month; HC = hydrocarbons and CO = carbon monoxide) and 4] cost savings to the motor carrier industry (based on reduction in delay - $ per month).

Delay savings = [1] 5 minutes per bypass (Oregon Green Light Program); [2] Fuel savings 0.5 gallon if no waiting at the static scale (Transportation Management and Engineering Magazine, Aug.-Sept. 2002); [3] emission factors (by CDOT ITS Branch) pounds HC = (0.08359) vehicle-hours, pounds CO = (0.8776) vehicle-hours; [4] cost savings = (fuel + time saved) = fuel (gallons) x $2.00 + vehicle-hours saved x $60 (average cost of truck and driver from Colorado Motor Carriers) .

* April 2004 data used; SB POE closed by construction in August 2004.

August 2004 was selected for Table 7 because it is felt to be a "typical" month however similar percentages and levels of improvement are present year round. The table indicates automation of Colorado POE yields substantial benefit to the motor carrier industry in reduced delay and fuel consumption – both of which directly translate to cost savings for the private sector.

Automation of the three POE in the I-25 TSIP (Monument, Fort Collins and Limon) provides a **monthly** reduction of delay of about 8,000 vehicle hours (13,500 vehicle hours statewide), and a reduction in fuel consumption of about 48,200 gallons (81,200 gallons statewide).

Environmental and safety benefits were also realized. Vehicle emissions from idling commercial vehicles have been reduced nearly 7,700 pounds at the three sites combined (13,000 pounds statewide), providing environmental benefit to the public. In terms of safety, properly credentialed, safe carriers are allowed to bypass the POE - leaving state employees more time to inspect and cite unsafe carriers – ultimately providing an improvement to public safety. Finally, fewer entering and exiting trucks reduce vehicular conflicts at the ramp terminals to and from the POE, also resulting in a net public safety benefit.

Total trucks bypassing POE facilities in Colorado continue to increase at about 5% annually. Currently, Colorado has the highest percentage of bypasses versus total truck traffic in the United States.

Magnitude of Improvement
POE automation yields a monthly and annual cost savings to the private sector that would otherwise be unrealized without the automated bypass capability. For the three POE included in this project, those cost savings are approximately $579,000 monthly and $6.95 million annually. Statewide, these figures are even more impressive with monthly and annual savings of $974,000 and $11.7 million annually. Air quality improvements have been realized in areas immediately surrounding the ports. Overall public safety has been improved because port operators can devote additional time to unsafe carriers; and the vehicular conflicts at ramp terminals have been reduced. Finally, work on the POE task orders allowed CDOT to strengthen an existing internal partnership with the Colorado Department of Revenue.

Functionality

POE operations were markedly enhanced through the provision of the automated systems. The number of private carriers using the Colorado PrePass system (highest percentage in the country) indicates the program has been a success for the private sector as well. In addition to installation of the WIM/AVI, a number of peripheral items were provided. At Fort Collins, cameras were installed for the POE operators.

The system allowed operators to view the off ramp to the POE (not within his or her field of vision) to allow the operator to turn the port open/closed signs on/off when trucks were queued in the gore area. This activity was also completed at Monument, except that state funding was used. At all ports, the open/ closed sign systems were upgraded from hard-wire to 900 MHz wireless communications due to sporadic failures in the existing wiring. In addition and where needed, conduit, pull boxes and markers were installed to replace

aging equipment. In addition, as part of the web activities described elsewhere, kiosk-style monitors were placed in the POE buildings to allow POE personnel and truckers to access road weather information on Colorado highways.

A functional overview describing how a typical truck bypass system "works" in concert with the WIM, AVI and central system software is included in Appendix B.

Management Structure

All POE installation work was completed by the Integrator and its subcontractors. CDOT ITS Branch staff, in coordination with the specific CDOT Regions managed the task orders and provided construction inspection and verification of system tests.

Photo 16 – Traditional (non-bypass) POE Signing

4A.3 Evaluation Category 3 – Partnerships and Data Exchange

Task orders in Category 3 had the intent of working within the framework of existing ITS partnerships and developing data exchange capabilities with outside parties. Those task orders included the following:

- Task Order #2A – POE Web Enhancements.
- Task Order #6E – Denver Metro Fiber Ring.
- Task Order #7 – I-25 Interconnect, CTMC to CSTOC.
- Task Order #19 – Denver Area Traffic Signal Interface, Region 6.
- Task Order #27 – Traveler Information Center (TIC).
- Task Order #28 – Public Information and Incentive Leverage.

Other communication-related task orders were assigned to Category 1 because their intent was focused on collection of field data and transmission to CTMC over the high-speed fiber optic network. Most web-related task orders were also assigned to Category 1 because: 1] much of the work was devoted to organization and packaging data; 2] much of the work tied together data elements from disparate subsystems; and 3] the ultimate intent of the web activities was "public" data distribution rather than inter-agency. Finally, Task Order #16 (Hanging Lake Tunnel Integration) was felt most appropriate in Category 1 because although initial work consisted of an integration study for a remote site, the latter activities changed out tunnel video subsystems and thus the overall task order was felt more appropriate within that category.

These activities address the project goal of "addressing ITS infrastructure deficiencies" as well as the objectives of "enhancing the availability of data for partner agencies," providing "enhanced functionality," and "enhancing incident management capabilities."

Magnitude of Improvement

Percentage improvements are not available for these activities, yet it is apparent that CDOT abilities to exchange information with remote partners internal and external to CDOT were substantially improved by the project. In all, data links were developed between three CDOT locations (CTMC, CDOT Region 6 and CDOT Headquarters), three cities (Denver, Lakewood and Colorado Springs) and one transit agency (RTD). The networks deployed herein were later used to provide initial data exchange between these parties. Finally, additional data was provided via installation of kiosk-style monitors at POE facilities accessing the Co-Trip site to provide truckers and port personnel with access to statewide road weather information.

Functionality

Functionality was enhanced for POE operators through the provision of camera systems to view off ramp areas, on-site communication between devices and the deployment of kiosks (using the web browser application) at the POE to allow operators to access statewide travel information and pass such information along to truckers.

Installation of end equipment to light the Denver Metro fiber ring allowed CDOT to communicate directly with internal and external partners. The initial deployment linked the CTMC, CDOT Region 6, CDOT Headquarters, the Cities of Denver and Lakewood, and RTD.

The I-25 interconnect project provided initial planning for active interface between the CTMC and the CSTOC. The deployment phase contributed a portion of task order funding toward installation of the "missing" 33 miles of interconnect cable between the two centers. Temporary data exchange methods were also implemented to provide communications prior to deployment of interconnect cable. Full integration has been deferred until a later project.

The interface to the City of Lakewood was similar to that developed with Colorado Springs. Initial planning studies, temporary data exchange and permanent interconnection were all undertaken. Full integration has been deferred until a later project.

The Traveler Information Center (TIC) project brought an Information Service Provider (ISP) into the CTMC to develop a means for dissemination of travel information to the public via subscription. While functionality was temporarily enhanced by deploying the ISP information system at the CTMC, the project was later abandoned due to cost and other concerns. Difficulties encountered in the TIC task order were one contributing factor to increasing levels of antagonism between CDOT and the Integrator – eventually leading to the Integrator's dismissal from the project. The latter situation is discussed in greater detail in the following sections.

Management Structure
CDOT started and completed the referenced POE work and the Denver fiber ring activities. The initial planning stages of the Lakewood and Colorado Springs projects were completed by the Manager. All work on the subsequent deployment phases of the task orders was completed by CDOT. The TIC and Public Information task orders were undertaken by the Integrator prior to later abandonment.

4A.4 Evaluation Category 4 – Intangibles
This evaluation category represents a qualitative measure to address two areas: 1] the overall success of the I-25 Truck Safety Improvements; and 2] the organizational, technical and management structure for the project.

4A.4.1Overall Success of the Project
CDOT believes the overall project has been an unqualified success. Previous needs in infrastructure; amount, type and flow of data; communications; CVO; incident management, and overall functionality have been addressed by the project task orders.

Of the individual task orders, all have been judged successful with the following two exceptions:

- Task Order #27 – Traveler Information Center (TIC). This task order was developed as an operational test to determine if the presence of an ISP within the CTMC would be beneficial to CDOT or the public or would otherwise increase functionality. Ultimately, CDOT contributed additional state funds beyond the project budget and eventually determined the services of the Integrator and ISP were too costly. The ISP operation was not able to become self-sustaining after start-up and was therefore terminated.

- Task Order #28 – Public Information and Incentive Leveraging. This task order was intended to use project funding to augment matching funds to be contributed by the Integrator. Although limited funding was expended on the opening ceremonies for the Fort Collins POE, no private contribution was realized and the task order cancelled.

These two task orders as well as all the others comprising the I-25 TSIP are described in greater detail as part of Appendix B of this report.

4A.4.2 Organizational, Technical and Management Structure

Although the end result of the overall I-25 TSIP has been deemed to be quite successful, the project was not completed using the organizational structure originally planned.

CDOT made the determination in the previous RMDI project that having access to two private sector teams provided a workable mechanism for review, feedback, advice and access to more resources. The result was a management structure for the I-25 TSIP including: 1] a systems integrator ("Integrator"); and 2] a program/systems manager ("Manager").

Both were selected via a competitive Request for Proposals and were teams of companies rather than individual firms. The Integrator had primary responsibility for field design and construction, procurement, software development and other integration – approximately 90-95% of the work. The Manager was not a "systems manager" in the classical/traditional systems engineering sense but instead provided technical oversight, completed portions of specific task orders, and otherwise assisted CDOT with the technical, administrative, management, coordination and reporting aspects of the project, including evaluation – approximately 5-10% of the work. The I-25 TSIP began in early 1999 with this organizational, technical and management configuration.

<u>Project Organizational, Technical and Management Difficulties</u>
During the I-25 TSIP, the level of partnership between CDOT and the Integrator deteriorated to an extent that recovery was not deemed possible. As a result, the participation of the Integrator in the project ended in 2001. The difficulties underlying the dissolution of the CDOT/Integrator partnership were a combination of disagreements resulting from: 1] the outcome of the previous RMDI project (which used the same Integrator); and 2] progress and performance on a separate, state-funded task order not related to the I-25 TSIP; and 3] progress and performance on a few specific I-25 TSIP task orders. Because the end of the previous RMDI project overlapped the start of this one, several issues of contention arising in the first area were not apparent at the outset of the I-25 TSIP.

Ultimately, the Integrator's participation in the I-25 TSIP was mutually ended due differences of opinion between CDOT and the Integrator in the following areas:

- Completion and/or status of RMDI deliverables.
- Progress and compensation on a state-funded task order apart from the I-25 TSIP (I-25 HOV Lane software).
- Task order schedules.
- Task order budgets.
- Reporting.
- Proposed private match.
- Human factors.

<u>Resolution and Recovery</u>
Dissolution of the CDOT/Integrator partnership forced CDOT to complete a risk assessment and recovery plan to enable work on the project to continue toward its eventual successful completion. These actions are identified in further detail in Appendix A but included deferring certain tasks, providing additional State funding to others, and establishing responsibilities for completion on the ongoing task orders. In the case of the latter, some tasks were completed by the Integrator, with the majority completed by State forces.

<u>Summary</u>
Although the CDOT/Integrator partnership was unsuccessful in this project, the CDOT/Manager partnership was very positive. The two-tiered (Integrator and Manager) structure was therefore only a half-success in terms of this project. CDOT believes the rationale for having two private partners in large-scale ITS projects remains sound – due to additional review capabilities, expertise, feedback and resources.

4B Institutional Issues – Elective Activity #1
As its first elective activity for the local evaluation report, CDOT has chosen to recount selected institutional issues encountered during the project. Institutional issues can best be described as those items that are not technical in nature that needed to be overcome or otherwise addressed to achieve success in the I-25 Truck Safety Improvements project. These include items such as in-house expertise, coordination with internal and external stakeholders, developing new partnerships, organizational structures and processes, and flexibility. These items are discussed in additional detail in this section.

4B.1 In-House Expertise
Installation, operation and maintenance of ITS systems requires personnel with highly specialized technical skills. Such skills include expertise in non-traditional civil engineering areas such as computer networks, communications, computer hardware and peripheral equipment, electronics, the Internet, software development, databases, and protocols to allow these elements to interact.

At the project outset CDOT had one task order manager who was well-versed in networks, communications and hardware. There was only limited internal expertise in the remaining areas among the staff of the CDOT ITS Branch. The CDOT intention was that the missing skill sets would be (primarily) provided by the Integrator and Manager.

Midway through the project, CDOT made the determination to part ways with the Integrator and complete the project using (primarily) its own forces. Recognizing it did not have the requisite skill sets required to accomplish this, the ITS Branch obtained the missing expertise through a combination of new full-time employees, contract employees, the ITS Maintenance contractor and the Manager.

Photo 17 – CTMC Operations Control Room

Over a relatively short time, CDOT was able to greatly enhance its expertise in networking, hardware, electronics, the Internet, software development and databases – allowing CDOT to complete the I-25 TSIP virtually in-house. By project conclusion, the CDOT ITS Branch had greatly increased its internal technical skill base in these categories through addition of several full-time or contract employees. Many non-traditional (civil engineering) tasks such as communications and network architectures; web site development (including static and dynamic maps); database enhancements; development of device drivers; electronics set-up and installation for cameras, switchers and multiplexers; and so on were thus successfully completed by CDOT.

As a result, CDOT has made two conclusions: 1] had it had the current levels of expertise throughout the project, many of the difficulties encountered with the Integrator could have been prevented, minimized or otherwise mitigated; and 2] non-traditional in-house skill sets are an indispensable resource most definitely required for success in complex ITS projects.

4B.2 Coordination with Internal and External Stakeholders
CDOT was fortunate the RMDI project immediately preceded the I-25 Truck Safety Improvements because an extensive multi-agency partnership was already in place. The existing partnership had previously established the names of contact persons and lines of communication and outlined the parameters of working together to achieve common ITS goals. These elements were reinforced via a number of Letters of Agreement, Memoranda of Understanding and Intergovernmental Agreements. CDOT ITS partners at the beginning of the project included:

- City of Aurora;
- City of Colorado Springs;
- City & County of Denver;
- City of Lakewood;
- Colorado State Patrol (CSP);
- Denver Police Department (DPD);
- Denver Regional Council of Governments (DRCOG);
- Regional Transportation District (Denver) (RTD); and
- University of Colorado at Denver (UCD).

Establishing this partnership was by no means easy in 1996 and issues overcome during the coalition building phase included: 1] educating the partnership on ITS in general; 2] selling the participants on the need for, and benefits of ITS; 3] laying the groundwork for a team – rather than individual agency – approach; and 4] developing interpersonal relationships based on trust between the partners. As a result, the core partnership listed above remains intact to the present day.

At the outset of the project, some task orders were strategically selected by CDOT and FHWA to capitalize on the previous successes and working relationships established through the partnership. As a result, Task Orders #7 and #23 developed a interconnect and planned for an interface with Colorado Springs; Task Order #9 purchased DMS for Colorado Springs; Task Order #18 assisted Denver with its stadium traffic and parking management issues; Task Order #19 planned for an interface with Lakewood; Task Order #30 established incident management interfaces with CSP and DPD; and UCD was identified to assist in developing the speed map activities (Task Orders #17, #22 and #24).

The agencies were involved throughout their respective task order(s). Common activities typically included reviewing the initial scope of services; attending the kick-off meeting; attending regular project technical or coordination meetings; working with CDOT on day-to-day coordination; and providing support services, technical review or installation with their own employees.

CDOT's conclusion is that continuing these previous and ongoing working relationships through new task orders created by the I-25 Truck Safety Improvements Project served to strengthen the existing partnerships.

4B.3 New Partnerships

A number of new partnerships were created during the course of the project. A great number of new partnerships were achieved through parallel activities being completed simultaneously using alternate funding sources, while others were a direct consequence of the I-25 TSIP.

4B.3.1 New Partnerships – Parallel Projects

As part of separately-funded projects CDOT was able to expand the size and geographic reach of its partnership structure. This was primarily achieved through three activities: 1] the incident management planning efforts along nine major corridors in Colorado – which brought together the traffic engineering, enforcement and emergency response personnel of multiple agencies statewide; 2] development of the Denver area and Colorado Springs/Pueblo/CDOT Region 2 Regional ITS Architectures; and 3] development of the I-25 Southeast Corridor ("T-REX") project.

The number of new partnerships developed over the recent five-year period in parallel projects is probably too numerous to itemize by agency but includes the following broad categories of participants.

- I-70 transportation, enforcement and emergency response agencies Denver to Utah (IMP).
- I-25 transportation, enforcement and emergency response agencies Denver to Colorado Springs (IMP).
- I-25 transportation, enforcement and emergency response agencies T-REX project Denver (IMP).
- US-6 transportation, enforcement and emergency response agencies Denver to Golden (IMP).
- Six county Denver area transportation agencies (Regional Architecture).
- Two county Colorado Springs/Pueblo area transportation agencies (Regional Architecture).
- Colorado Bureau of Investigation (Amber Alert Program).

4B.3.2 New Partnerships – I-25 Truck Safety Improvements

As part of the I-25 TSIP, CDOT was able to establish new inter-agency partnerships with three entities. These were: 1] Douglas County; 2] the Colorado Tourism Board; and 3] the City of Fort Collins.

Photo 18 – Task Order #7 installed "missing" I-25 fiber between Denver and Colorado Springs – Castle Rock section shown

Douglas County

The extent of CDOT work with Douglas County prior to the I-25 TSIP had primarily been in coordinating the repair, installation and use of various CCTV cameras; and high-level discussions regarding ways to better work together. Under Task Order #7 of the TSIP, CDOT investigated the feasibility of installing 33 miles of fiber optic cable that had previously been "missing" between Denver and Colorado Springs - all of which would require installation along I-25 in Douglas County. This county is squarely between the Denver area to the north and Colorado Springs to the south and has been the focus of explosive growth over the previous 15 years - in fact, it has been among the five fastest growing counties in the country for about eight of the past ten years.

During task order development, CDOT worked with Douglas County staff to plan, develop shared use agreements, design and construct the referenced interconnect. The County participated in construction of the project with a sizeable funding contribution and is currently one of CDOT's strongest ITS partners.

Colorado Tourism Board

CDOT was able to develop a working relationship and partnership with another State agency – the Colorado Tourism Board – through the deployment of traveler information kiosks at Welcome Centers.

Because CDOT does not typically have many ITS devices in the highly rural areas near Colorado borders, traveler information is difficult to disseminate to motorists entering the State. This is particularly true for commercial carriers, tourists and other travelers from the east that will eventually make their way to the mountain segment of I-70 west of Denver.

Through the referenced partnership, CDOT was able to place kiosks in the Welcome Center facilities that provide still photos of traffic conditions in the state and scroll current roadway conditions and road alerts across the bottom of the screen. CDOT worked closely with the Board to discuss potential deployments and negotiate agreements for short- and long-term operations and maintenance.

City of Fort Collins

CDOT was also able to develop a new partnership with the City of Fort Collins as a result of Task Order #8 – intended to provide Highway Advisory Radio coverage along I-25 between Denver and the Wyoming border. The task order was originally intended to provide this coverage by relocating four HAR stations from CDOT Region 6. Ultimately, those units could not be relocated as planned, therefore CDOT needed to develop an alternate plan to provide equivalent coverage. The new plan required installing one new HAR at Mead and developing an agreement with Fort Collins for shared use of its 40-watt HAR. In return for the shared use rights, CDOT agreed to install static signs along I-25 to "advertise" the presence of the HAR. Through cultivation of this unlooked-for partnership, CDOT was able to provide equivalent coverage to that intended at no additional cost to the project.

CDOT's conclusion is that inter-agency partnerships are valuable resources to the ITS Program. Not only do such working relationships facilitate successful day-to-day operation, but open communications help form a solid foundation from which to build future ITS initiatives.

4B.4 Project Structures and Processes

The two-tiered project structure including a separate Integrator and Manager has been discussed elsewhere in this document. Instead, this section identifies selected managerial or administrative aspects of the project that worked well.

Project Division into Task Orders

The previous RMDI was configured as one large project without a contractual separation between the tasks to be accomplished. Although this represents the traditional format for most CDOT projects, the task order subdivision of the I-25 TSIP provided a number of apparent advantages. These included:

- *Better cost tracking of all labor and direct expenses on a task basis*. Because each task was broken out separately, it was easier for the CDOT management team to identify areas incurring a potential over-run, as well as areas not incurring sufficient labor to meet schedules. Due to the size and complexity of this project, the task order system was deemed superior in tracking and controlling costs.

- *Better schedule tracking on a task basis*. Because schedules were reported on bi-weekly, it was easier for the CDOT management team to identify areas encountering schedule difficulties. Again, the task order system was deemed superior in identifying critical scheduling issues as they arose.

- *Better subdivision of CDOT management responsibilities*. Because CDOT assigned a number of task order managers to the project, it had more "eyes and ears" available to actively monitor progress of the work across multiple task areas.

- *Modular aspect of the deployment*. In the RMDI project, the Integrator was tasked to deliver a single large deployment at once. This system ultimately led to major disagreement and controversy between the two parties. The modular aspect of ITS delivery created by the task order system allowed the work to be better organized and helped ensure delivery and acceptance of the required product on budget.

Technical Management Structure

The technical management structure used in the I-25 TSIP was originally implemented during the RMDI project. It was maintained during this project due to its proven effectiveness. Generally, the configuration is comprised of five levels of oversight configured as follows. The structure is listed from the highest (upper management with less frequent meetings) to the lowest (day-to-day participants with more frequent meetings) levels.

- *Executive Management Team/Transportation Commission Subcommittee*. The established committees are briefed when major project releases are implemented to ensure the proper direction fits into overall Department planning and budgeting profiles.

- *Policy Steering Board (PSB)*. The PSB consists of the heads of departments or organizations having significant project (or task order) participation. The PSB meets quarterly (or less frequently) to define overall program policy issues and monitor progress of the work.

- *Project Management Oversight Committee (PMOC)*. The PMOC consists of senior line managers who meet monthly (or less frequently) to review general project status. Discussion items include but are not limited to: project status: budget; schedules; and risk management review. Should the PMOC be unable to resolve a given priority or issue, the item in question is elevated to the PSB for resolution.

- *Project Manager's Committee (PMC)*. The PMC includes project/task managers from CDOT and stakeholder agencies or organizations. The committee meets every other week or as required to discuss detailed project status. This includes but is not limited to: timelines; design; technical issues; milestones; risk management and budget. Should the PMC be unable to resolve a given priority or issue, the item in question is elevated to the PMOC for resolution.

- *Change Control Board (CCB)*. The CCB oversees the change process and consists of representatives from all interested parties including customers, developers and users. The CCB makes decisions to approve (or not approve) design changes. If the proposed change highly impacts the project, the request is elevated to the appropriate management level.

The structure above is more applicable to software development and because the I-25 TSIP is primarily a deployment activity, some levels of the structure outlined above (most notably the CCB and PSB) were not a part of this project. The oversight structure as described will be fully implemented for the FY01 Earmark addressing the new ATMS/ATIS for the CTMC.

CDOT's conclusion is that breaking the project into individual task orders is a positive means to maintain better control over the ITS contractor in large-scale ITS projects. The multi-tiered oversight structure is an efficient management strategy and will be carried forward into other (future) ITS projects – most notably the FY01 Earmark addressing the new umbrella software system for the CTMC.

4B.5 Flexibility
Due to successful application of the risk management principles that form a key part of systems management, CDOT was able to develop recovery plans to complete the intended work without the Integrator. Although some schedule delays were encountered as a result of reassigning tasks, all intended work was completed at no additional (unintended) cost to the project.

4C Lessons Learned – Elective Activity #2
As its second elective activity for the local evaluation, CDOT has chosen to summarize its experiences on the project in a lessons learned format. The first category addresses the contractual and managerial relationship between CDOT and the Integrator. The remaining items relate to the use of systems engineering practices and various other categories.

4C.1 Systems Integrator Contract
During the I-25 TSIP, the contractual relationship between CDOT and the Systems Integrator was dissolved by mutual agreement between the two parties. By the time the referenced contract ended, differences of opinion between the two had progressed to an emotional level between individuals and would have been, if not beyond recovery, difficult to mitigate. These areas of disagreement were mostly non-technical in nature and are briefly described below.

- *Business Philosophy* - CDOT concluded the Integrator did not understand the CDOT business philosophy that: 1] schedules are limited; 2] there are funding constraints; and 3] that the Department, as a State agency, is answerable to its constituency and must have deliverable products in hand as a final outcome. CDOT opinion was the Integrator never truly understood the State's requirement to perform business under these limitations, especially pertaining to cost. The Integrator opinion was that CDOT did not understand systems engineering and complex project development and therefore had misinformed expectations.

- *Matching Funds* - CDOT felt the intended public-private partnership of the I-25 TSIP was almost immediately transformed into a traditional owner-contractor relationship after contract start-up. CDOT perspectives were that: 1] the Integrator failed to provide pledged up-front or in-kind services; and 2] matching activities and contributions itemized in the Integrator's proposal were not realized. Approximately $6M in match was listed in the Integrator's proposal. The Integrator position was that this match had, in fact, been at least partially provided.

- *Deliverables* - CDOT did not feel the Integrator consistently provided the required deliverables on schedule or on budget. Throughout the I-25 TSIP there was a consistent gap between the two parties regarding definition of deliverables and schedules. The CDOT position was that the deliverables were outlined in each task order, agreed to by Integrator signature, and included proposed schedules and budgets and therefore the Department had a contractual right to expect the applicable products in exchange for compensation provided to the Integrator. The Integrator's perspective was that many of these items had, in fact, been delivered; or were otherwise late or over budget due to shortcomings in CDOT management.

- *Management* - Project-wide, about 11% to 13% of the overall project expenditures due the Integrator were for management fees over and above technical management of individual task orders (this amount was paid for using State funds). CDOT opinion was that this level of management should translate to a reasonable expectation of consistent on-time, on-budget performance. The Integrator position was that CDOT management was insufficiently trained and did not provide the required levels of support – therefore driving management costs higher.

- *Human Factors* – Differences of opinion between the two parties were evident in the subjective areas of communication, listening, personality conflicts, the perceived capabilities of members of the opposing technical or management teams and customer service.

It is readily apparent from the items described above that communications and the professional relationship between CDOT and the Integrator had deteriorated by late 2001 to a state of distrust, resignation and "finger-pointing." Although CDOT was successfully able to recover the project by changing the I-25 TSIP implementation focus from the Integrator to one using State forces, a number of lessons learned were apparent – specific to the CDOT-Integrator (or owner-contractor) relationship.

Lessons Learned – Systems Integrator Contract
Conclusions apparent at the conclusion of the I-25 TSIP – as they pertain to CDOT and the Systems Integrator – include the following:

- *In-house expertise in ITS specialty areas is helpful*. CDOT believes that had it had the current levels of in-house expertise throughout the project, difficulties with the Integrator could have been lessened or avoided altogether. Addition of these skill sets ultimately allowed CDOT to subdivide technical responsibilities for completion of multiple task orders between five or six capable and knowledgeable individuals – rather than two or three "thinly spread" individuals.

   CDOT believes in-house skills in ITS-related technical areas are an indispensable resource definitely required for success in complex ITS projects.

- *Get the right contract*. The task order contract configuration provided much better control of the contractor than did the previous CDOT/Integrator cost-plus-fixed-fee contract – which essentially relieved the contractor of the responsibility to deliver finished products; as well as removing CDOT's contractual "clout." Additional time commitments are required on part of the owner in a task order environment to better monitor contractor progress on a greater number of total activities.

- *Although task order contract configuration is not necessarily more efficient for the contractor, it provides a better mechanism for the owner to track progress and control schedules and costs*. The previous RMDI project was configured as a single large project with mixed results, leading to set-up of the I-25 TSIP using task orders to allow better owner control. This task order configuration has been kept for three later projects earmarked (one in FY00 and two in FY01) for Colorado.

- *Open communications are critical to success*. During the I-25 TSIP, open communications were crippled by a gradual eroding of trust as a result of the previous RMDI work; activities on related state-funded (stand-alone) task orders; and selected task orders within this project. Once a certain level of trust no longer existed between CDOT and the Integrator, continuation of the contract became a losing proposition for both parties.

- *Build the project in small pieces*. Similar to the task order discussion above, CDOT has now moved to an across-the-board ITS acquisition philosophy including smaller dollar-value implementations using shorter schedules. Cost and schedule problems are typically reduced due to lesser complexity and easier manageability, along with a shorter period of time for "things to go wrong."

- *Avoid "classic" mistakes*. Once the relationship between CDOT and Integrator began to deteriorate, both parties fell back into some of the repetitive mistake patterns seen on past ITS projects nationwide. These mistakes included (in specific areas and generally by both parties): too little management; micromanagement; immediate assignation of blame to the other party; unrealistic expectations; squeezing the schedule (for CDOT); and falling back into "change order" mentality (for the Integrator).

- *Devote attention to contractor staffing and expertise*. The Integrator was a large multi-national company with exceptional skills in systems engineering developed over many years participation in Department of Defense-related projects. Although this should have led to success, it may have been difficult for the contractor to attract its best and brightest employees to a "non-exciting" subject area such as surface transportation.

- *"Smaller" may be better*. Generally, it is CDOT's opinion that the smaller companies attached to the project (on either the Integrator or Manager teams) provided not only their best employees, but better customer service.

4C.2 Lessons Learned - Systems Engineering

Although these items are discussed in more detail elsewhere in this document, the application of systems engineering principles benefited CDOT in a number of ways. Lessons learned include the following:

- *The five-tiered technical management structure described in Section 4B.4 is sound*. The structure will be of even greater value as applied to the future FY01 earmarked project to develop the CDOT core ATMS/ATIS. Because of the deployment focus of this project, CDOT was able to eliminate two of the management levels normally required for a "normal" software development project.

- *Employ proactive risk management*. Risk management was the paramount factor allowing CDOT to achieve a winning project outcome after participation of the Integrator ended. Various projects were deferred, identified for completion by the Integrator or identified for completion by the State. Completing certain task orders using State forces ultimately led to increasing CDOT's in-house expertise in ITS-related areas.

Photo 19 – Port of Entry (POE) Inspection Station

4C.3 Lessons Learned – Other Areas

Perhaps the greatest lesson learned by CDOT over the course of the project was the value of inter-agency partnership. Not only was CDOT able to strengthen existing or previous partnerships through the project, but a number of new partnerships were realized.

For example, the partnership between CDOT, the Colorado Department of Revenue, Colorado Motor Carriers and Prepass was strengthened a great deal by the statewide automation of POE. All ports in Colorado are currently automated (with one exception in one direction) – three as part of this project.

The result of the POE partnership is one of which all participants can be proud – as Colorado currently bypasses the highest percentage of trucks in the United States.

Economies of scale were realized on other task orders. For example, on each of the task orders including the participation of Denver, Lakewood and Colorado Springs, the agency participant contributed to the project in terms of purchasing, in-kind services, assistance in obtaining related services or contracts, or the provision of ancillary materials. The result of such partnership was deployment with a total value exceeding that originally planned.

Such partnerships have helped set the basis for additional coordinated work in the future with the same partners and also set the basis for such participation with new agencies as part of future projects.

END LOCAL EVALUATION REPORT