TRAFFIC OPERATIONS CENTER TOUR

Intelligent Vehicle-Highway Systems

Denver Metro Area

Project IVH-MP 9108(1)

for the
COLORADO DEPARTMENT OF TRANSPORTATION

C-STAR

October 1992

by:
CENTENNIAL ENGINEERING, INC.
CASTLE ROCK CANSULTANTS
IBI GROUP
ABO ARCHITECTS

Denver Metro Area Traffic Operations Center

TRAFFIC OPERATIONS CENTER TOUR

COMPASS (Toronto) & INFORM (New York)

Task 2 - Review State-of-the Art Facilities

Technical Memorandum #I

for the

COLORADO DEPARTMENT OF TRANSPORTATION
Project IVH-MP 9 108(l)

October 1992

by:

CENTENNIAL ENGINEERING, INC.
CASTLE ROCK CONSULTANTS
IBI GROUP
ABO ARCHITECTS

TABLE OF CONTENTS

Traffic Operations Center (TOC) Tour

(COMPASS - Toronto and INFORM - New York)

LESSONS LEARNED

Castle Rock Consultants
September 1992

1. OVERVIEW

The purpose of this document is to relate the experiences learned during the recent Traffic Operations Center (TOC) Tour. This tour included visits to the following:

- COMPASS - Highway 401 Traffic Management System in the Toronto Metropolitan Area.
- INFORM - Long Island, NY Freeway Traffic Management System.
- Metro Toronto SCOOT Demonstration Project.

The purpose of the TOC tour was to allow the participants to gain an insider's view of the activities which comprise each center's daily operations.

This document will present details concerning the center's functions, responsibilities and provisions in order to provide a thorough understanding of how these facilities operate and what they aim to accomplish Within subsequent sections of this document, details of each center's system will be compared to the initial design criteria and operational needs of the Denver Metro Area TOC. These sections will identify key areas in which to examine the need for and feasibility of implementing specific TOC functions in the Denver Metro Area.

Since many of these centers' activities concentrate on efforts similar in nature to those of the Denver TOC, issues pertaining to their implementation and operation can be considered within the framework of the Denver TOC design. Desirable aspects of each facility will be assessed for inclusion within the Denver TOC, while those characteristics which are not applicable will be rejected.

Finally, this document will provide a summary of issues and concerns for each system function related to the Denver TOC. Questions concerning the TOC's operations, functions, responsibilities and service provisions will be addressed to more fully understand the direction the TOC should take.

2. COMPASS

2.1 Introduction

The Ministry of Transportation of Ontario (MTO) has developed an advanced tool for managing traffic on its urban freeway system -- COMPASS. The COMPASS program assists the MTO in the following areas:

- Collecting traffic flow information (via inductive loops, microwave detection and CCTV monitoring).
- Detecting incidents (e.g., accidents, breakdowns, hazardous material spills, etc.).
- Providing accurate traveler information (via VMS displays).
- Providing a reduction in congestion and associated delay during rush hour periods and emergency situations.

The initial section of the Highway 401 program contains both express and collector lanes which allow alternate route selection. The COMPASS operations center is located adjacent to Highway 401 and provides a focal point for traffic management along this freeway corridor.

2.2 Traffic Flow Information Collection

Inductive Loop Detector Stations

The COMPASS program makes extensive use of inductive loop detector stations in its data collection efforts. The following outline provides a summary of the system's detector station characteristics:

System Coverage Length	10 miles
Detector Station Spacing	0.4 miles
Number of Freeway Detectors	700
Detector Station Controller Type	170F
Detector Station Polling Interval	20 seconds
Detector Station Communication Ports	RS232
Detector Station Communication Type	Fiber optics
Detector Station Information Type	Speed, Volume, Occupancy

At each detector station, two inductive loops are placed in each lane. This tandem setup provides the basis to receive the vehicle speed information per lane of directional travel.

Toronto's controllers, 170Fs, are different from conventional 170s used in California or New York The MTO has enhanced the controller by speeding up its clock speed and processing speed.

Toronto's detector station polling interval is every 20 seconds. Every detector station's data are accumulated into five minute intervals and stored in a monthly form. Additionally, each detector station's information is tabulated on a hourly basis and stored in an annual format. This type of comprehensive data collection allows for the analysis of the corridor's historical trends. These include analysis by day-of-week, holidays, weather-related issues and seasonal trends.

The COMPASS program uses fiber optic data links as its communication medium between the 170Fs and the Operations Center. MTO indicated its preference for this medium due to its low maintenance requirements, multi-mode and high bandwidth capabilities and its relative immunity to interference.

Finally, the MTO has reported a loop detector reliability rate of 90 percent system wide. This number indicates the average percentage of loop detectors which are on-line, currently in operation, fully-functioning and processing vehicle detection data. Therefore, at any one time, 10 percent of all inductive loops are typically not in operation.

Microwave Detection Equipment

The MTO is in the process of testing a Road Traffic Microwave Sensor (RTMS) as part of its vehicle detection system. The RTMS is a low-cost FMCW radar; it transmits an FM (frequency modulated) CW (continuous wave) signal through its antenna. The unit is designed to be a pole-mounted, side-of-the-road vehicle sensor. MTO provided partial funding for the development of the RTMS, which was produced by the Canadian firm Electronic Integrated Systems (EIS) Inc.

Internally, there are multiple high-speed, low-power processors within the RTMS which are responsible for systems operation, digital signal processing, and programmable external communications. The RTMS is fully programmable and can format custom serial communications to bypass the need for a side-of-the-road 170 type or similar controller.

Installation and setup of the RTMS are performed using a laptop computer. There is no need to open the sealed casing or remove the unit from the pole for software upgrades or reprogramming.

The TOC tour visited two demonstration sites and viewed the RTMS in the following modes of operation:

1) Freeway side-fire multi-lane mode-in-tandem RTMSs tracking up to 12 lanes simultaneously with volume, occupancy, speed and vehicle length data. This setup is similar to the tandem inductive loop detector stations in current freeway traffic management operations.

2) Intersection side-fire mode - a single RTMS yielding multi-lane vehicle presence, volume and occupancy data. The RTMS in this mode of deployment can provide left-turn activation, up/down stream volume, and derived queue length information.

Initial tests indicate results that range from 93 percent to 105 percent of the control group's (inductive loops) readings. No correlation of performance degradation was observed even with exposure to a wide variety of temperature and precipitation conditions.

MTO indicates that initial costs for the RTMS have been approximately $4,000 per unit. After widespread system deployment, MTO estimates that costs will decrease to $2,000 per RTMS unit. No maintenance costs or unit reliability estimates are available at this time.

For more information on the RTMS, see the paper by Wang, Case and Manor that was distributed to tour participants.

CCTV Monitoring

Closed circuit television (CCTV) cameras transmit live images to the Operations Center to confirm information from the inductive loop detector stations and to quickly identify problems on the freeway system. The following outline provides a summary of the system's CCTV camera field characteristics:

System Coverage Length	10 miles
CCTV Camera Spacing	.6 miles
Number of CCTV Cameras	19
CCTV View Range	.4 miles
CCTV Zoom Ratio	12:l
CCTV Communication Type	Fiber optic
Camera Lens Freezing Prevention Type	Heaters

In addition, the COMPASS Operations Center possesses the following CCTV camera characteristics:

- 54 monitoring screens (with the capability to expand to 90).
- Operator workstations containing 3 screens, all of which can monitor images from any CCTV camera.
- Full CCTV camera functionality (e.g., zoom, pan and tilt features).
- 6 second scanning capability between all CCTV cameras,

The current CCTV monitors within the operations center are monochrome displays. COMPASS is in the process of changing this viewing capability to color. MTO does not expect any visibility difficulties at night as a result of this viewing color change.

The COMPASS program uses fiber optics as its communication medium for its data link between the CCTV cameras and the Operations Center. This medium is favored by MTO for reasons described previously. In addition, as the CCTV camera network expands, MTO will be able to place 6 CCTV cameras on a single fiber optic line.

Within the COMPASS Operations Center, a full weeks' coverage can be documented on a single tape for each CCTV camera. These CCTV informational tapes can be subpoenaed for legal use in court by the Police and the general public. However, MTO indicates that this rarely occurs. More frequently, however, the Police utilize the tapes to view accident scenes and observe incident management techniques.

In addition, a number of local TV stations can link into the CCTV monitoring system to display camera images on their own channels. These TV stations do not have any control of the CCTV cameras or choice of camera from which images are received. The TV stations can only request a communication link-up to a CCTV camera display, subject to authorization by the COMPASS operator. Such links are usually related to a major incident or accident which requires immediate notification to the motoring public before they embark on a freeway journey.

Data Collection Summary

In light of the data collection systems used in Toronto's COMPASS program, the following Charcteristics appear desirable for inclusion within the Denver TOC.

Inductive Loops The Denver TOC should make use of its existing data collection techniques and coordinate new activities with these current efforts. Primarily, this will focus on the use of inductive loop detectors. Existing activities which utilize inductive loop detectors in the Denver Metro Area include the expanded freeway ramp metering system, North I-25 Traffic Management System and the freeway inductive loop program.

If CDOT chooses to install additional inductive loops along its freeway system, the following characteristics seem desirable:

- Uniform loop detector station spacing (e.g., 0.5 mile).
- Model 170 controllers for data processing (widespread use currently exists in Denver Metro Area).
- RS232 communication ports.
- Fiber optic communication link.
- Speed, volume and occupancy information.
- 20 second polling intervals.
- Historical trend analyses of traffic data (e.g., aggregate 5 minute counts).

Overall, implementation of any new inductive loop projects should be closely coordinated with existing activities to ensure program compatibility.

Alternative Detection Equipment - CDOT should consider using an alternative data collection source to inductive loops. This has the potential to supplement, or in the future, replace current loop detectors. Microwave detection is one such alternative, as seen in Toronto. Desirable characteristics of the RTMS system and similar approaches include:

- Fully programmable in-unit processing equipment.
- Software upgrades or reprogramming via modem link-up.
- Pole-mounted, side-of-the-road positioning which allows maintenance activities without having to close freeway lanes.
- In-tandem units which allow tracking of multiple lanes simultaneously with volume, occupancy, speed and vehicle length data.

CDOT should investigate test results for RTMS units and other emerging data collection technologies to make sure they achieve reliable results. Also, CDOT should make sure that the systems are cost-effective within their overall data collection efforts.

CCTV Monitoring - CCTV cameras are a reliable tool to verify problems and incidents on the Denver Metro Area freeway system. Installation of any new CCTV cameras should be coordinated with the North I-25 TMS project. Some desirable CCTV camera characteristics include:

- CCTV camera spacing which allows comprehensive monitoring without overlapping coverage areas.
- Fiber optic communication link.
- In-unit heaters to prevent freezing.
- Full zoom/pan/tilt CCTV camera functionality.
- TOC operator workstation screens capable of viewing any CCTV camera images.
- CCTV scanning capability between all cameras.
- Color monitoring displays within the TOC.
- Taping capability for each CCTV camera.
- CCTV camera link-up with TV stations.

Summary - Overall, data collection sources will be one of the most important components of the Denver TOC. CDOT should compare its data collection needs to the competing and emerging technologies which exist in today's market. These technologies include inductive loop detectors, RTMS, magnetometer, ultrasonic, conventional radar and video image processing.

CDOT's required measurement capabilities for data collection will likely include the following:

- Passage (volume counts).
- Presence.
- Occupancy (lane).
- Speed/direction of Motion

- Queue length.
- Range, or distance to a vehicle, for headway determination between vehicles.

CDOT should investigate each vehicle detection system on its potential cost-effectiveness (i.e. effectiveness and life-cycle cost) as defined in terms of the following:

- Purchase price (per lane or other measurement location).
- Performance (variables measured, accuracy, repeatability, sensitivity to environment, etc.).
- Communications requirements, availability and cost.
- Availability (mean time between failures plus mean time to repair).
- Installation requirements (complexity, convenience, cost, etc.).
- Maintenance requirements (complexity, convenience, cost, etc.).

The search for the ideal vehicle detection system has been going on since the installation of the first activated traffic signal control system many years ago. The ideal detection system would be inexpensive, easy to install and maintain, long-lasting and would monitor traffic conditions accurately and reliably In reality, however, the choice of a detector often represents a trade-off of functionality and cost. A key challenge is therefore to develop control systems which function effectively with less than perfect data, possibly from a variety of sources.

2.3 Incident Management

One of the COMPASS program's main functions is in the area of incident detection. COMPASS operators use the information from the inductive loop detector stations and CCTV cameras to respond quickly to traffic congestion and emergencies as they arise.

Detection/Verification

The COMPASS program uses the following data sources for its detection/verification efforts:

- Inductive loop detection stations.
- CCTV cameras.
- Provincial Emergency Road Patrol Service (ERPS).
- Ontario Provincial Police radio.
- News Agencies' reports (e.g., radio, TV, print, etc.).
- MTO maintenance radio.

The COMPASS program does not use an emergency phone call box service for incident detection. However, MTO has indicated that a cellular phone service is to be introduced shortly. Since there is a high concentration of cellular telephone users in southern

Ontario, this service has the potential to provide a good source of incident detection and emergency aid. Although some private-sector initiatives have been undertaken, a comprehensive service has yet to be initiated. Such a service would have significant operating costs; MTO is investigating a pilot project with at least partial corporate sponsorship. However, MTO does not foresee a specific operator for this activity within the COMPASS Operations Center. Therefore, a communication link from the COMPASS Operations Center to this cellular phone service location.

The COMPASS program makes extensive use of its inductive loop detector stations in identifying incidents on its freeway system. It operates the California Comparative Type Incident Detection Algorithm which identifies a potential incident within approximately 2-5 minutes of an occurrence. At one of the graphical workstations, the system brings up a red circle on a display map to indicate the area or location of a potential incident or accident. In addition, the incident detection screen displays a flashing red "INCIDENT" indication and automatically types the incident time and location on the screen.

To assist in incident detection and verification, the COMPASS program makes use of an automated expert system capability. Within the graphical system display map, the software indicates the location of the potential incident as outlined above. The software also allows the operator to click on the nearest detector station which presents the numbers of the nearest CCTV cameras for rapid verification. Currently, since the COMPASS program involves only 19 CCTV cameras, the operators have indicated that they do not use this function since they are familiar with the cameras' locations. However, they also indicated that this function would be more useful when CCTV coverage expands.

Response

In the event of an incident, the COMPASS operators contact the appropriate authorities for response action. Depending on the nature of the incident, the operators contact one or more of the following agencies:

- Toronto Metropolitan Police.
- Ontario Provincial Police.
- Emergency Road Patrol Service (ERPS).
- Fire departments.
- Ambulance services and hospital authorities.
- MTO maintenance crews.

The goal of the COMPASS program is to dispatch an appropriate response in a timely manner, time is of the essence. Efforts are underway to develop a sense of urgency among the operations staff and promote a vigilant, proactive atmosphere.

In addition, the COMPASS program has the ability to store data on incident detection occurrences and their associated response plans for both one week and one month periods. This digitally based CD-ROM storage permits an easy search of information for consistent operator reference. This type of historical database reference allows for review of previous experiences, supporting consistent and appropriate response whenever an incident may occur.

Clearance

In Toronto, timely removal of an incident is accomplished by the appropriate agencies listed above. The Ontario Provincial Police (OPP) have jurisdiction over provincial freeways and are actively involved in all aspects of incident management. Most police cruisers are equipped with push bumpers and lighted arrow boards.

There is no full-time police presence in the Operations Center, however, a light-duty constable may be stationed in the facility to serve as a liaison with police dispatchers and to provide police authorization in certain situations. Additional police support may be temporarily transferred to the Operations Center in the event of severe incidents. Police personnel are key players in managing a large proportion of incidents, and their response time is critical to the success of the incident management effort. In addition, accident investigation sites are being developed off the freeway to minimize rubbernecking by passing motorists and to maximize safety.

MTO employs its Emergency Road Patrol Service (ERPS) to provide a fast and flexible clearance effort for many incidents. ERPS vehicles are equipped with push bumpers, gasoline, booster cables, fire extinguishers, lighted arrow boards and other simple tools for quick clearance strategies. These vehicles patrol a regular mute and can also be dispatched by the Operations Center. This service can handle most minor incidents and provides traffic management assistance to police during major incidents.

The COMPASS Operations Center utilizes a speed-dial telephone link to both the OPP and ERPS control stations. MTO indicated this method was preferred over a dedicated telephone line because the dedicated line could possibly go down. With speed-dial service, no matter how busy the phone network is at the moment, completion of the call is assured.

Private towing vehicles have free access to Highway 401 and generally provide prompt (but sometimes expensive) service. MTO uses dedicated or on-call contract towing in certain situations, such as in constricted construction zones or where a motorist refuses to move a vehicle. MTO recently organized a 24-hour voluntary dispatch service with the heavy towing companies for removal of large trucks, tractor trailers, etc. However, for normal towing needs, MTO indicates that it will continue with the current first come, first serve tow truck service and will not pursue private contract tow arrangements.

Recovery/Motorist Advisory

Proper traffic management can reduce the impact of an incident and provide a safer environment for response teams and motorists. In Toronto, most traffic management efforts are conducted by OPP. This is the agency responsible for redirection of traffic at the site of the incident. OPP and ERPS first-response units are equipped with appropriate traffic control devices as described previously.

MTO maintenance staff has an important role to play in providing clean-up and major traffic control services. In the past, standard work schedules meant that maintenance staff were not readily available before the morning or during the afternoon peak. MTO is now experimenting with staggered hours for some key equipment operators.

To minimize the traffic impact of an incident, motorists must be supplied with timely, accurate, and useful information. Such information might allow them to avoid the problem area by selection of an alternate route, or at least will lessen their chances of being involved in a rear-end collision on arriving at the traffic queue.

The COMPASS program uses 13 Variable Message Signs (VMS) located upstream of strategic diversion points. The COMPASS central computer recommends a specific set of signs and messages based on the location and nature of the incident. The operator must review and approve the response plan before the messages are sent out to the signs.

For incidents of prolonged duration, MTO is considering the deployment of portable VMS units at key diversion points. MTO has several of these signs and is developing strategies for rapid mobilization and effective message presentation.

In addition, the COMPASS Operations Center Staff maintains a Traffic and Road Information System (TRIS) covering all provincial highways and freeways within the Toronto district. Both scheduled and nonscheduled incident information (e.g., construction, maintenance, accidents, breakdowns, etc.) is entered into a database. Traffic reports are automatically sent by facsimile to the media on both a regular and an emergency basis. The traffic reporting media can be an effective tool for communicating with motorists, highlighting the benefit of a productive relationship with this group.

An effective recovery/motorist advisory strategy not only encourages diversion and driver vigilance, it also reassures the traveling public that the responsible agencies are aware of and responding to the incident,

Benefits

A recent study by MTO estimated that implementation of a freeway traffic management system, combined with effective incident management response, has resulted in the following benefits:

- 75% reduction in delay related to nonrecurring congestion.
- 20-30% reduction in the number of accidents.
- 10 -30% reduction in delay related to recurring congestion.
- Marked reduction in incident response time.

A reduction in congestion saves time and money and reduces accident potential, driver frustration, pollution emissions and gasoline consumption.

Incident Management Summary

Incident management is a key element in the successful operation of freeway traffic management systems. MTO's use of the COMPASS program in this capacity has significantly improved travel conditions in the Toronto Metropolitan Area. Desirable characteristics of the COMPASS program's incident management efforts which can be considered for inclusion within the Denver TOC's activities include the following:

- Detection/Verification
  - Inductive loop detector stations

- CCTV cameras
- Emergency Road Patro1 Service (Courtesy Patrols)
- Police department radios
- Maintenance crew radios
- News Agencies reports (e.g., radio, TV, print, etc.)
- Cellular phone service
- Incident detection algorithm
- Expert System (incident detection to CCTV camera location)

• Response
  - Police departments
  - Emergency Road Patrol Service (Courtesy Patrols)
  - Fire departments
  - Ambulance services
  - Maintenance crews
  - Storage of incident occurrences and associated response plans

-Clearance
  - Specially equipped police department vehicles
  - Specially equipped Emergency Road Patrol Service vehicles
  - Speed-dial telephone service

• Recovery Motorist Advisory
  - Specially equipped police department vehicles
  - Specially equipped Emergency Road Patrol Service vehicles
  - Maintenance crews (with staggered work shifts)
  - VMS displays
  - Automatic communication with media (e.g., TRIS)
  - Alternate muting schemes.

Significant benefits can be produced by a freeway traffic management system coupled with an effective incident response program. Some measures can be introduced without significant increases in capital or operating budgets. Many of the more sophisticated measures will require a major ongoing budget commitment. Technology and techniques are valuable, however, equally important are interagency cooperation, an openness to innovation, and an appreciation of the overall value of reduced motorist delay.

2.4 Traveler Information

VWS Displays

The primary method of disseminating traveler information to the motoring public within the COMPASS program is by the use of VMS displays. The following list provides an outline summary of the system's VMS characteristics:

Number of VMS units	13
VMS location	Upstream of strategic diversion points
VMS size	42' (W) x 10' (H)

VMS display type	Light emitting diodes (LEDs)
VMS information type	Traffic/incident information
VMS communication type	Fiber optics
VMS costs (USA)	
- Sign	$250,000
- support structure	$85,000

The COMPASS program's 13 VMS displays are strategically located upstream of potential diversion points. These VMS displays are primarily located along the COMPASS coverage mute of Highway 401, as well as other local connecting highways and arterials.

To inform motorists of upstream highway conditions, operators key in traffic information for presentation on the VMS displays. The COMPASS VMS units have the ability to display current traffic/incident messages. The COMPASS central computer recommends a specific set of signs and messages based on the location and nature of the incident. The operator must review and approve the response plan before the messages are sent out to the appropriate signs.

The messages given in incident situations indicate the traffic conditions which lie ahead (e.g., "Express Lanes Blocked Beyond Yonge Street"). However, no recommendation is made concerning alternate route selection. Alternate routes are chosen individually at the driver's discretion. When traffic/incident information is not required, the VMS displays are easily changed to indicate upcoming exits.

The COMPASS VMS displays have the abiity to operate on a tune-of-day (TOD) schedule (e.g., message #3 on sign #2; on at 10 a.m., off at 3 p.m.). However, COMPASS operators indicate that they do not generally use this feature because there is greater control associated with manual operation

All COMPASS VMS display messages are stored in a message database. This contains the only displays which are allowed on the COMPASS signs. COMPASS operators have indicated that they would like more flexibility in determining the information presented on the VMS units. In essence, they would like to be able to manually type in informational messages for display which specifically reflect current traffic/incident conditions. However, COMPASS management is concerned that this operator flexibility would lead to inconsistent VMS displays that would create confusion among the motoring public.

Both COMPASS operators and management have indicated that efforts should be made to increase the number of messages in the VMS library to more accurately reflect traffic/incident conditions. By the end of 1992, MTO officials expect to have an operating expert system which will automatically send traffic/incident information reports to the appropriate VMS displays. In the near future, MTO officials have also indicated that the VMS response system will be enhanced to include not only traffic/incident information, but also general congestion information.

The COMPASS VMS units are capable of displaying three lines of text using low-maintenance LED displays, which provide good visibility under most conditions. Each LED character within the VMS unit is composed of 55 green and 9 red colored diodes. This combination provides a variety of color schemes to choose from in selecting an optimal display for current environmental conditions. The VMS units can display lines of text across the entire message area. At each end of the VMS unit, 1/4 of the full display area is also capable of presenting graphics. In addition, the sign is capable of displaying both dynamic and static messages. Due to the heat emitted by the LEDs, fans were installed to cool the VMS equipment in the summer to prevent overheating. The heat emitted by the LEDs is sufficient to prevent freezing conditions from impairing operations in the winter.

Traffic and Road Information Service (TRIS)

The COMPASS Operations Center staff operates the TRIS system covering all provincial highways and freeways within the Toronto district. Details on this service are included in the previous section.

Highway Advisory Radio (HAR)

At this time, the COMPASS program does not utilize Highway Advisory Radio (HAR) among its traveler information dissemination techniques. MTO is currently in the initial stages of trying to secure a frequency for HAR use with the opening of the new upper portion of the AM radio band. In conjunction with this effort, MTO has also expressed interest in developing an expert system which would automatically send traffic/incident HAR reports to the motoring public.

Traveler Information Summary

characteristics of the COMPASS program's current or proposed traveler information dissemination systems which can be considered for inclusion within the Denver TOC design include the following:

- VMS displays
  - strategically located signs along both the freeway and arterial road system
  - traffic/incident information as well as general congestion information
  - Expert System (incident detection to appropriate VMS display)
  - fiber optic communication link

- TRIS
  - TRIS database containing scheduled incidents (e.g., construction, maintenance, etc.) and nonscheduled incidents (e.g., accidents, breakdowns, etc.)
  - Information automatically sent to media on both a regular and an emergency basis

- HAR
  - HAR reports on AM band
  - Expert System (incident detection to appropriate HAR reports).

2.5 COMPASS Operations Center

The COMPASS Operations Center provides a focal point for multi-agency traffic management and incident response efforts in the Toronto Metropolitan Area. In the previous sections, details concerning the COMPASS program's data collection system, incident response plans, and traveler information techniques were presented to provide a view of the program's operational capabilities. The Operations Center controls these capabilities, receives all road condition, construction, and maintenance activity reports and serves as MTO's District 6 radio room. All of these efforts rely on the Operations Center's abiity to assimilate data in a reliable, comprehensive manner in order to provide timely, accurate response actions and traffic/incident information to the motoring public. The following discussion provides a summary of some of the COMPASS Operations Center's characteristics.

Hours of Operation

The COMPASS Operations Center monitors traffic conditions and initiates incident response plans 24-hours-a-day, 7-days-a-week.

Staffing/Personnel

Operations within the COMPASS program are perfonned by a variety of staff personnel with a range of functions and responsibilities. Primarily, these functions relate to all aspects of vehicle information collection and incident response programs, along with their associated traveler information dissemination efforts. The following list provides an outline summary of the staffing positions found within the COMPASS operations command center during peak hours:

- (1) COMPASS program supervisor.
- (2) COMPASS program operators.
- (2) radio operators.
- (1) Traffic and Road Information System (TRIS) operator.
- (1) OPP officer (occasional, or as-needed during incidents).
- (1) COMPASS systems/operations analyst.
- (1) construction crew liaison (during construction season).

In addition, the COMPASS program utilizes a support staff which consists of one COMPASS Program Supervisor/Operations Chief, three systems engineers, and three traffic engineers.

COMPASS management officials indicated that each Operations Center staff member received 100 hours of training on the COMPASS system. This training was jointly provided by MTO and the Ministry of Labor.

COMPASS staff members are employees of MTO's District 6. However, it is worth noting MTO's dissatisfaction with this arrangement. This stems from the fact that MTO Headquarters developed the COMPASS Operations Center and associated hardware and software equipment, while District 6 operates the system. MTO Headquarters apparently would have preferred to operate the COMPASS .program with its own personnel.

COMPASS Control Center Layout

The COMPASS program's control center is the hub of its Toronto Metropolitan Area operations. Its layout is intended to provide a location of sufficient size and utility to allow participating agencies to coordinate and manage all aspects of the COMPASS system. Overall, the COMPASS control center occupies approximately 2,500 square feet of space. Some specific areas are identified in the following discussions.

COMPASS Supervisor Workstation - The COMPASS supervisor's workstation is an elevated, U-shaped workstation located in the middle of the control center. This workstation contains the following features:

- Interactive keyboard communication with central COMPASS computer.
- CCTV control and video switching.
- Telephones with speed-dial service.
- Automatic incident detection alarm.
- VMS equipment control.
- (3) CCTV monitoring screens.
- (1) color CRT for graphical information displays.
- (2) color CRTs for textual information displays.

COMPASS Operator Workstations - The COMPASS operator workstations are located in a large, semicircular formation at the front of the control center. Each operator workstation is 9 feet in length and contains the same features as the COMPASS supervisor workstation described above. There are three operator workstations within the control center, which are manned by the two COMPASS operators and the OPP officer.

Radio Operator Workstation - The radio operator workstations are located in a wide, elevated, V-shaped formation at the back of the control center. The two (2) radio operator workstations contain the following features:

- IBM PC-type computer with keyboard and monitor.
- Radio transmitter and receiver control panel.
- Telephones with speed dial service.
- CCTV control and video switching.
- CCTV monitor screen.

TRIS Operator Workstation - The TRIS workstation is located in the back of the control center. The 4-foot-long workstation contains the following features:

- IBM PC-type computer with keyboard and monitor; and
- fax machine.

Systems Analyst and Construction Liaison Workstations - These two workstation areas are located at opposite ends of the semicircular COMPASS operator workstations. The 4-foot-long workstations did not contain any equipment but did provide a work space for these positions. MTO indicated that since the construction liaison is only present during construction season there was no reason for an extensive workstation setup. In addition, MTO indicated that the systems analyst works primarily in a separate office area. When the systems analyst needs to use the COMPASS equipment, access is provided to one of the COMPASS supervisor or operator workstations.

CCTV Monitors - The COMPASS control center currently contains 54 CCTV monitor displays located in a semicircular fashion at the front and sides of the control room. This positioning allows for easy viewing by all staffing positions within the control center. The monitors display monochrome images, however, MTO indicates that these will be replaced with color CCTV monitor displays. Within the control center, the design is such that MTO could expand the number of CCTV monitors to 90 by continuing the semicircular formation on both sides.

System Display Map - The COMPASS control center contains a large, static system display map located above the CCTV monitor displays at the front of the room. This map displays an accurate depiction of the COMPASS system road network. All express lanes, collector lanes, interchanges, etc., associated with Highway 401's COMPASS coverage are displayed. However, MTO officials stated that this map is not generally used because it provides little useful information. Their preference is for a new system display map of a dynamic nature. This would display real-time speed, volume, and occupancy information per system segment as well as indicating potential incident locations.

VMS Display - A unique feature of the COMPASS control center is the inclusion of a VMS display unit This unit is 6 feet (W) by 2 feet (H) and is a scaleddown model of the VMS equipment used in the field. This allows the COMPASS operators to test VMS informational messages without using one of the 13 field VMS units. MTO officials indicated that they do not want to confuse the motoring public by flashing test messages in the field The test VMS is located at eye-level on the left side of the control center.

Control Center Summary - MTO officials indicated that, overall, they are pleased with their control center layout. However, they noted a few detailed areas they would change if given the opportunity:

- The 9-foot-long operator workstations are too long and too spread out. MTO indicated that the U-shaped supervisor workstation seems to work better because the equipment is more easily within the operator's reach.

- MTO indicated that the elevation of the supervisor's workstation is not ideal. Since this workstation is in the middle of the room, this elevated position creates too much distance to allow easy communication between the radio and system operators. These positions coordinate their work efforts more closely than originally anticipated by MTO.

- There are too many CCTV monitor displays within the control center. The monitors display multiple images from the same camera sources which is not efficient use of space and equipment.

COMPASS Conference Room

The COMPASS program has included a conference room to one side of its control center. This room provides an area for training sessions, public observation activities and emergency operations coordination. An interactive operator's workstation is located in the conference room to provide convenient direct operator interface during emergency situations as well as for training exercises and visitor viewing. The conference room also contains CCTV video control and switching equipment. The CCTV camera displays can be shown on a monitor screen or on a large, portable projection screen. In addition, the large projection screen is used by OPP officers to view videotaped CCTV camera images.

COMPASS Program Software

MTO officials indicated that the COMPASS program is operable using Powerhouse and FORTRAN software capabilities. MTO is responsible for modifying and updating the COMPASS software, having developed the initial design in-house. This software operates the local area network (LAN) which runs the COMPASS program and allows for communications between the operators' interactive keyboards and the COMPASS central computer.

The software used for the COMPASS program's graphical interface is a package called DataViews. This was jointly developed by Delcan and the VI Corporation. The software package used for the COMPASS program's graphical display features was developed by the National Engineering Technology (NET) Corporation. NET's software allows for a dynamic, real-time graphical display of speed, volume and occupancy information along the COMPASS program's coverage.

These graphical displays show the inductive loop detection station locations, VMS unit locations and CCTV camera locations. For each of these locations, the graphics also illustrate the system's current status (e.g., on-line, off-line, equipment failure, etc.). In addition, the graphics bring-up a red circle to indicate the area or location of a potential incident or accident. Within these graphics, the COMPASS operator can click on the detection station adjacent to this incident indication to display the number of the nearest CCTV cameras.

The COMPASS program's graphic facilities are broken down into three segments, which include separate eastbound and westbound displays, within the system. For each eastbound or westbound segment, colored speed, volume, and occupancy bar graphics are illustrated corresponding to each detector station location. For each of the speed, volume, and occupancy displays, a green display indicates the best scenario, a yellow display an intermediate condition, and a red display the worst condition as related to each of these vehicle characteristics. MTO is extremely pleased with this informational display and hopes to place this type of information on a new, dynamic system display map.

Another feature of this graphical display involves the VMS equipment. Within each eastbound or westbound segment, the software can display the messages which the VMS units are showing. This feature allows the COMPASS operators to quickly verify that the VMS informational messages are both accurate and up-to-date.

Location

The COMPASS Operations Center is located adjacent to Highway 401. Since the COMPASS program is primarily concerned with freeway traffic management and incident response plans, MTO officials feel that this location provides easy system access for maintenance crews, incident response teams and communications links.

Cost

MTO management officials provided a brief estimate of some of the costs they have incurred and maintain as a result of implementing the COMPASS program. The following outline provides a summary of these estimated costs in U.S. dollars:

• VMS display units (13)	
- sign	$250,000 each
- support structure	$85,000 each
• microwave detection units	
- initial	$4,000 each
- widespread deployment	$2,000 each
• field equipment and communications (w/o VMS)	
- initial	$1,500,000 per mile
- expansion	$1,375,000 per mile
• associated hardware and software	$1,700,000
• COMPASS operating costs	$940,000 per year.

Public Awareness Program

For the COMPASS program to be truly effective, it needs the support of the motoring public. Before the official start of the program, MTO initiated a 7-week advertising effort using local radio stations and newspapers. In addition, MTO held an open house for the public to come and view the COMPASS Operations Center. They received over 2,000 visitors.

Continuing efforts to make the motoring public aware of the COMPASS program lie in the VMS display units and media traffic reports. Timely, accurate and reliable information will reassure the traveling public that the responsible agencies are addressing freeway management needs. The public's awareness of the COMPASS program's activities and the benefits they receive from these efforts should increase support for continuing expansion of the COMPASS system.

Future COMPASS Activities

The COMPASS program intends to expand its system coverage and enhance its current operations in the following manner:

- Extensions of the current Highway 401 COMPASS system are currently under design. Planning is underway to extend the system to include most of the freeway network in the Toronto Metropolitan Area.
- Introduction of HAR reports.
- Implementation of a cellular phone call-in service to report incidents, accidents, breakdowns, etc.
- The addition of general congestion information to the VMS displays.
- Deployment of ramp metering along newly-constructed interchanges.
- Implementation of lane control signing.
- Freeway and arterial coordination (e.g., signal timings, traffic information sharing, CCTV displays, etc.).
- Introduction of new expert systems (e.g., incident detection will automatically generate appropriate HAR and VMS reports).
- Deployment of dynamic route guidance technologies.

COMPASS Operations Center Summary

The COMPASS Operations Center provides many desirable characteristics which can be considered for inclusion within the Denver TOC design. Some of these are addressed within the following discussions:

(1) An effective Traffic Operations Center should operate 24-hours-a-day, 7-days-a-week and provide (at a minimum) traffic management, incident response, and traveler information service operations.

(2) The COMPASS program's personnel/staffing positions descriptions are broadly in line with the Denver TOC's initial requirements. However, a construction crew liaison does not seem necessary within the center itself. The number of staff for the Denver TOC positions will depend on the functional requirements identified.

(3) The 2,500 square feet of control center space seems appropriate for the Denver TOC's initial plans.

(4) The COMPASS operator and supervisor workstations contain feature possible inclusion in the Denver TOC's consoles. The U-shaped workstation provides equipment within easy reach of the operator. The radio operator and TRIS (media liaison) workstations also contain desirable attributes. Never, the 9-foot-long operator workstations should be replaced with U-shaped, consoles and the supervisor's workstation should not be elevated in the middle of the center.

(5) The CCTV camera monitoring displays are in full view of the entire control center staff. These CCTV displays would be easier to interpret if they provided full-color pictures. However, the use of as many as 54 monitor screens appears to be unnecessary. As few as 12 may be sufficient, depending on the number of CCTV cameras.

(6) A conference room should be implemented which contains features similar to those described within the COMPASS Operations Center.

(7) Software which provides similar graphical displays as COMPASS should be implemented within the Denver TOC's workstations and large screen projection displays. However, this software should be designed or purchased to allow the Denver TOC more flexibility when modification or updating is required.

(8) The location of the COMPASS Operations Center near the freeway system is appropriate for its role. In the Denver Metro Area, the TOC will also focus on arterials. A site adjacent to a freeway may still be appropriate, though less critical.

(9) The Denver TOC should promote itself extensively to the motoring public. Advance advertising by TV, radio and newspaper should prepare the public for its implementation. Timely, reliable and accurate traveler information will solidify public support for both initial operations and TOC expansion In addition, public tours should be encouraged so that the public feels that the TOC is their program, not just the govemment's.

(10) Like COMPASS, future activities such as planning for route guidance systems should be included within the Denver TOC's deployment program.

3. *INFORM*

3.1 Introduction

The INFORM system is a comprehensive traffic management and incident response program which operates on Long Island in the State of New York. This system utilizes a number of parallel expressways, parkways and arterials to provide alternate routing schemes when severe congestion or incidents occur. In addition, INFORM is one of the first traffic management systems to actively deploy freeway and arterial coordination.

The INFORM system covers a 35-mile corridor which includes the following road network:

1) I-495/Long Island Expressway: a 6-lane, east-west, freeway.

2) Northern Parkway: a 4-lane, east-west, freeway (no commercial vehicles allowed).

3) Grand Central Parkway: a 4-lane, east-west, freeway.

4) Jericho Turnpike: a 4-lane, east-west arterial with synchronized traffic signal Control.

All major north-south arterials which intersect the roads listed above possess synchronized traffic signal control.

The INFORM system utilizes the following functions in its operational capacities:

- Vehicle information collection (e.g., inductive loops, ramp metering and CCTV cameras).
- Traffic management system.
- Incident response management.
- Traveler information dissemination (e.g., VMS, radio, TV, Shadow/Metro Traffic, etc.).

INFORM's traffic management facilities and incident response program make extensive use of its freeway system and 112 arterial intersections which operate under synchronized traffic signal control. INFORM's comprehensive approach seeks to reduce congestion and motorist delay in one of the country's most heavily traveled corridors.

3.2 Vehicle Information Collection

Inductive Loop Detectors

The Long Island INFORM system utilizes over 2,500 in-pavement, inductive loop detectors in its freeway vehicle information collection efforts. These detectors are positioned at l/3-mile or l/2-mile intervals to obtain vehicle volume and occupancy information. In addition, some loops are placed in tandem per directional lane of travel to obtain vehicle speed information.

The inductive loops also form the backbone of INFORM's ramp metering system. INFORM makes dual use of these loops to control access along its freeways with the on-ramps in each direction. INFORM estimates that $45 million per year is saved in terms of motorist delay and congestion by its extensive use of ramp metering.

INFORM uses Type 170 controllers for its inductive loop and ramp metering efforts. These controllers communicate 4 times per second with the loops to gather vehicle information. The controllers then format the data into l-minute increments for easy polling from the INFORM Traffic Operations Center. Currently, INFORM uses a direct, coaxial cable link as its communications medium. INFORM personnel indicated that they are going to update to a fiber optic communications link in the near future. A further planned modification will implement a circular communications system due to its increased continuity and redundancy capabilities.

INFORM personnel indicated a desire to reduce the system's dependence on inductive loops. They cited the loops' reliability (l0-20 percent failure rate), maintenance (need to close travel lanes) and the emergence of new vehicle detection technologies (e.g., microwave, spread spectrum radio, infrared, etc.) as reasons for this opinion INFORM appears to be leaning toward infrared sensor technologies in the vehicle information collection area. Operating staff were attracted by its diversity in obtaining vehicle information (e.g., location, weight, passenger occupancy, emissions, etc.) by the use of vehicle registration tags.

CCTV Cameras

INFORM also makes use of CCTV cameras in its data collection efforts. CCTV cameras are located at strategic locations along the freeway to provide an overall view of traveling conditions. INFORM personnel indicated that there are gaps in this CCTV coverage, and they would like to install additional cameras for a more complete viewing network

INFORM's CCTV cameras possess full zoom/pan/tilt functionality which is operator controlled from the Operations Center. These CCTV cameras possess a 10:l zoom ratio and operator-selected time scanning capabilities. Within the Operations Center, the CCTV monitor screens can be divided into 4 quadrants to enhance this scanning capability. INFORM operators have indicated that they find both the scanning and split-screen viewing capabilities of their CCTV system useful. In addition, operators indicated that they would like an expert system which would allow an incident detection algorithm to identify the closest CCTV cameras for incident verification and coverage.

Summary

The Denver TOC design should make use of the INFORM program's experience in data collection efforts. INFORM's use of inductive loop detectors, ramp metering, and Type 170 controllers closely parallel the current conditions which exist in the Denver Metro Area. This supports the concept that, initially, Denver should make extensive use of its current system and enhance its abiities when necessary. Denver, like INFORM, should also consider fiber optic communications as well as emerging vehicle detection technologies.

3.3 Incident Response Management

INFORM possesses a comprehensive incident response program. INFORM operators use the information from its data collection sources to respond quickly to traffic congestion and emergencies as they arise.

Detection/Verification

INFORM uses the following data sources for its incident detection/verification efforts:

- Inductive loops.
- CCTV cameras.
- New York State Police patrols.
- New York Department of Transportation maintenance crews.
- Commuter Assistance Teams (CATS).
- Media reports (e.g., Shadow/Metro Traffic agencies, radio, TV, etc.).
- *911 telephone service.

INFORM does not use an emergency phone call box service for incident detection. INFORM management officials indicated that neither they nor the State Patrol are in favor of implementing such a service.

Along the Long Island Expressway, the CATS courtesy patrol service (similar to the Chicago Minutemen) is responsible for monitoring traffic conditions and assisting motorists in need. The CATS emergency response teams are a special group of DOT maintenance workers employed by New York State. These crews work staggered shifts (4:00 a.m. to 12:00 p.m. and 12:00 pm to 7:00 p.m.) to provide both morning and evening rush hour coverage. During any one shift, CATS has five people on duty. Three people are assigned to the patrols while two others are responsible for dispatching duties.

New York State Police patrols are responsible for providing incident detection services along INFORM's parkways. Although there is no State Patrol liaison inside the INFORM Operations Center, INFORM operators communicate directly and frequently with the police as well as monitoring the State Patrol radio broadcasts.

Response

In the event of an incident, INFORM operators contact the State Patrol or CATS patrols depending upon its severity. INFORM does not possess any police, CATS or maintenance dispatching capabilities within its Operations Center. Rather, it is the responsibility of the State Patrol or CATS to call in the appropriate response personnel (e.g., fire department, paramedics, ambulance/hospital, etc.) if they require support

INFORM does not maintain direct communications lii with the CATS patrol vehicles in the field. INFORM must contact the CATS dispatcher to advise the vehicles of a potential incident. It is then the CATS dispatcher's decision to give the patrol vehicles any specific directions. INFORM personnel noted that the CATS dispatchers often do not report incidents to their patrol vehicles, because they expect the vehicle to arrive at the incident scene just as fast within its normal patrol route.

Clearance

On Long Island, timely removal of an incident is accomplished by the appropriate agencies noted above. State Patrol personnel are key players in managing a large proportion of incidents, and their response time is critical to the success of the incident management effort The CATS vehicles assist the State Patrol in major incident response procedures. CATS vehicles are equipped with gasoline rations, push-bumpers, phones, etc., to handle most minor incidents. INFORM personnel indicated that interagency communications during both the response and clearance phases are the key to successful incident management. They insist that these capabilities be used to their fullest extent before any other approach is taken.

Recovery/Motorist Advisory

Proper traffic management at the scene of the incident is the State Patrol's responsibility. These efforts are assisted by the CATS patrols. Motorist advisory features deployed by INFORM are outlined in the following discussions.

Variable Message Signs - The backbone of the INFORM program's motorist advisory efforts is their VMS displays. INFORM utilizes 96 VMS units (plans to expand to 108 are in progress) over the freeway and arterial road network. INFORM deploys a three-tiered response plan within its VMS displays:

1) Normal Traffic Conditions. When vehicle speeds are greater than 30 miles per hour (mph), INFORM operators display a motorist advisory message which reflects these conditions (e.g., "Normal Traffic Ahead," etc.). In this scenario, it is up to the motoring public to choose a route depending on their familiarity with the corridor's "normal" traffic conditions.

2) Advisory. When vehicle speeds are less than 30 mph, INFORM operators display an advisory message which tells the motoring public of an upcoming delay (e.g., "Delays Exits 46-49," etc.). The travelers are advised of upstream traffic conditions and have the choice and ability to select an alternate route. Consideration and choice of an alternate mute depend on user familiarity and knowledge of alternatives. INFORM officials estimate that 20 percent of motorists choose alternate routes when they view an advisory display.

3) Control. INFORM operators display a control message when they determine that an incident will cause over 15 minutes of delay to the approaching vehicles. These messages advise the motoring public of a preferred alternate route (e.g., "Use Northern Parkway - Long Delays Ahead," etc.). Motorists can then choose whether or not to follow this advice.

Media Advisory Messages - In addition, the INFORM program sends traffic advisory messages to the news media agencies. Recipients include Shadow and Metro Traffic reporting services, radio stations and TV stations. Every 15 minutes, traffic reports are automatically sent by fax to the media to provide traveler and incident information.

Incident Management Summary

INFORM's incident management plan has many desirable features. Within its detection/verification phase, all of its incident detection sources am reliable, although operating staff indicated some dissatisfaction with inductive loops. An emergency phone call box service can also be evaluated for inclusion in Denver. Within both the response and clearance phases, the agencies involved in INFORM are appropriate and broadly similar to those that would operate in the Denver Metro area. However, dispatching positions for the State Patrol, courtesy patrols, maintenance crews, etc., should be housed within the Denver TOC.

INFORM's motorist advisory system is comprehensive in both scope and coverage. The three-tiered motorist advisories are an appropriate idea for consideration in the Denver Metro Area, The approach allows for the proper level of response by both the operating agency and motorists. These types of advisory displays are well suited for VMS as well as other communication media (e.g., HAR, RDS-TMC, etc.). In addition, INFORM's use of an automatic fax communications with the media to report traffic conditions represents a simple method of information dissemination which can be included within the Denver TOC.

3.4 Traveler Information Dissemination

VMS Displays

The primary method of disseminating traveler information to the motoring public within the INFORM program is by the use of VMS displays. INFORM makes extensive use of its 96 VMS displays within the corridor. INFORM's VMS displays are strategically located along its freeway and arterial road network to provide traffic information at potential diversion points.

INFORM uses Telespot Flip-Disk VMS displays of varying size within its system. Operating staff indicated that some of these signs are being enhanced with LED and fiber optic capabilities for better visibility. The VMS displays' clear, lexon plexiglass covers are also being replaced after 10 years due to degradation caused by ultraviolet radiation.

Traffic information messages for the VMS displays are generated by the INFORM operators. The operators have total VMS message generation capabilities, within the text length limits imposed by the signs They have the flexibility to generate unique messages within all levels of the three-tiered (normal, advisory, control) traffic message hierarchy.

This flexibility allows the INFORM operators to relay specific details to the motoring public when needed. The operators at INFORM like the ability to create VMS traffic advisory messages, and INFORM management has not received complaints about inconsistent or confusing VMS displays.

INFORM also contains a computer-generated library database of VMS messages. During "normal" traffic conditions, INFORM operators may display safety messages (e.g., "wear your seatbelt," "don't drink and drive," etc.). INFORM officials indicate that they do not wish to leave the VMS display blank - a message should always be displayed. It was explained that telephone calls from motorists who thought the signs were not working when they were not displaying any messages had led to this policy. INFORM officials also advised that the VMS displays be deployed as the final component of system implementation. They cited public perception of VMS displays without messages as tax dollars being wasted on expensive, high-tech equipment that does not work.

Media Liaisons

INFORM utilizes the traffic reporting services of a number of commercial traffic information companies. Information from INFORM is automatically faxed every 15 minutes to these companies for broadcast to their listening audiences. INFORM charges an annual fee for the traffic information supplied. In addition, firms such as Shadow and Metro Traffic deploy their own aircraft to gather traffic information, and provide this data to INFORM. This two-way exchange between the media and INFORM allows for timely, accurate and reliable traveler information to be received by the motoring public.

Traffic information is also faxed every 15 minutes to some radio stations. INFORM personnel reported that some radio stations have even broadcast "live" traffic reports directly from the Operations Center. Each radio station pays INFORM an annual fee for the traffic information supplied.

A 24-hours-a-day cable TV news station has recently purchased the ability for a video feed hook-up to the INFORM Operations Center. This video feed can show live CCTV images (INFORM-selected), system-wide speed graphics display and other INFORM system graphical map updates (e.g., volume, occupancy). The cable TV station installed the necessary hardware and system interconnects for this video feed pick-up. INFORM officials are enthusiastic about this venture because it provides prime time TV air coverage.

In a similar initiative, INFORM has recently begun dissemination of its system-wide speed graphics display to 24 interested organizations (e.g., AVIS, Hertz, etc.). These organizations pay INFORM $200 per year for a dial-up connection. INFORM personnel indicated that most of these organizations install monitors at their work locations to advise employees and customers of traffic conditions on Long Island.

Traveler Information Summary

The Denver TOC is expected to include VMS displays at strategic locations, possibly near preplanned diversion routes. However, careful consideration should be given to the exact type and number of signs implemented and the value of their location. Experiences from Toronto and Long Island suggest that Denver TOC operators should be given some flexibility to create unique messages on the VMS displays which pertain to specific traffic conditions. Guidelines defining when and how messages are to be generated should be established to maintain message integrity and consistency. In addition, Denver will need to establish a position on what the VMS displays will show during "normal" traffic conditions (e.g., safety messages, "Normal Traffic Ahead," time and date, no message, etc.).

INFORM's relationship with its media liaisons is as comprehensive as it is impressive. The Denver TOC should seek to establish relations with traffic reporting services, radio stations, TV (cable and regular), and interested companies or organizations. These relations not only have the potential to raise revenue but stand to reach a large segment of the Denver Metro Area population They represent a simple, available and user-friendly method of distributing traffic information based on data collected at the TOC.

3.5 *INFORM Operations Center*

The INFORM Operations Center provides a focal point for multi-agency traffic management and incident response efforts on Long Island. INFORM's vehicle information collection system, incident response program and traveler information techniques rely on the Operations Center's abiity to assimilate this information in a reliable, comprehensive manner, in order to provide timely, accurate traffic/incident information to the motoring public. The following discussion provides a summary of some of the INFORM Operations Center's characteristics.

Staffing/Personnel

One of the most unique characteristics of the INFORM program is their contractual arrangement with a private consulting firm to operate the system. During the first five years of operation, the INFORM contract was performed by JHK and Associates. This year, INFORM awarded a three-year contract to Parsons Brinckerhoff for $1,200,000 per year. The INFORM contract was awarded to the private consulting firm which matched the RFP's operational and functional requirements for the best price.

INFORM management officials are extremely pleased with this staffing arrangement. They indicated the following reasons for this position:

1) Entry-level positions. INFORM feels that it is easier for a private firm to hire employees strictly for an entry-level position than a public agency. Prospective public agency employees traditionally seek long-term positions, whereas most private firms' employees are more transient and change jobs more often.

2) Less work time off. Public agencies traditionally allow their employees more holidays and vacation days than private firms. Therefore, there is a decreased need to hire more employees for each staffing position.

3) Employee wages. INFORM feels that a private firm can pay their employees slightly less than a public agency. INFORM indicated that private firms (in the transportation industry) rarely have to contend with labor unions and their demands.

4) Employee termination. INFORM believes that it is easier for a private firm to fire an employee than a public agency. INFORM feels that public agencies' contain bureaucratic entrenchment which make it difficult to terminate a staffing position.

In addition, INFORM awards its system maintenance contracts to outside private firms. These system maintenance contract awards are worth $2,300,000 per year. These system crews are responsible for maintaining all of INFORM's field equipment (e.g., VMS, CCTV, inductive loops, etc.) and their associated communications links.

INFORM also awarded a $750,000 per year contract to an engineering firm to maintain system integrity. This company is responsible for keeping the INFORM system's operating components in working order; independently, and more importantly, as a complete traffic/incident management system. They recommend modifications and updates that will enhance INFORM's operational capabilities.

Overall, INFORM indicated that they maintain the following staffing arrangements to operate the Long Island system:

- Eight people employed by NYDOT; clerical positions, management/supervisory positions, accounting, etc.
- 16 people employed by Parsons Brinckerhoff; TOC operators, systems analysts, etc.
- 16 people employed by the maintenance contractor.

INFORM Control Center Layout

<u>INFORM Operator Workstations -</u> The INFORM operator workstations are located on a large, arc-shaped table which is located in the front of the control room. There are two operator workstations in this area. Each workstation contains the following features:

- interactive keyboard communication with INFORM computer.
- CCTV control and video switching.
- telephones.
- VMS equipment control.
- (1) color CRT for graphical information displays.
- (1) color CRT for textual information displays.
- police radio monitor.
- (1) printer.

Urban Trafic Control System stations

The INFORM control center contains an area in the right, back corner which houses the Urban Traffic Control System (UTCS). This system operates the 112 arterial intersections which are under synchronized traffic signal control.

Telefax Station

The telefax workstation sits on a table in the center of the INFORM control room. This station contains two fax machines which automatically fax traffic information every 15 minutes to the appropriate parties.

CCTV monitor displays

The INFORM control center contains approximately 15 CCTV monitor displays located on the right side of the control mom. CCTV monitors in this position contain both monochrome and color screens. INFORM plans to replace the monochrome screens with color monitors in the near future. At the front of the control room, above the INFORM operators' heads, two color CCTV monitor screens are located which are capable of split-screen viewing.

System display map

The INFORM control center contains a large, dynamic system display map located at the front of the control mom. This map is approximately 17 feet (H) by 7 feet (H), and is the focal point of the INFORM control center. This map displays an accurate depiction of the INFORM system mad network coverage. All freeway lanes, arterial roads, interchanges, etc., associated with INFORM's coverage are located to scale. In addition, all CCTV camera locations, VMS display locations, and inductive loop speed detector locations are indicated for easy operator reference.

INFORM's system display map is an integral part of its traffic/incident management features. The map contains a colored graphical display of mad conditions on the INFORM network. The INFORM network is broken down into 1/2-mile segments which reflect its inductive loop speed detector locations. This graphical display can show speed, volume and occupancy displays for various operator threshold inputs. However, only one display per threshold can be shown for each segment (e.g., speed display at 30 mph). The system display map will indicate which segments do not meet the operator threshold input by showing these segments in red.

INFORM Software

INFORM officials indicated that the software used to operate the INFORM computer system was written by the Sperry Corporation. Sperry wrote the software 10 years ago in FORTRAN. Since that time, the software was modified and enhanced by JHK during its tenure. INFORM officials mentioned that Sperry also wrote the software used by Virginia DOT in its Northern Virginia Traffic Management System, but that VDOT has not made any software changes.

Under its contract with Parsons Brinckerhoff, the INFORM system has a dedicated systems analyst. This position's responsibility is to update and modify the software used by INFORM. INFORM officials indicate that well-documented software is needed if modifications are necessary to support new applications.

INFORM also contains a graphical display package which presents speed, volume and occupancy displays. For each of these displays, a green display indicates the best scenario, a yellow display an intermediate condition, and a red display the worst condition as related to each of these vehicle characteristics. This graphical display is linked to the cable TV station and the 24 interested organizations.

INFORM Hardware

The INFORM program uses a Perkins-Elmer computer to run its systems operations. INFORM officials indicated that they feel this computer is outdated and that it could be replaced by two or three IBM-type computers.

Location

The INFORM operations center is located in an existing New York State government building in Hauppauge, New York. This location is near both the Long Island Expressway and the Northern Parkway. However, it is not directly on an interchange access point. The Hauppauge location is at the easternmost end of the INFORM coverage area. INFORM officials indicated that they would like the Operations Center to have a central location in regards to the coverage area.

Costs

INFORM management officials provided a brief estimate of some of the costs they have incurred as a result of implementing the INFORM program. The following summary provides an estimate of these costs:

• INFORM operating costs	$1,200,000 per year
• INFORM maintenance costs	$2,3OO,OOO per year
• INFORM systems integrity	$750,000 per year
• INFORM initial construction costs (TOC, field equipment, hardware/software)	$45,000,000

INFORM management officials indicate that they receive roughly 98 percent of their funding from federal and state funds. Initially, federal funds were procured as INFORM was considered an IVHS demonstration project. Currently, INFORM receives funding support from the NYDOT to handle its annual costs.

Benefits

INFORM management officials provided a brief estimate of some of the benefits realized by Long Island motorists as a result of implementing INFORM. They include the following:

- savings of $13.50 per hour per person realized by the reduction in delay/congestion times;
- savings of $1 million per hour by keeping all six lanes open on Long Island Expressway;

- savings of $45 million per year by deployment of ramp metering system; and
- savings of 300,000 hours of delay per year by motorist use of VMS diversion routes.

Revenue Methods

INFORM management officials shared some revenue raising methods. They are as follow:

- User-fee charges. INFORM charges the traffic reporting services (e.g., Shadow, Metro, etc.), cable TV stations, radio stations and interested organizations a separate annual fee for the traffic information it provides.
- VMS adopt-a-sign. INFORM is considering a program which would allow interested organizations to adopt a VMS display. This program would allow the organization to place their logo or advertisements on the VMS support structure. INFORM officials estimate they could raise $4,000,000 per year with this Program.
- Dial-up traffic information. INFORM officials have an idea to allow motorists to access computer-generated HAR reports via the telephone. This program would collect its payments in the same manner as a *900 service.
- Ramp tolls. In combination with ramp metering, INFORM officials would like to install AVI technology for toll collection on its ramps. This could be a fixed price toll or be based on congestion pricing techniques.

Future Activities

INFORM management officials indicated that they have some expansion activities planned for the INFORM system. They are as follow:

- expanding the number of VMS displays from 96 to 108;
- adding HOV lanes in strategic corridor locations;
- adding the Southern Shore Parkway within INFORM's coverage (e.g., loops, CCTV, VMS, incident management, etc.); and
- interconnecting the INFORM TOC with proposed TOC hubs at JFK International Airport, the Bronx, Queens and Staten Island

INFORM Operations Center Summary

The INFORM Operations Center possesses many desirable characteristics for possible inclusion within the Denver TOC design. They include the following:

1) A skilled TOC operations staff knowledgeable on all aspects of the traffic/incident management program.

2) Staffing position or outside agency responsible for systems integrity.

3) INFORM operator workstations' features and characteristics.

4) Facsimile communications with media.

5) Color CCTV monitor screens (capable of split-screen viewing).

6) Large-scale system display capable of speed, volume and occupancy graphics.

7) Software graphical display package which generates speed, volume and occupancy scenarios.

8) Federal and state funding sources.

9) User-fee charges for traffic information.

10) VMS adopt-a-sign.

11) Dial-up traffic information via HAR.

12) Use of HOV lanes in strategic locations.

In addition, INFORM officials indicated that the following ideas be taken into consideration when designing the Denver TOC:

- Obtain professional architectural abiities for TOC design and layout.
- Implement noise control techniques.
- Deploy proper lighting strategy.
- Segregate control center from other tasks.
- Position other tasks in rooms with glass overlooks to control center.

4. METRO TORONTO SCOOT DEMONSTRATION PROJECT-

Metro Toronto is currently implementing a SCOOT demonstration project for traffic signal control. SCOOT, meaning “Split, Cycle and Offset Optimization Technique” is an off-the-shelf computerized traffic signal control system that provides real-time traffic adaptive control (TAC) on a signal-cycle-by-signal-cycle basis. SCOOT seems to be a significant enhancement over the operation of traditional first-generation-type traffic computer systems implemented previously in North America. First-generation systems operate with predetermined signal timing plans stored in computer memory that are originally developed off-line based on manual traffic survey counts taken from historical data.This description accurately describes the 1,641 signalized intersections under Metro Toronto’s existing traffic signal control system operation.

By comparison, SCOOT automatically adjusts coordinated signal timings in frequent small increments to match the actual traffic condition on-street. This is accomplished by vehicle detector data being analyzed in real-time by an on-line computer which contains software programs that calculate and implement optimized signal timings to maximize vehicle progression and to reduce congestion. The Metro Toronto SCOOT demonstration project encompasses 75 signalized intersections within three distinctly different operational control areas. The first control area includes 42 intersections within a grid network of the central business district. The second control area includes 20 intersections along a major controlled access arterial route that operates parallel to the Gardiner Expressway. The third control area includes 13 intersections along a major uncontrolled access arterial The three distinctly different control areas were chosen in order to evaluate the benefits of SCOOT under various types of operating and road environment conditions.

The Denver design should carefully consider implementing SCOOT within its overall IVHS program. Previously measured benefits of SCOOT include significant reductions in travel time, overall vehicle delay and fuel consumption. Additional benefits include the availability of comprehensive traffic monitoring data and significant reductions in the staffing effort required for updating fixed timing plans.

In addition, SCOOT has the potential to diffuse the signalized intersection control issue which exists in Denver. Many communities and jurisdictions in the Denver Metro Area maintain their own time-of-day (TOD) and traffic responsive (TRP) signal control timings. These communities have invested a lot of time and money in their arterial signal systems and proudly maintain these services. Each of these communities would be reluctant to give up control of their signal systems in the event of freeway/arterial coordination, However, these communities and CDOT could jointly enter into a program to implement SCOOT on a trial basis on the arterials which parallel the freeway system. Since SCOOT optimizes the individual intersections along an arterial route, it is assumed that the entire arterial will be optimized. SCOOT’s ability to operate in a real-time mode would allow signalized intersection control to remain on the street - not in the hands of various public agencies.

5. TOC TOUR, SUMMARY

5.1 Introduction

At the end of the Toronto and New York TOC tour, representatives of CDOT, CSP, FHWA, Centennial and CRC sat down to discuss some of the information they had received during the trip. While all of this TOC information was fresh in everyone's minds, it was thought an excellent opportunity to conduct a brainstorming session.

This session concerned itself primarily with the Denver TOC's functional requirements. It was thought that the best way to design an effective TOC was to plan just exactly which functions the TOC would house. By now, most of the representatives of the individual parties should have read the first draft of Task 8 of the Denver IVHS Study - the Traffic Operations Center technical memorandum. This document provides a comprehensive outline of some of the desirable characteristics which the Denver Metro Area TOC should consider for inclusion. At this point, comments have not been received concerning the TOC document's contents.

This "Lessons Learned" document has detailed information and characteristics which other TOCs contain. At the end of each section, desirable characteristics have been mentioned for their possible inclusion in the Denver design. The intent of this section is not to reiterate those desirable characteristics nor is it to provide a second draft of the Denver TOC design.

The intent of this section is to identify concerns, issues and possible stumbling blocks, both institutional and technical, which are associated with implementation of a TOC of this nature. This section will use the TOC functions list as identified during the brainstorming session as a starting point for the ensuing discussions. Related issues involved within each function will be listed to allow the reader a broad, comprehensive perspective. These issues, along with the Denver TOC design document and the Toronto and New York TOCs' desirable characteristics, should lay the foundation for an effective approach concerning the design, construction and implementation of a Traffic Operations Center in the Denver Metro Area,

5.2 TOC Functional Design Issues

Information/Data Collection

- Type of vehicle detection equipment to use.
- Location of vehicle detection equipment.
- Vehicle detection equipment maintenance (e.g., complexity, convenience, cost, etc.).
- Identification of other information collection sources (e.g., environmental, cellular phone call-ins, vehicle probes, etc.).

Ramp Metering (traffic information and control)

- Expansion of ramp metering system (e.g., timeframe, location, cost, etc.).
- Type of vehicle detection equipment to use.
- Possible tie-in with arterial coordination.
- Advanced ramp metering algorithms.

Freeway/Arterial Control and Coordination

- Centralized (CDOT) and/or decentralized (communities) control.
- SCOOT (on-street real-time control).
- Traffic signal system synchronization.
- Preplanned diversion mutes.

Incident Management

- Incident detection/verification sources.
- Incident command/control personnel.
- Involvement of appropriate agencies.
- Determination of standard operating procedures (e.g., identify potential incident scenarios, create operations manual, etc.).
- Motorist advisory techniques.
- Number of personnel required.
- Inclusion of CIMC recommendations.

Special Events/Incidents

- Planning/organization of major incidents (e.g., hazardous materials spill, etc.).
- Command station located in TOC conference room.
- Communication with appropriate agencies.
- Standard operating procedures.

Towing Service Information

- Contract towing arrangements with private companies.
- Courtesy Patrol or CDOT maintenance towing.
- First come, first serve basis.
- Lane clearance/car removal legislation.

CDOT Maintenance Dispatching

- Inclusion within TOC control center.
- Identification of involved/cooperating.
- Number of personnel required.
- Location of maintenance crews (e.g., within TOC, separate facility, etc.).

CSP Dispatching

- Inclusion within TOC control center.
- Number of personnel required.
- Amount of TOC space required.
- Special work area considerations (e.g., NCIC access requires security and limited visual access, etc.).

Media Involvement

- Inclusion within TOC control center.
- Number/type of agencies.
- Communications medium.
- Informational requirements (e.g., type of traffic information broadcast, etc.).
- User - fee charges (e.g., payments for information/space, etc.).

Maintenance Crews

- Where to house/facilitate crews.
- Combine or separate TOC and field equipment maintenance efforts.
- Private or in-house maintenance.
- Maintenance issues (e.g., complexity, convenience, cost, etc.).

Multi- Jurisdic tional Involvement

- Freeway/arterial control and coordination.
- Special event activities (baseball, football, inclement weather, etc.).
- Multi-jurisdictional data/information sharing.
- Major incidents (e.g., hazardous materials spill, etc.).

Interconnection/Data Sharing with TOCs

- Statewide TOC hubs (C-Star).
- Jurisdictional/signal control TOCs (e.g., Aurora, Arvada, etc.).
- Truck port-of-entries.
- AAA control center.
- Type of information to share.
- Type of communications mediums.

Communications Support

- Type of communications equipment to use.
- Identification of involved parties.
- Private firm or in-house work.
- Coordination with existing/current communications efforts.

Statewide 800 MHz Communication (2-way)

- Identification of involved parties.
- Procurement of appropriate equipment.
- Type of information to be broadcast.
- Establishment of operational guidelines.

Freeway Work Permitting System

- Identification of involved parties (e.g., utility, maintenance, construction, etc.).
- Areas of involvement (e.g., planning and coordination of work zone traffic control, etc.).
- Establishment of operational procedures.
- Coordination of work activities.

RTD activities

- Coordination with I-25 bus/HOV lanes.
- Incident detection source.
- Potential for traffic probes (e.g., use GPS and AVL techniques to gather link-travel times).
- Multi-mode transportation activities.

Mapping

- Types of maps to create.
- Area of coverage.
- Inclusion with possible route guidance systems.
- Agency responsible for developing/creating maps.

Research Test Bed

- Identification of equipment to research and develop.
- Funding sources.
- Agency responsible for determining research areas.
- Agency responsible for conducting R&D work.

Public Awareness

- Open house tours.
- Viewing/conference room in TOC.
- Advertising (TV, radio, print, etc.).
- Brochures and flyers which relate TOC functions and public's role.

Traveler Information

- Type of equipment to use (e.g., VMS, HAR, RDS-TMC, etc.).
- Type of information to broadcast.
- Informational control (e.g., who decides just what messages are broadcast, etc.).
- Media involvement.
- Communications mediums.

Institutional Issues

- Who will manage TOC facility.
- Freeway/arterial coordination.
- Funding sources.
- Who will operate TOC facility.
- Incident management responsibilities.
- Multi-agency information sharing and coordination.

TOC Building Characteristics

- Construct new building (CDOT' s goal).
- TOC layout/design (e.g., type of rooms, size, etc.).
- TOC location.
- Identification of involved parties (e.g., who will work/use TOC facility).
- Level of staff training (e.g., operators, maintenance, incident response, etc.).

TOC Control Center Layout/Design

- operator interactions in separate offices or combined in control center (e.g., who is where, number of work stations, etc.);

- hierarchy and location of workstations
  - CSP's special needs
  - view of control center
  - view of monitor screens
  - elevated workstations
  - noise level in room;

- workstation layout
  - shape (e.g., U or T shaped, human factors/ergonomics, modular desks, flexibility to rearrange, etc.)
  - features (e.g., common control equipment via software, number of CRT screens, telephones, etc.); and

- monitor screens
  - location (e.g., operator viewability, size, color, etc.)
  - number of CCTV monitors (e.g., few with split-screen capability, one screen per CCTV camera, etc.)
  - number of projection screens (e.g., display purposes, possible CCTV viewing for incidents, etc.).

5.3 Public and Private Involvement

One of the main issues facing the Denver TOC design is the selection of the appropriate level of involvement by the public and private sectors. The first thing to consider when involving the private sector in the Denver TOC design process is identification of the proper areas for their involvement. The main areas for private sector TOC involvement concern design, construction, implementation, operation and maintenance activities. A few of these issues are approached in the following section to promote discussion on this topic by all involved parties.

1) Operating knowledge. What is the appropriate level of involvement for CDOT and potential private sector firms? Should it be consultant operated (INFORM) or done in-house (Toronto, San Antonio), or should it be an in-between combination of both

approaches? CRC feels that CDOT should be involved at a high level of detail within this approach, either operating the TOC or providing continuing project management support.

2) Maintenance activities. It is essential that maintenance activity involvement be determined at an early stage. Whoever the responsible party (CDOT or consultant), each will need to train their personnel with the appropriate technical background to allow experience to develop quickly. Maintenance concerns include complexity, convenience, cost, etc., for either CDOT or consultant crews.

3) Private sector involvement. How does CDOT involve private sector firms? Does CDOT allow private firms to design, construct, implement, operate and maintain the TOC's activities in return for certain rights? If so, CDOT must develop guidelines on just what rights and concessions they must make. In addition, should CDOT approach private sector involvement strictly on a bid contract arrangement?

4) Costs. For all of these TOC activities, is it cheaper for CDOT to perform them in-house or contract out to private firms? Will private firms low bid just to receive the contract and not perform up to expectations ? In addition, what funding sources are available to CDOT to cover the TOC activities' costs?

In summary, an involved parties must determine the appropriate level of participation for both public agency and private sector involvement. The main areas for private sector TOC involvement concern design, construction, implementation, operation and maintenance activities. Currently, the Denver IVHS Study Master Plan is concerning itself with these issues. Detailed project work scopes, program approaches and agency roles (public and private) are identified for each potential activity within the Denver TOC design. The Master Plan document, along with all the involved Denver parties' opinions and suggestions, will produce an effective approach for the design, construction and implementation of a Traffic Operations Center for the Denver Metro Area.