CHAPTER 3 - FREEWAY CORRIDOR TRAFFIC MANAGEMENT

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3-1.00 INTRODUCTION

MnDOT is responsible for the planning, design, integration, operation, and maintenance of freeway corridor traffic management systems. These responsibilities, within the metropolitan area, are assigned to the Regional Transportation Management Center.

3-1.01 Purpose

The purpose of freeway traffic management systems is to optimize traffic flow in the metro area freeway corridors, with specific objectives including the following:

1. Minimize the magnitude and duration of congestion.
2. Maximize the traffic flow through freeway bottlenecks.
3. Reduce the crash rate and improve safety.
4. Minimize the impact of incidents.
5. Provide freeway operations support of special events, construction, and maintenance activities.
6. Promote travel demand management via High Occupancy Vehicle (HOV) facilities and other demand management initiatives.
7. Provide aid to stranded motorists.
8. Provide traveler information.

3-1.02 Chapter Organization

Chapter 3 is subdivided into six sections, 1) the Regional Transportation Management Center, 2) Surveillance Systems, 3) Control Systems, 4) Preferential Treatment Systems for HOVs, 5) Incident Management, and 6) Computer Systems. Each subdivision describes the purpose and nature of the systems in that subdivision, and provides guidelines for design and operation. In addition, a list of important terms used in freeway traffic management is provided below.

3-2.00 GLOSSARY

Bottleneck

A section of freeway where the capacity is less than previous sections thereby creating a restriction in the normal flow of traffic in peak-demand periods.

Capacity

The maximum number of vehicles that can pass over a section of roadway during typical conditions (normally expressed as vehicles per hour per lane).

Delay

An interruption of normal travel involving a slowing or stopping. It is the difference between interrupted and uninterrupted travel times.

Demand

The number of vehicles desiring to use a section of road during a specific time period.

Density

The number of vehicles on a section of freeway per unit of length, usually expressed in vehicles per mile.

Headway

The time (in seconds) between consecutive vehicles, measured from the front bumper of one vehicle to the front bumper of the next vehicle as they move past a given point.

Incident

An event on or near the roadway which blocks or restricts the flow of traffic or has the potential to do so. Examples are crashes, stalled vehicles, and spilled loads.

Metering Rate

The rate at which vehicles are permitted to enter a freeway via a ramp control signal usually measured in seconds per vehicle.

Occupancy

The percentage of time that a detector in a lane on a roadway is covered or occupied by a vehicle or vehicles. The occupancy is computed for given lengths of time, i.e., 30 seconds, one minute, or five minutes, and expressed as a percentage. Occupancy, as computed using 6' x 6' loop detectors, may be used as a direct measure of traffic density with each 10 percent occupancy being equivalent to 25 vehicles per mile.

Platoon

A group of vehicles traveling together as a group, either voluntarily or involuntarily, because of traffic signal controls, geometrics, or other factors. Traffic leaving a signalized intersection when the light turns green is a platoon.

Queue

A line of vehicles waiting at a traffic signal or ramp meter signal, or backed up at a bottleneck.

Recurrent or Recurring Congestion

Congestion that occurs at predictable times daily or weekly due to demand exceeding capacity.

Shockwave

The phenomenon which describes the movement of the point in a traffic stream where stopping or slowing of successive vehicles occurs. If the upstream flow rate is about equal to the downstream flow rate, the shockwave will stay in one location on the freeway (standing shockwave). If the upstream flow rate is greater than the downstream flow rate, the shockwave will move upstream. This is a principal cause of rear-end collisions on a freeway.

Weaving

A situation in traffic flow which describes necessary lane changing both right to left and left to right by numerous vehicles, usually at freeway entrances, exits, or diverge areas.

3-3.00 REGIONAL TRANSPORTATION MANAGEMENT CENTER (RTMC)

The original Traffic Management Center opened in 1972 as part of the I-35W Urban Corridor Demonstration Project. The new RTMC has re-located from downtown Minneapolis to the Waters Edge campus at 1500 West County Road B2 in Roseville. As part of the relocation, MnDOT's Metro Maintenance Dispatch, MnDOT's Metro District Traffic Operations Section, and the Department of Public Safety's State Patrol Dispatch have integrated into a unified command center in the new RTMC.

Freeway corridor operations activities coordinated from the RTMC include traffic management system maintenance and operation, incident management, and integration of freeway operations with agencies operating arterial street traffic signal systems.

The RTMC currently operates 480 ramp meters, 800 closed circuit television (CCTV) cameras, 160 dynamic message signs (DMS), 330 lane control signs (LCS), the MnDOT Traffic Radio program, and provides traveler information for various media outlets including the internet and 511.

Fiber optic communications cables have been installed between the RTMC and a number of key agencies involved in arterial street traffic control, enforcement, transit operations, and incident response. These agencies include the State Patrol, MnDOT Maintenance Operations, Metro Transit, the cities of Minneapolis and St. Paul, and Hennepin and Ramsey counties. The fiber optic communications subsystem makes it possible to provide integrated corridor traffic management in the entire metro area. Fiber optic communications has also been extended to the Center for Transportation Studies (CTS) at the University of Minnesota providing video and data for a student traffic management lab and CTS traffic management research projects. CCTV signals have also been made available to many of the Twin Cities television stations.

3-4.00 SURVEILLANCE SYSTEMS

3-4.01 Purpose

Surveillance systems provide department personnel and computer systems with “real-time” information regarding traffic flow and incidents on the freeways so that appropriate control decisions and immediate action can be taken to maintain safe and efficient operation. Surveillance data is also used to provide information to motorists approaching an incident or congested area.

Continuous information is provided on the volume of traffic and level of congestion (lane occupancy) on each monitored freeway segment. This information is used to determine metering rates at ramp control signals, appropriate displays on DMSs and lane control signals, and the operation of a color graphics map display indicating volume or occupancy which allows department personnel to monitor overall operation of the freeway.

The principal surveillance systems used by the department are electronic vehicle detectors and CCTV. Additional surveillance is provided through visual observations via cellular 911 calls monitored by the State Patrol and local police radios, Freeway Incident Response Safety Team (FIRST) emergency response vehicles, and aerial surveillance via helicopter through a partnership with the State Patrol.

Detector data and CCTV pictures of incidents on the freeway provided to emergency service providers (police, fire, ambulance) allow them to accelerate dispatching.

3-4.02 Electronic Vehicle Detectors

Electronic vehicle detectors are devices used to indicate the presence of vehicles in a lane. MnDOT utilizes two types of vehicle detectors; inductive loops and microwave radar detectors.

Inductive loops are 6’ x 6’ loops of wire, cut and sealed into the pavement of the freeway. The wire in the loops is connected to an amplifier in a nearby cabinet. The electrical current in the loop sets up a magnetic field which is disturbed when a vehicle moves above it. This disruption is reported to a controller and in turn to a central computer at the RTMC. Through these detectors, it is possible to determine traffic volume (e.g., vehicles per hour, vehicles per five minutes, and vehicles per 30 seconds) and the general traffic density, level of congestion, and/or lane occupancy.

To measure lane occupancy of inductive loops, the controller records the percent of time, over a 30-second time interval, that the space monitored by the loop is occupied. If the loop is occupied 40 percent of the time (12 seconds of a 30 second period), the traffic density on the freeway is approximately 100 vehicles per mile. If it is occupied 20 percent of the time (six of the 30 seconds) the density is approximately 50 vehicles per mile.

Microwave radar detectors are electronic devices mounted on poles alongside of the freeway. They detect individual vehicles and measure their speed, occupancy, length, and lane assignment.

Vehicle detectors are the backbone of the freeway surveillance system because they provide continuous system-wide volume and lane occupancy data which can be monitored and analyzed by a computer. “Mainline” detectors at one half mile spacing measure volume and occupancy in each freeway traffic lane. “Queue” detectors are placed at the top of ramps upstream of ramp meters. These are used to measure queue lengths and ensure that vehicles do not wait more than the prescribed four minutes. “Exit” detectors count the number of vehicles leaving the freeway. “Entrance” detectors count the vehicles entering the freeway.

Data from mainline detectors are displayed in the RTMC which show the “real-time” status of traffic on the freeways. The display is a map of the freeways representing vehicle detectors in the roadway which show green, yellow, or red in response to occupancy (traffic density) on the freeway, as indicated by the computer analysis of the data received from the detectors.

3-4.03 Closed-Circuit Television (CCTV)

CCTV systems consist of a series of cameras mounted on 50-foot poles at strategic vantage points to provide a comprehensive visual surveillance of roadways. Good viewing capability is limited to about one half mile in each direction. Therefore, a spacing of one mile or less between cameras is necessary for total coverage.

Remote control of the cameras originates from a CCTV control panel located within the RTMC. Currently two types of cameras are used. One type of camera has pan and tilt capability, zoom lenses, iris and focus adjustment, environmental housing with thermostatically controlled heaters, and blowers. The other type of camera is the dome camera with zoom lenses, pan and tilt, and 360 degree rotation. Most of the CCTV signals are transmitted to the RTMC via fiber optic cable. The control of the camera and the camera environmental housing utilize fiber optic cable and a single pair of communication cables.

CCTV enables operators in the RTMC to view traffic conditions on the freeway. CCTV provides the operator the ability to respond quickly with the appropriate course of action to warn approaching vehicles. For example, a vehicle detector might alert the RTMC operator to a congestion problem. The operator would respond by aiming and focusing a camera in the area where the congestion was reported. If the problem was created by an incident, the dispatcher would contact FIRST or the State Patrol and relay all information as to type of incident, severity, and probable needed services. CCTV is also used to verify the validity and determine the severity of incidents detected by other means.

3-4.04 Radio Relay of Visual Observations

Surveillance information is also obtained in the RTMC by monitoring the State Patrol and local law enforcement agencies' radio frequencies. This information enables the operator at the RTMC to locate incidents on the freeway, monitor complications, and proceed with incident management accordingly. Department personnel, who spend a considerable amount of time working or driving on the freeways, provide surveillance information by two-way radios and cellular phones.

3-5.00 CONTROL SYSTEMS

3-5.01 Purpose

Ramp metering has been used by MnDOT for more than thirty years to improve freeway traffic flow and to enhance motorist safety. One objective of ramp metering is to ease the merge of ramp traffic into the flow of traffic on the mainline. The main benefit at the merge area is to minimize the disruption of flow on the freeway caused by platoons of merging vehicles. Early in Minnesota's experience with freeway traffic management, another necessary objective of ramp metering became apparent. If not controlled, flow on the freeway will exceed the capacity at critical bottlenecks and the resultant congestion (shockwave activity) will cause crashes and reduce traffic flow. To accomplish the second objective, the Minnesota algorithm has evolved into a real-time, density based, zone control equation.

3-5.02 Ramp Control Signal Systems

Ramp control signal systems are used for regulating or metering access to the freeway. Traffic signals are mounted on the freeway ramp approximately 500 feet (350 foot minimum) upstream from the point where the ramp and freeway merge.

Ramps with a two-lane, single vehicle release operation require a pedestal with dual signal heads mounted on each side of the entrance ramp. The signal heads are three-section, 8-inch circular red, yellow, and green indications mounted at 5 and 10 feet, respectively. One head is aimed at the stop line and one is aimed upstream at vehicles entering the ramp. Two lane ramps, with a pavement width of 22 feet, require similar pedestals with similar dual signal heads mounted on the left and right sides of the ramp.

The signing sequence for a two-lane, single-vehicle release operation consists of the "Signal Ahead" sign (W3-3) and a "ONE CAR PER GREEN" sign (R10-X2 or R10-X6) mounted on the pedestal shaft. Multi-lane, single vehicle release ramps also have appropriate lane signing mounted on the signal pedestal shaft.

Flashers are installed above standard "Signal Ahead" signs on high-speed ramps requiring advance warning of the metering operation. The flashers, 8-inch circular yellow indications mounted at a height of 10 feet, operate during the metering period.

Proper utilization of the ramp control signal system is achieved when a vehicle approaches the signal, stops for the red signal, waits for the green signal, and then proceeds onto the freeway. Subsequent vehicles utilize the same operation. Vehicles are released alternately from each lane. In periods of light traffic flow on the freeway, the signal flashes yellow and vehicles may proceed directly onto the freeway.

In traffic-responsive metering systems, the ramp control signal operations are based on commands from a controller in a field control cabinet. The control cabinet in turn responds to the central computer at the RTMC. Ramp meters will begin metering as local (within three miles) traffic conditions approach congestion. The metering rate of a ramp control signal is based on the local traffic density as determined by the central computer using data from the surveillance system. The higher the traffic density, the more restrictive the ramp meters will be. Ramp conditions are also monitored and the signal timing is adjusted to avoid long wait times and vehicle queues backing up onto side streets. If conditions warrant, the RTMC control room staff can override the computer selected metering rate. (See Section 3-5.03 for a detailed description of the metering rate algorithm.)

3-5.03 Ramp Meter Algorithm

3-5.03.01 Minnesota Experience

Freeway ramp metering has been used by MnDOT for over thirty years to improve freeway traffic flow and to enhance motorist safety. There are two main objectives of freeway ramp metering. The first objective is to ease the merge of traffic from an entrance ramp with traffic on the mainline. The benefit to the merge area is to minimize the disruption of flow on the freeway caused by platoons of merging vehicles. The second objective of freeway ramp metering is to minimize congestion. With little or no volume control of traffic on entrance ramps, flow rates on a freeway may exceed the capacity at critical bottleneck locations. The resultant shockwave activity (congestion) limits the flow rate on the freeway to below 1700 vehicles per lane per hour, and has the potential to cause an increased number of crashes. The Minnesota algorithm allows sustained flow rates on a managed freeway of 2200 to 2400 vehicles per hour per lane. To accomplish the second objective, the Minnesota algorithm has evolved into a real-time, density based control equation, called segment density ramp metering.

Segment density ramp metering considers traffic densities on the mainline and volumes on ramps, and attempts to maximize mainline traffic volume while limiting queue waits to four minutes on local access ramps and two minutes on freeway to freeway ramps. If queue detectors sense ramps queues exceed the limits or are backing up onto local streets, the metering rates increase which clears the queue backups in the ramps.

3-5.04 Ramp Design

The following are general design guidelines for metered freeway entrance ramps:

1. Minimum of 300 feet between the ramp control signal and the nose (end of physical curb separation between ramp and freeway).
2. Minimum storage distance of 25 feet per vehicle for a six-minute metered volume between the cross street and the ramp control signal.
3. Two-lane ramps with single-lane entrance for all ramps with projected volumes of 500 vehicles per hour or greater.
4. Adequate graded width on all ramps for future pavement widening to accommodate an HOV bypass ramp.
5. Maximum of plus one percent grade for the last 500 feet of the ramp.

3-5.05 Lane Control Signals

3-5.05.01 Standard Lane Control Signals

Standard lane control signal systems, such as the I-94 Lowry Hill tunnel system, are used to warn or control traffic on the freeway. Lane control signals are 18-inch square indications which display either a red X, a downward yellow arrow, or a downward green arrow. Lane control signal systems are used on potentially hazardous sections of freeway to provide adequate advance warning of traffic conditions in each lane.

3-5.05.02 Intelligent Lane Control Signals

Intelligent lane control signals (ILCS) are four (4) foot by five (5) foot full color matrix dynamic message signs mounted above each lane on overhead sign structures. ILCS are capable of displaying symbols as well as text to provide motorists advance warning of traffic conditions in each lane.

ILCS are used to display advisory variable speed limits. Advisory variable speed limits are posted on ILCS in advance of slowed traffic. The goal of the advisory variable speed limit system is to mitigate shock wave propagation from downstream bottlenecks by gradually reducing speed levels of incoming traffic flow.

The priced dynamic shoulder lane (PDSL) on I-35W is controlled using ILCS. Messages are displayed on the ILCS approaching and within the PDSL indicating the open or closed condition.

3-6.00 PREFERENTIAL TREATMENT SYSTEMS FOR HIGH OCCUPANCY VEHICLES AND MNPASS

3-6.01 Purpose

Preferential treatment for High Occupancy Vehicles (HOVs) (buses, car pools, and van pools) is one approach to improve the operational efficiency of freeways (i.e. moving greater numbers of people without moving greater numbers of vehicles). Time savings and higher Levels of Service (LOS) due to preferential treatments are meant to provide an incentive for Single Occupant Vehicle (SOV) drivers to change their mode of travel.

Preferential treatment systems for HOVs include ramps to allow HOVs to bypass meters, MnPass lanes, reversible lanes, and a cooperative effort with Metro Transit, called Team Transit (see Section 3-6.05).

3-6.02 Preferential Treatment Ramps

HOV preferential access to the freeway is generally provided with an adjacent ramp lane (meter bypass lane) separated from other ramp lanes by a raised island. Given right-of-way and freeway operational constraints (e.g., access openings, right-of-way costs, number and proximity of freeway access points, etc.), HOVs and SOVs generally should share ramp entry and freeway merge locations. In this case, it is important that the length of freeway ramp is sufficient to accommodate the ramp meter queue without blocking HOV access to the ramp meter bypass. Exclusive HOV ramps, with separate ramp entry and freeway merge points, may be constructed when justified.

Ramp meter bypasses are not metered unless platoons on the bypass have potential to cause problems on the freeway.

Preferential treatment for HOVs entering a freeway is provided whenever vehicle occupancies are such that person-delay at the ramp control signals is sufficient to warrant the expense of constructing special meter bypass ramps and sufficient right-of-way exists.

3-6.03 MnPass Express Lanes

MnPass express lanes are high occupancy toll (HOT) lanes which charge single occupant vehicles a fee for use but allow free use for vehicles with two or more occupants, buses and motorcycles. MnPass express lanes are designed and operated to provide a congestion free alternative to freeway general purpose lanes. MnPass lanes on freeways offer time savings and higher LOS over travel in congested mixed-use traffic lanes.

User compliance with MnPass express lanes may be difficult to enforce. To minimize problems with the user not understanding diamond lane requirements, HOV lane signing and diamond pavement markings should be displayed at frequent intervals.

3-6.04 Reversible Lanes

On some freeway segments where peak period travel demand is directional by time-of-day, reversible lanes for MnPass may be constructed to provide added capacity in the peak direction. MnDOT is currently using reversible MnPass express lanes on I-394 between I-94 and TH 100. The development of reversible MnPass express lane facilities requires special traffic control systems. To ensure compliance to directional flow roadways, a physical control similar to a railroad crossing gate is used.

3-6.05 Team Transit

Team Transit is a cooperative effort by several transportation agencies including MnDOT, Metro Transit, and the Cities of Minneapolis and St. Paul. Together, the team plans and implements innovative improvements to the transportation system in order to move buses and other HOVs efficiently through peak period traffic congestion.

Bus-only shoulders allow transit buses to use the shoulder to pass traffic congestion on freeways and queues at traffic signals (i.e., T.H. 36 from T.H. 61 to I-35W). Currently there are over 250 miles of bus-only shoulders. There are operating guidelines that bus drivers must follow to ensure the safe use of the shoulder.

Team Transit projects also include advantages for transit at ramp meters (i.e., ramp meter bypasses and bus-only gates) and other projects to encourage transit use (i.e., park and ride lots).

3-7.00 INCIDENT MANAGEMENT

3-7.01 Purpose

Incidents cause approximately 60 percent of the congestion and between 10 and 15 percent of the peak period crashes on metro area freeways. Incident management systems minimize the impact of incidents and reduce secondary crashes via the following:

1. Rapid detection, response, and removal.
2. Providing motorist information services.
3. Integrated corridor traffic management techniques.
4. Deployment of emergency response vehicles.

The RTMC control room staff coordinates incident management activities with the State Patrol, MnDOT maintenance operations, Metro Transit, commercial radio stations, and other agencies responsible for traffic signal operations.

3-7.02 Incident Detection and Response

Most incidents are initially detected and reported by motorists who make 911 calls to the State Patrol dispatcher. Incident reporting in this manner is so fast that the RTMC currently does not employ an incident detection algorithm. Occasionally, the RTMC system operators observe an incident on CCTV that has not been dispatched on police scanners. In these cases, the system operators call the State Patrol dispatcher on a hotline.

Response to and removal of incidents is the responsibility of the State Patrol. The state trooper responding to an incident is in charge of on-site incident management and traffic control, including arranging for a tow truck and other emergency response vehicles as needed.

3-7.03 Motorist Information and Route Guidance

Traveler information systems provide real-time traffic information to motorists at a variety of locations before they enter the highway system, as well as en route. Information is presented on lane closures, congestion, incidents, and the advisability of taking an alternate route. The route guidance and vehicle navigation systems of the future are in the planning stages as part of the ITS program.

The following is a brief overview of the traveler information techniques utilized by the department.

3-7.03.01 Dynamic Message Signs (DMSs)

DMSs are used to provide real-time information to motorists on the freeway and on city streets prior to freeway entrances. DMSs mounted over the freeway provide advance warning of hazardous situations or incidents, including their location and the action the motorist should take to assure safety and minimize delay. DMSs mounted on entrance ramps or on city streets provide advance warning of conditions on the freeway in order to allow motorists to consider taking an alternate route.

DMSs are used during weekday morning and afternoon peak periods to display freeway travel times. Travel times are calculated using information from vehicle detection stations throughout the freeway corridors. Displaying travel times provides motorists with information that assists them in planning their routes and allows them to divert away from congested freeway segments.

3-7.03.02 Commercial Radio

Commercial radio relays traffic information to the motoring public and has the advantage of reaching a large listening audience. However, drivers often need detailed and specific information regarding freeway segments. Commercial radio broadcasters are generally reluctant to broadcast information targeted for a limited listener segment unless it is a newsworthy item also of general interest to other listeners. The Traffic Operations Section recognizes commercial radio as an important and widely used source of traffic information. Therefore, it places a high priority in providing information to these broadcasters. Some commercial radio stations contract with private traffic information sources and a few stations gather their own information. This information is available to the RTMC and can be particularly helpful on those freeway segments where surveillance is yet to be deployed.

3-7.03.03 MnDOT Traffic Radio

In 1989, MnDOT established a metro area traffic advisory radio service partnership with Minneapolis Public Schools (MPS). This service utilizes the MPS non-commercial student training station, KBEM 88.5 FM. The partnership provides for metro area traffic reports from the RTMC control room every ten minutes between 6:00 and 9:00 A.M., and 3:30 and 7:00 P.M., and reports every half hour between 11:30 A.M. and 1:00 P.M. In the event of a major incident, KBEM broadcasts continuously at RTMC's discretion. DMSs can be used to alert drivers to the continuous broadcasts. In addition to incident management, MnDOT Traffic Radio has also been used for special event traffic management.

3-7.03.04 511 Internet and Telephone Traffic Reports

MnDOT has made up-to-date traveler information available to travelers by phone, internet site, and mobile app. Dialing 511 will give the traveler information regarding highway traffic, and road, weather, and construction conditions. Internet site www.511mn.org gives information about current critical incidents, road and weather conditions, construction, commercial vehicle permit status, and camera images as well as a traffic congestion map. The 511 mobile app allows users to access many of the same features of the 511 internet site through their smart phones.

3-7.04 Emergency Response Vehicles

MnDOT's Freeway Incident Response Safety Team (FIRST) primary purpose is to minimize congestion and prevent secondary crashes through the quick response and removal of incidents. The FIRST program, originally known as Highway Helper, was initiated in 1987. There are presently 10 heavy-duty pickup trucks that patrol 220 miles of the most congested freeway segments. An Automated Vehicle Location (AVL) system has been implemented to better manage the operation of the FIRST program. This program has provided an average of more than 22,000 assists per year for the last several years.

3-8.00 COMPUTER SYSTEMS

3-8.01 Purpose

Computers are an important part of freeway traffic management because rapid control decisions are needed and large amounts of data must be managed. Computers are used in freeway traffic management both to process data at interchange locations and to manage the overall system. They are used to provide continuous real-time response to freeway conditions and to provide off-line support for other freeway traffic management activities. At the system-wide level, the computer supports surveillance and control systems. It operates automatically with minimal human intervention on a seven day, 24-hour basis to gather information, calculate parameters, and make traffic control decisions. Computers operate in real-time and are programmed so that events initiate processes and functions to handle freeway traffic situations. These functions are pre-established by traffic engineers. Computer systems also record system performance and perform related calculations and analyses.

3-8.02 Field Microprocessor Activities

Detector inputs are normally scanned at a high rate (30 times per second) by field microprocessors to accumulate lane volume and lane occupancy. Output commands are sent to field microprocessors which control many field devices, including ramp meter signals, lane control signals, and DMSs.

3-8.03 Intelligent Roadway Information System (IRIS)

The RTMC Intelligent Roadway Information System or IRIS, is an advanced traffic management system consisting of an IRIS network server and workstations. It is used to monitor and manage freeway traffic. The main functions of IRIS are to:

1. Gather traffic-flow information from the field vehicle detection devices.
2. Display real-time traffic conditions to system operators.
3. Provide real-time displays for each field device to the system operators.
4. Allow operators to display messages on dynamic message signs and lane control signals.
5. Activate and control ramp meter signals.
6. Calculate and display freeway travel times on dynamic message signs during peak periods.

3-8.04 Communication with Field Microprocessors

Data communications between the IRIS server and field microprocessors are achieved in a variety of ways. Traditionally, copper cables have been used with standard modems on each end, but newer devices use a network of fiber-optic communication lines. In a few locations, leased telephone lines and wireless cameras are used.

3-8.05 Communication with Control Center Devices

The IRIS server communicates with a number of peripheral devices via the network, including workstations, graphic displays, storage units, and printers. The server is also connected to the Metro local area network (LAN) and the MnDOT wide area network (WAN).

3-8.06 Operational Reports

The traffic management system requires reports to evaluate day-to-day activities and to maintain a record of the systems performance. The reported data includes lane and station volume and occupancy by various time periods, ramp vehicle counts, logs of activity for lane control signals and DMSs, and logs of equipment malfunctions.

3-8.07 Data Retention

Data is retained to prepare long-term operational evaluations. Computer data is stored on the network, then recalled and processed. The retained data includes volume and occupancy for various time intervals.

3-8.08 Research and Statistical Reporting

Installations performing freeway traffic management have the capability for a wide variety of research and statistical reporting activities. The huge amounts of traffic data and related information available along with the hardware and software necessary to perform analysis, evaluation, and reporting tasks in traffic management systems make an attractive research environment. Examples of statistical reporting include:

1. Travel time study reports.
2. Carpooling studies.
3. Ramp-metering statistics.
4. Various speed analyses.
5. Plots, charts, and other graphic reports.
6. Traffic volume trends.
7. Violation studies.

In addition, the computer may be used for research activities not directly related to traffic management data, e.g., For example, crash studies or studies concerning roadway systems other than freeways.