INTERSTATE 405 Corridor Program
Congestion Relief & Bus Rapid Transit Projects

APPENDIX I1

ITS Design Guide

I-405, SR520 to SR522 Stage 1 (Kirkland Stage 1)

Request For Proposal
July 15, 2005

Washington State Department of Transportation

INTELLIGENT TRANSPORTATION SYSTEM (ITS)
(Formally Surveillance Control and Driver Information, SC&DI)
DESIGN GUIDE

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INTRODUCTION

Design Guide Purpose:

The purpose of the Intelligent Transportation System (ITS) Design Guide is to bridge the information gap between signal and illumination design and ITS design. ITS design includes ramp meter and data station design as well as Closed Circuit Television (CCTV), Variable Message Sign (VMS) and Highway Advisory Radio (HAR) installation and retrofitting. The design guide assumes the user has some working knowledge of signal design and illumination electrical work to aid in the ability to do ITS design work. The designer should reference the Signal Design Manual and the Traffic Manual, when appropriate.

Traffic Management in the Seattle Area:

Purpose

The primary objective of the Seattle area freeway Traffic Management System (TMS), is to improve the safety and efficiency of people and goods movement on the urban freeway network. These improvements are accomplished through various measures which are intended to reduce traffic congestion, fuel consumption, travel time, and accidents. All together, these measures are known as the Seattle Area TMS System (Figure 1). The ITS system is but one element of the TMS System. Other elements include the HOV lane system, arterial traffic signal systems, reversible roadways, park and ride lots, freeway flyer stops, ridematching services, a commuter information telephone line and incident management operations.

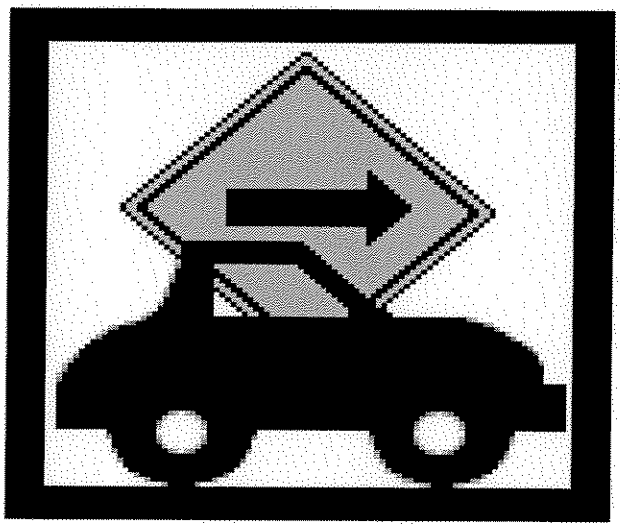

Figure 1

Improving the safety and efficiency of the arterials is also an objective of the TMS. This is done, partially, through the sharing of information, collected by WSDOT at the TSMC, with other local agencies. As the TMS system grows, so does the ability to gather, share and utilize this information. This utilization will include the capability to monitor freeway congestion and the ensuing ramp and arterial congestion and to alter arterial signal timing to help alleviate arterial congestion due to diverting traffic.

ITS System

The Intelligent Transportation System (ITS) system is operated by WSDOT personnel working out of the Traffic Systems Management Center (TSMC). Seattle area highways currently being served by ITS include:

-
- Interstate 5
- Interstate 90
- Interstate 405
- State Route 520
- State Route 167
- State Route 599
- Hwy 99

In addition to these roadways, there are plans to provide ITS coverage on SR 2, SR 9, SR 18, SR 509, SR 518, SR 519, SR 522, SR 525, SR 526, SR 539, and SR 543. WSDOT has long range goals to incorporate local arterials into the ITS system, as well as having local agencies tie into the TMS.

Elements of ITS: (See Figure 2)

The ITS system consists of the following components:

Surveillance
Electronic Surveillance (ES) / Data Stations (DS)
Closed Circuit Television Cameras (CCTV)

Control
Ramp Meters (RM)

Driver Information
Variable Message Signs (VMS)
Highway Advisory Radio (HAR) Systems
Commuter Information Telephone Line, 368-4499(368-HIWY)
Internet Web site (*www.wsdot.wa.gov/PugetSoundTraffic/*)

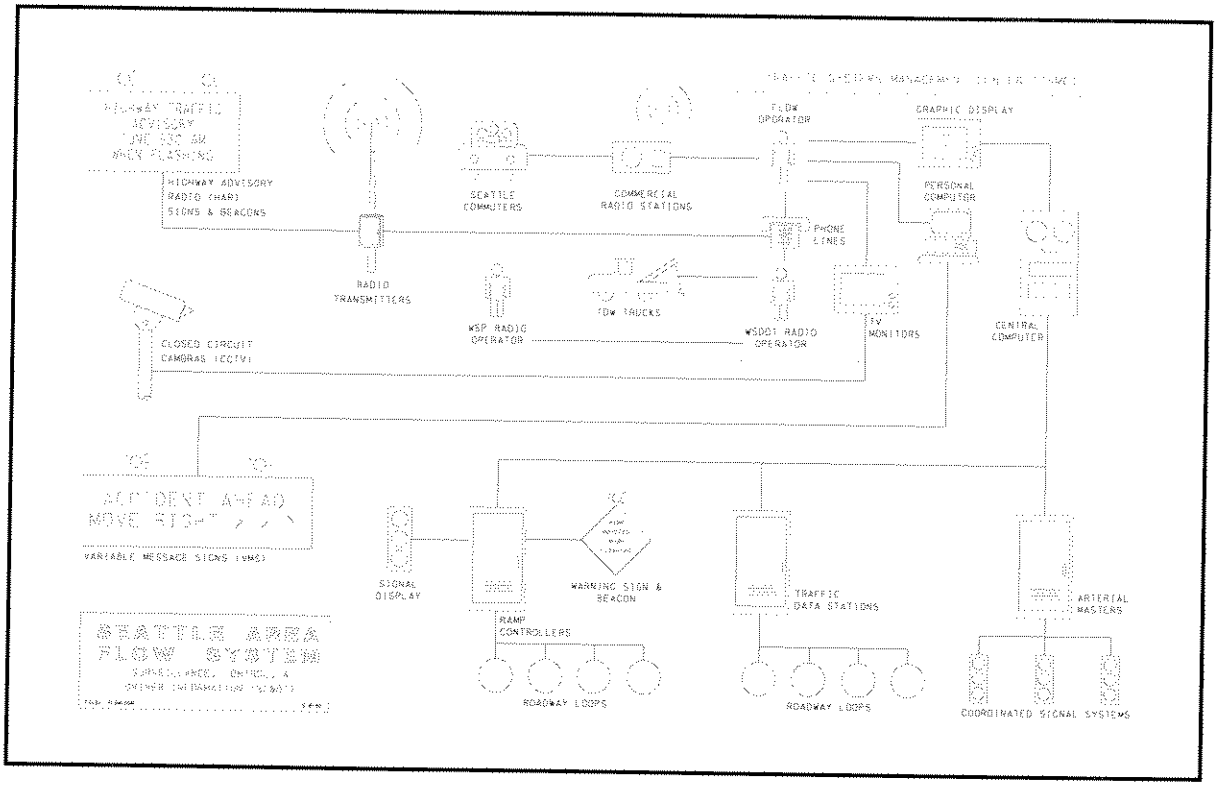

Figure 2

Each system component is described briefly below. Subsequent chapters discuss these elements in greater detail.

Surveillance

Electronic surveillance is the backbone of the ITS system. Data is collected, via roadway loops connected to roadside data stations (DS), and processed by the central computer. A graphic display is used to report current traffic conditions. This data is also used to detect accidents, disablements, and other incidents on area highways. The closed circuit television (CCTV) camera system functions as a supplementary surveillance tool. The graphic display and television information is supplied to Internet users, the State Patrol and other media outlets.

Control

Congestion occurs whenever roadway demand exceeds capacity. During peak commuting periods, freeway on-ramps are metered, using roadside traffic signals, to regulate the number of vehicles entering the freeway system. Safety is improved because the ramp-to-freeway merge is

controlled and platoons of vehicles normally arriving from adjacent signalized intersections are broken up by the ramp meter.

Driver Information

Commercial radio and dial-up traffic reports, via the commuter information line, home delivery of CCTV video via commercial television, variable message signs (VMS) and highway advisory radio (HAR) are used to transmit real time traffic conditions to highway users. The driver information system is also used to alert drivers to construction and maintenance activities which may affect normal travel patterns.

Note:
Entire ITS Design Guide can be located on the Internet at www.....

ELECTRONIC SURVEILLANCE
DATA STATIONS AND RAMP METERS

General (See Figures 2, 3)

For data station and ramp meter specifications, see Appendix B.1.

Although there is a significant difference in function between a data station (surveillance) and a ramp meter station (surveillance and control), equipment specifications for both are nearly identical. For this reason they are discussed together in this chapter.

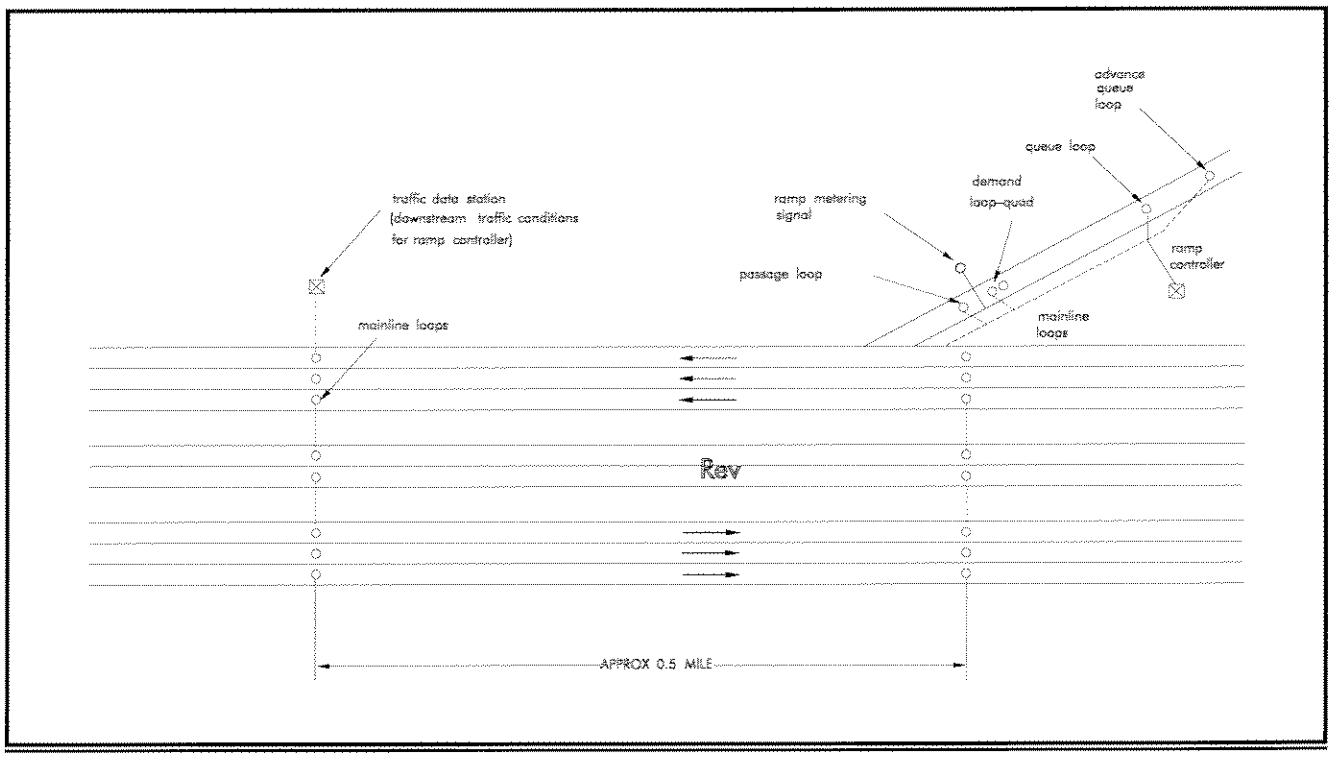

Figure 3 - RAMP METERING AND DATA COLLECTION SYSTEM

Data Station Function

Data stations collect current volume, occupancy and, when speed loops are present, speed data, from specific roadway locations. This information is transmitted to the central computer at TSMC for analysis and application.

Ramp Metering Function.

Ramp meters include all above mention data station functions as well as, control the flow of vehicles entering the freeway by allowing them on, one at a time, at a rate that can be accommodated by the mainline facility. This is accomplished with a standard traffic signal display which is actuated by the ramp meter controller. (Add how info gets to TSMC)

Motorists are given advance warning of the ramp meter operation prior to entering the metered ramp by means of warning signs and yellow flashing beacons located at the head of the ramp or on the adjacent local arterial.

Wherever possible, metered ramps should be provided with HOV bypass lanes. These allow transit, carpools, vanpools and motorcycles to bypass queues at the ramp meter signal. (See Design Manual section 1050.03(6)(c)).

There are two ways a metering rate is determined, remote and standby metering

Remote metering

In this mode of operation, metering rates for all ramp meter locations are determined by the central computer (Central), located at TSMC. This is the normal mode of operation for the Seattle system. The central computer is capable of adjusting upstream metering rates based on downstream conditions. A metering rate at an upstream location will be decreased if a bottleneck develops downstream. The length of each on-ramp queue is also taken into account. Metering start and end times can be adjusted from the Central. See Figure 4.

Standby metering (local control):

This is used when communications between the ramp meter and the central computer are interrupted. In these cases, each ramp meter will determine a metering rate for its on-ramp according to local traffic conditions or by a time of day table, taking into account the on-ramp queue conditions. In standby metering, a ramp meter operates independently, without coordinating with other ramp meters. See Figure 5.

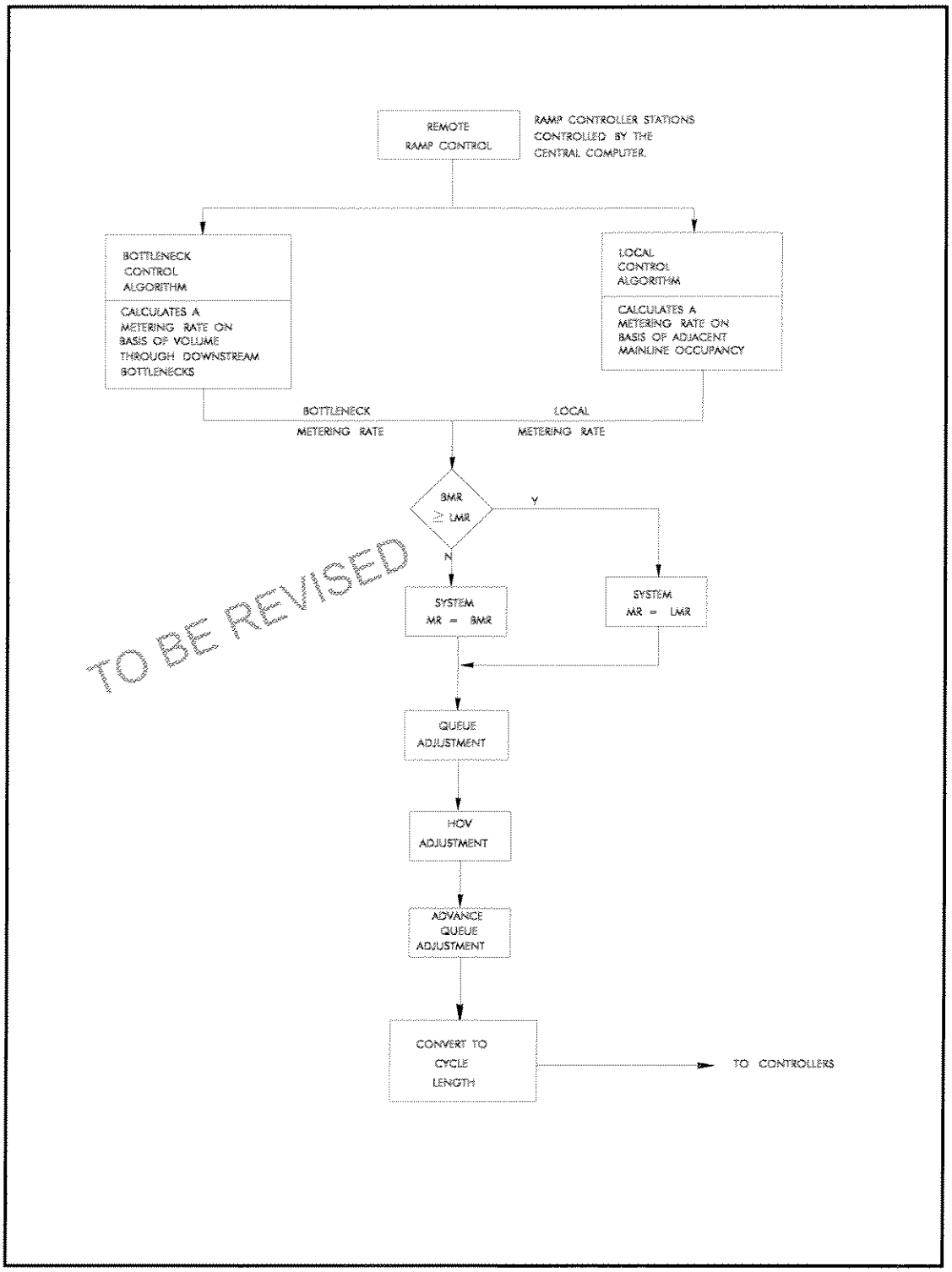

Figure 4 - REMOTE METERING RATE DETERMINATION

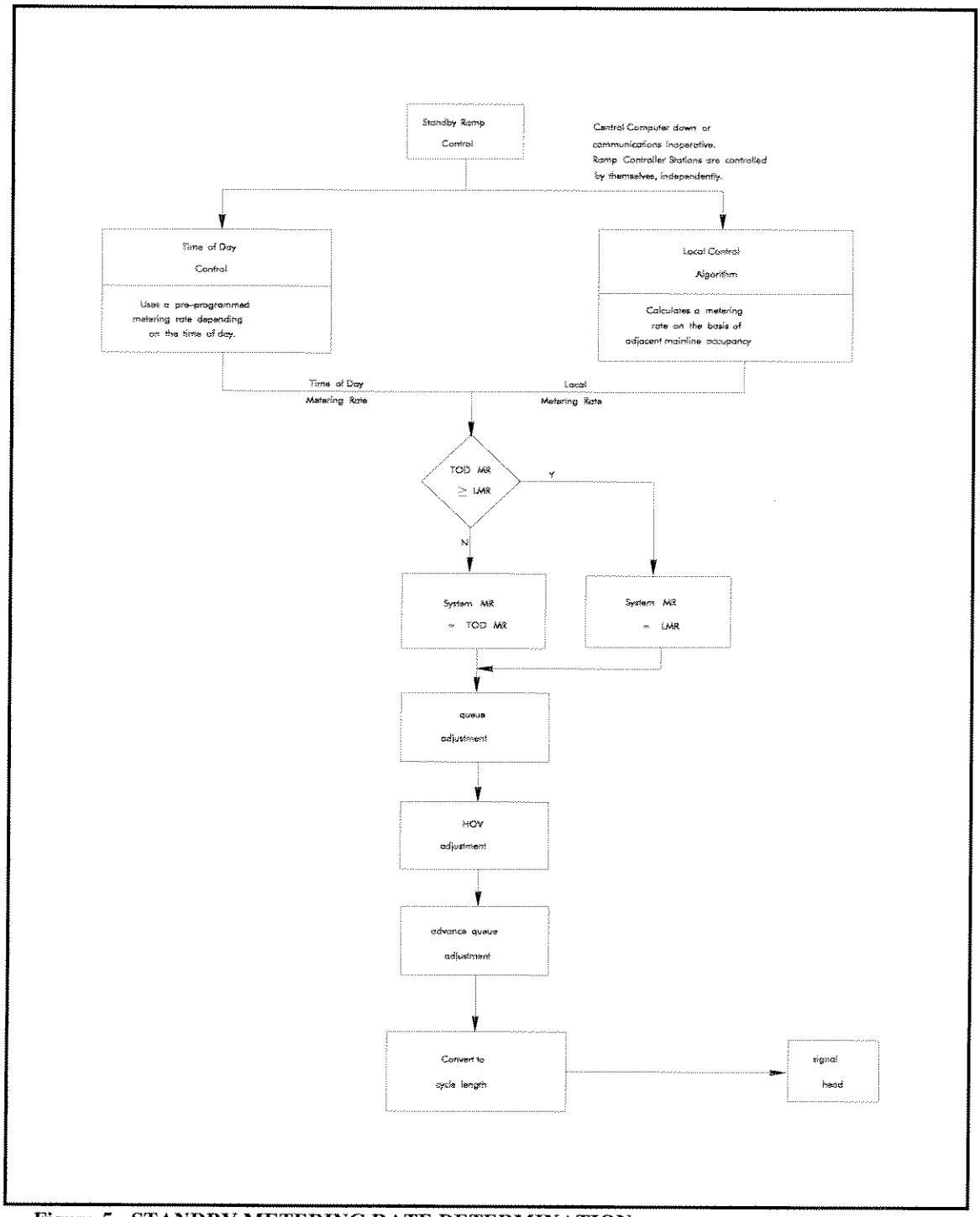

Figure 5 - STANDBY METERING RATE DETERMINATION

Location Criteria.

Data stations are generally placed at half mile intervals between interchanges. Intervals of much more than a half mile allow more traffic pattern fluctuations to go undetected, including accidents and congestion. The data station controller cabinet is situated along the freeway mainline adjacent to corresponding

roadway detection loops. Where ramp control is implemented, ramp meters are installed at on-ramp locations. See Figure 3. In areas where ramp meters are anticipated in the future, data stations should be placed near ramps then converted later to ramp meters when the need arises.

Hardware.

The major components of a data station/ramp meter are:

Cabinet Equipment:

1. Controller
2. Modem
3. Display Panel
4. Detector Amplifiers
5. Output/Power Distribution Assembly
6. Load Switches
7. Current Monitor (suggested)
8. Flasher for Warning Sign Beacon

Field Equipment:

9. Junction Boxes
10. Detectors
11. Signal Display
12. Warning Signs and Flashing Beacons
13. Central Computer (remote ramp metering only)

When no shoulder or HOV lane is available, preemption for emergency vehicles should be considered.

A data station does not require items 11-13.. From a construction standpoint, the only differences between a data station and a ramp meter are the signal display, warning signs, and the number of loops needed on the on-ramp of a ramp meter. A general description of each item follows. For further information see current specifications in Appendix B.1.

All cabinet equipment for new data stations and ramp meter controller stations are to be identical. The reason for this is simplicity in manufacture. In addition, data station cabinets can be used to replace ramp meter cabinets if no other spares are available.

Special Note: In order to insure proper accountability, cabinets, controllers and field equipment should all be provided and installed under the same contract

Controllers

The controllers used for data stations and ramp meters are Model 170 computers. The controller processes traffic volume and occupancy information and sends this information to the central computer at TSMC. At ramp meter locations, the controller also operates the signal displays and warning sign flashing beacons.

All controllers use a modem for communication of information to and from a compatible modem in a communication hub.

Cabinets

For cabinet details, see Appendix B.1.

Data station and ramp meter use Model 334 cabinets. These cabinets shall come fully wired and will include a model 170 computer. Cabinets must be easily accessible from the ramp and/or the mainline by maintenance and operations personnel. Cabinets should be placed so that the signal display, ramp and mainline loops are visible from the front door. The cabinet location shall be protected from traffic by placing them out of danger (behind a guardrail for example). The cabinets should also be placed out of the flood plain and above the water level.

Ramp meter cabinets are physically limited to 40 loops. However, the number of loops for a single cabinet should be below 30.

Modems Also see Chapter 6: Communications

Modems are used to communicate between the controller and TSMC. Different types of are used depending on the transmission medium deployed - Twisted Wire Pair (TWP) or Fiber Optic.

TWP (Copper)

Ramp meters and data stations utilize Model 400 internal modems, in the form of a printed circuit board, which plug into the model 170 chassy. These modems communicate at 1200 baud and 2 pairs of wire are required.

Fiber Optic

Ramp meters and data stations require drop-insert modems capable of re-transmitting a signal to the next modem and be capable of operating in a ring configuration.

Detectors

Loops

Loops are wires imbedded in the roadway and are used in conjunction with loop amplifiers to detect and measure vehicle presence.

A data station typically has one or two loops for each lane on the freeway, a mainline data loop or a mainline data and a speed loop. The Northwest Region standard for spacing of ramp meters/data stations is 1/2 mile, and for speed loops it is 1 mile, typically every other data station location. A ramp meter typically has one mainline loop for each freeway lane, which is used in determining the metering rate and loops for each ramp in its vicinity. Data loops and speed loops are usually placed in both directions,

See Figure 11. This way traffic and speed data is available for each lane and ramp.

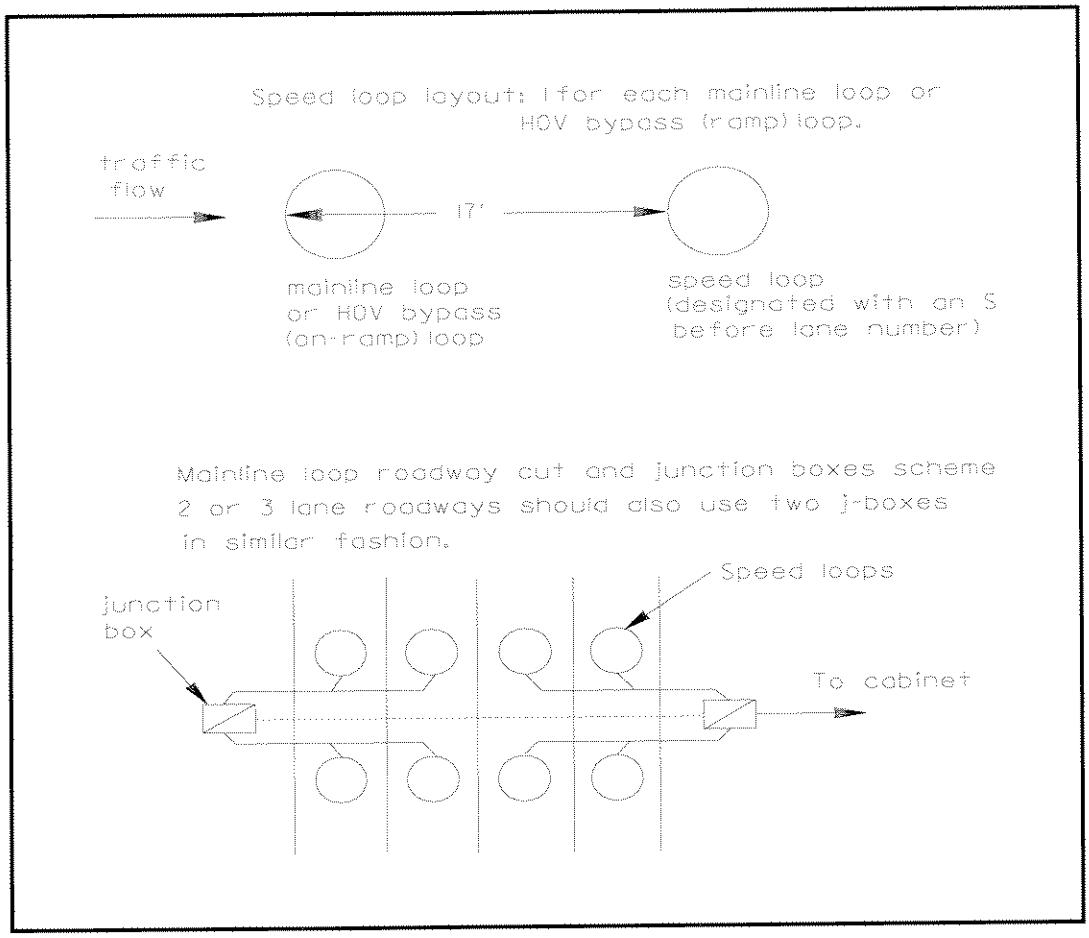

Figure 11 - MAINLINE LOOP LAYOUT

For a metered ramp, there are at least four loops on each metered lane (see Figures 6 through 10 for variations): the passage loop, the demand loop, the queue loop and the advance queue loop. The loops are situated as shown in Figures 6 - 10. On a metered ramp with an HOV bypass lane, there are at least three additional loops, HOV passage, HOV speed, and HOV demand, making a total of at least seven for this type of on-ramp. See Figures 8 and 9.

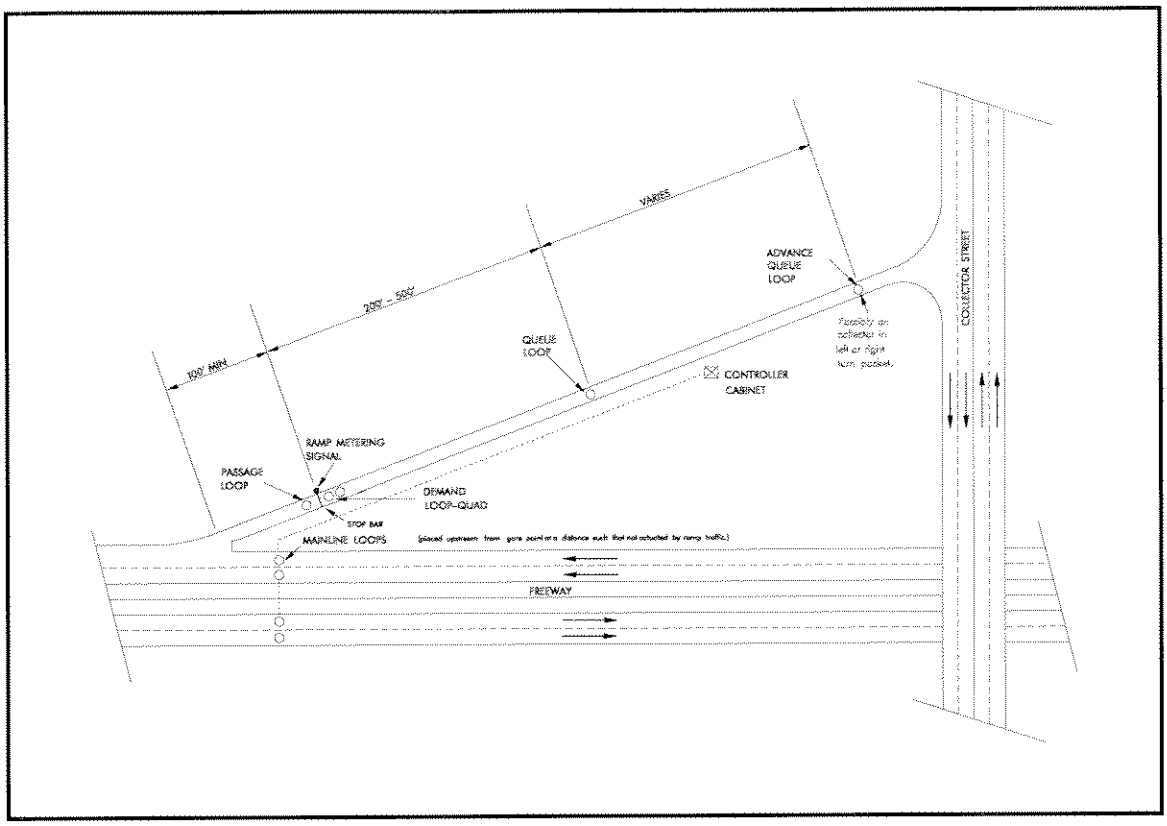

Figure 6 - SINGLE LANE METERED RAMP

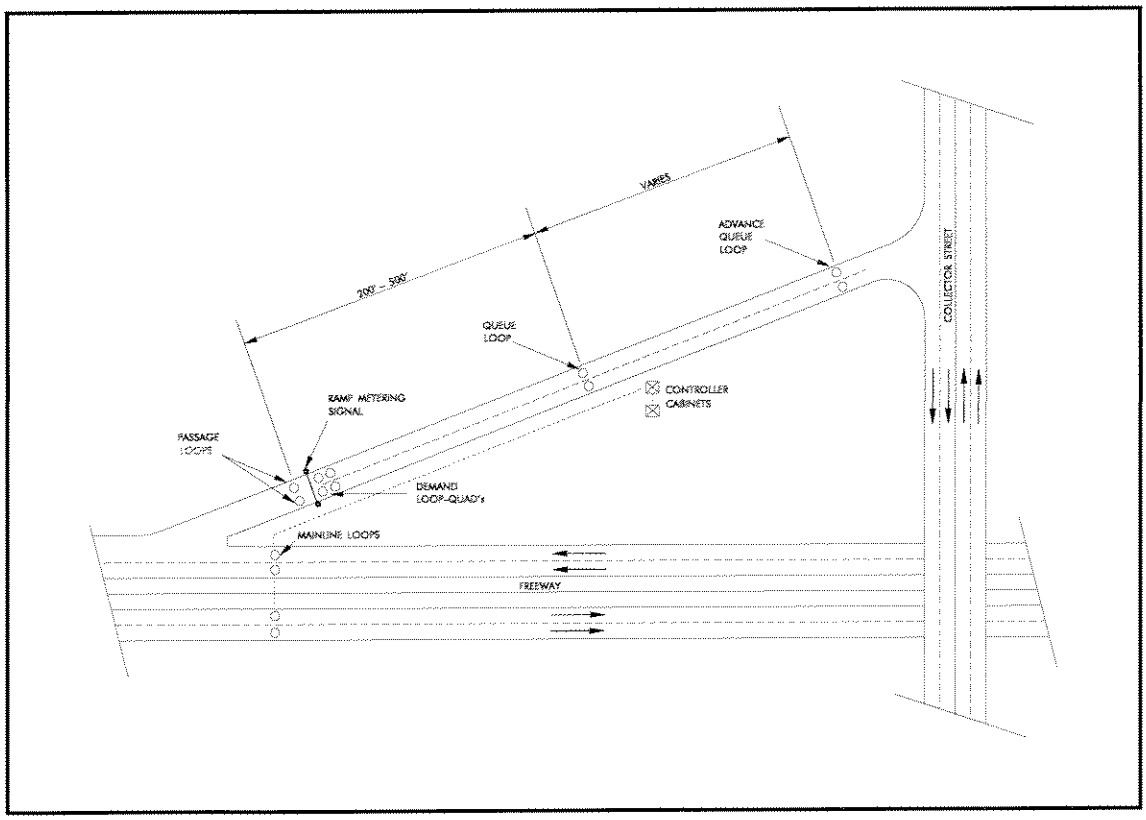

Figure 7 - DOUBLE LANE METERED RAMP

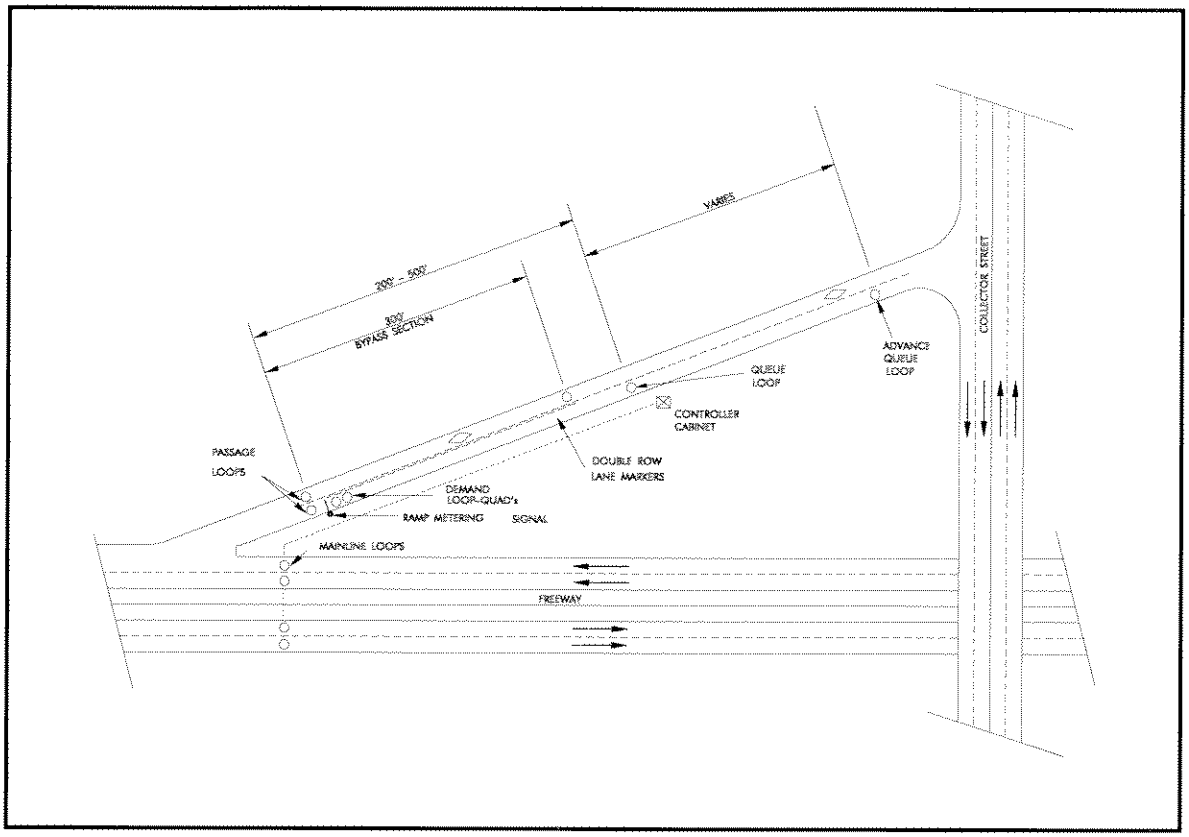

Figure 8 - SINGLE LANE METERED RAMP WITH HOV BYPASS

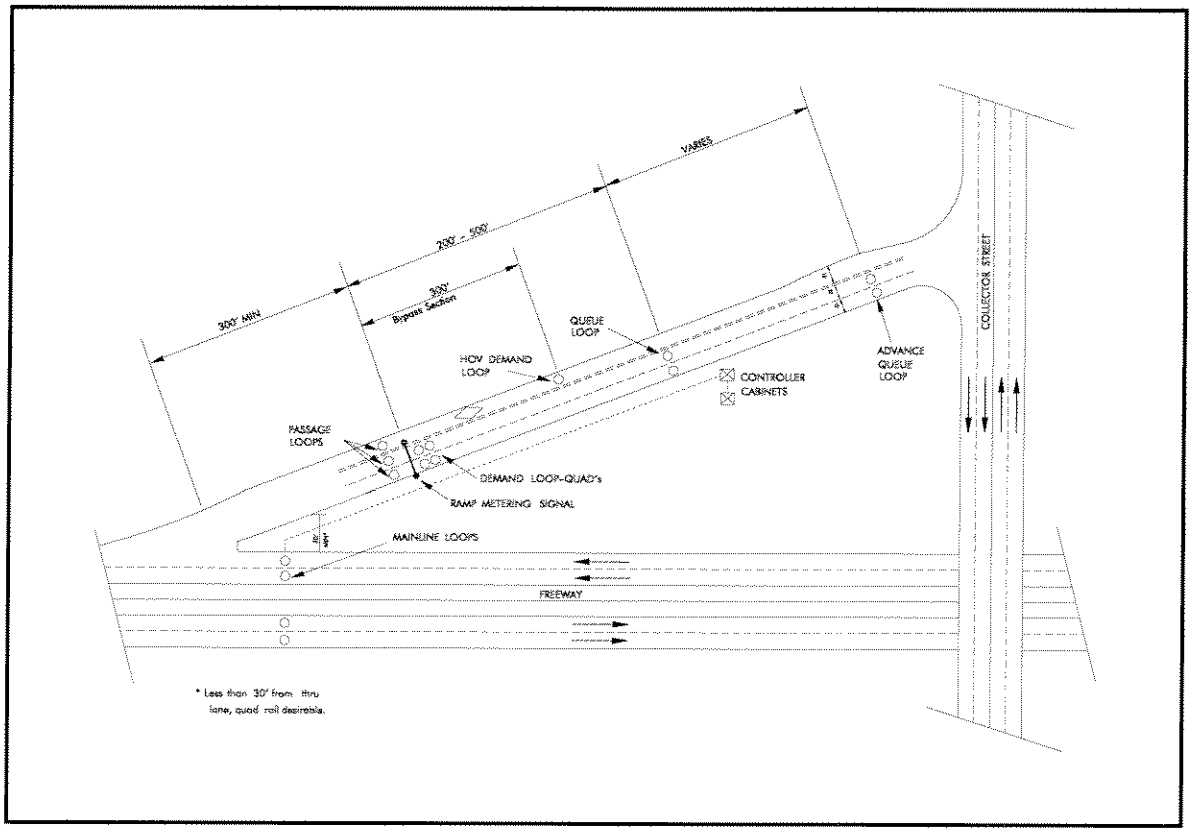

Figure 9 - DOUBLE LANE METERED RAMP WITH HOV BYPASS

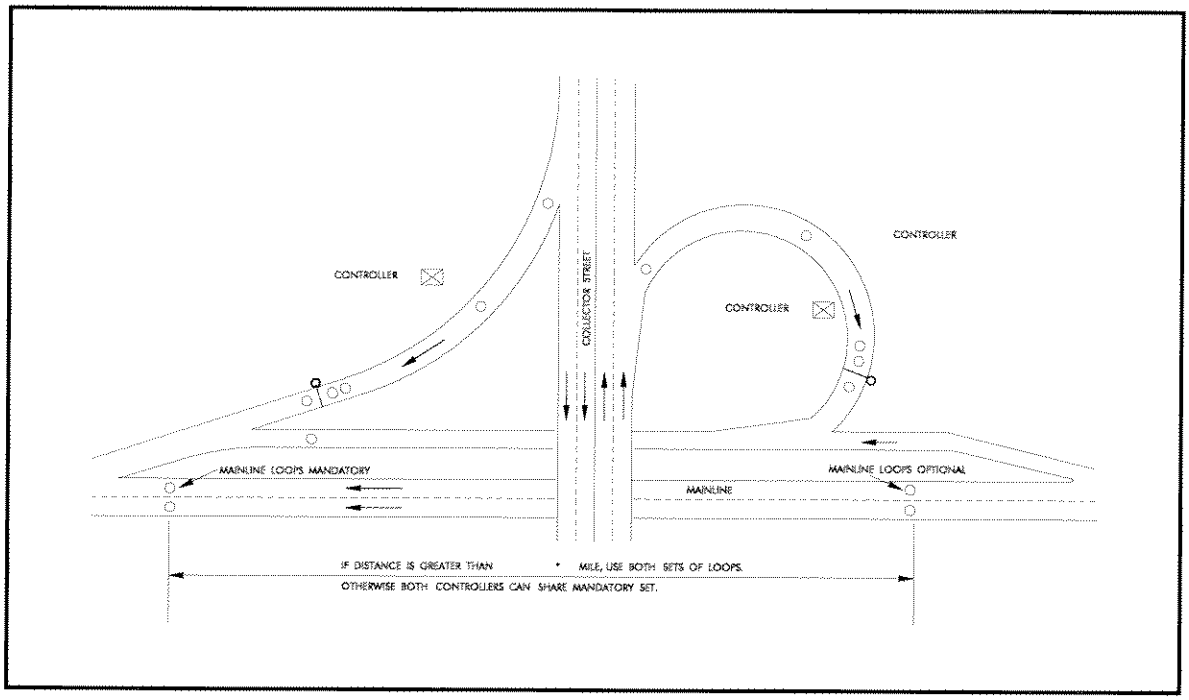

Figure 10 - MAINLINE LOOP OPTIONS

The passage loop is located 4 feet downstream of the stop bar. The demand loop is located 3 feet upstream of the stop bar, see Figure 21. The queue loop is situated 200 to 500 feet upstream of the demand loop, evenly spaced between the demand and advanced queue loops. See Figures 6-10.

The passage loop is used to detect a vehicle crossing the stop bar during the green cycle. The demand loop is used to detect the presence of a vehicle at the stop bar demanding a green cycle. The primary use of a queue loop is used to detect a queue of vehicles and adjust the metering rate to accommodate more vehicles. Longer ramps may benefit from an intermediate queue loop. This is the loop located upstream from the queue loop.

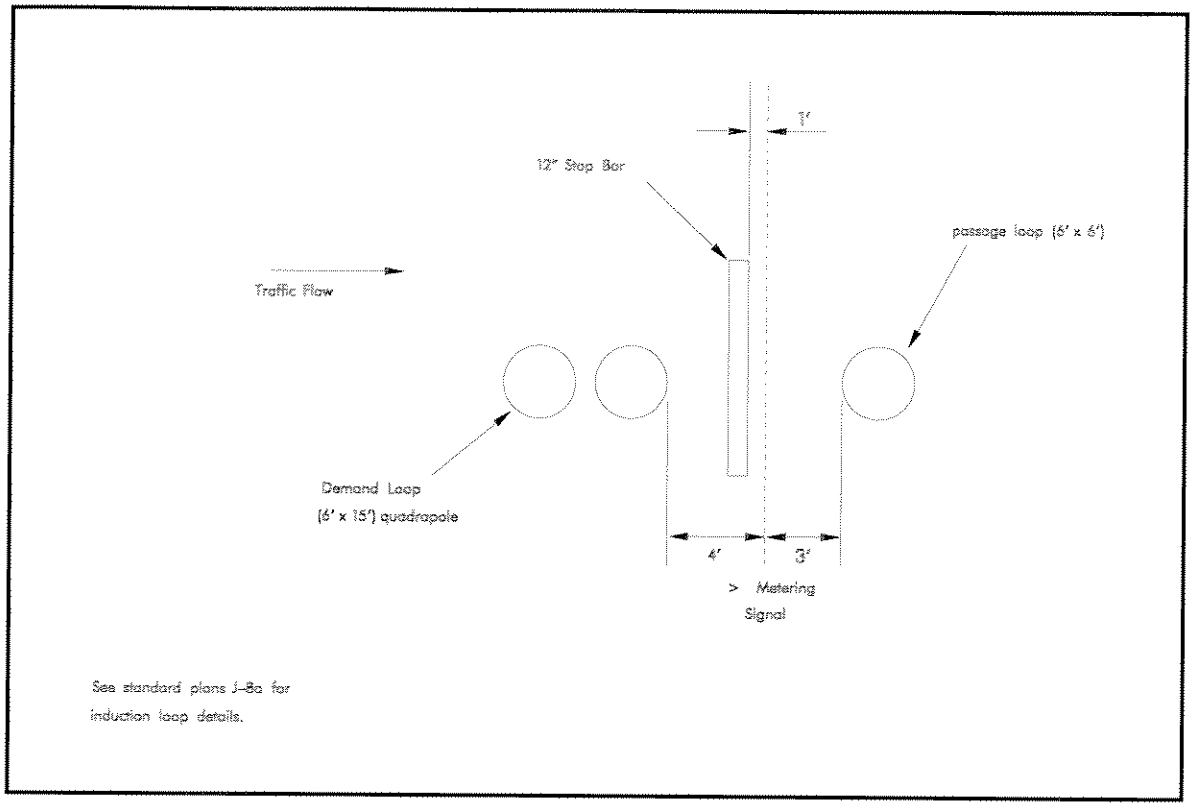

Figure 21 - PASSAGE AND DEMAND LOOP LAYOUT

The advance queue loop is located upstream of the queue loop(s). This type of loop is used to detect a very long queue of vehicles that may hinder traffic on the streets adjacent to the ramp meter and adjusts the metering rate to dissipate the queue at the expense of the freeway. There is typically one advance queue loop near the beginning of a ramp, however, additional advance queue loops may be placed in turn pockets.

The demand detector (Type R2) is two 6 ft. round loops connected in series. All other detectors are 6 ft. round loops (Type R1), unless otherwise specified.

Mainline loops must be placed upstream of the gore-point of the metered on-ramp, at a distance such that they are not activated by ramp traffic. This prevents the same car from being counted twice. See Figures 6 through 10.

For metered ramps with an HOV bypass lane, there are at least three additional loops, HOV passage, HOV speed, and HOV demand, making a total of at least six for this type of on-ramp. See Figures 8 and 9.

All loops on PS&E plan sheets must be named. See appendix A from rules on general loop naming.

New and retrofitted data stations should have mainline speed loops, located 17 feet downstream of the mainline loops, used for calculating

vehicle speed and length, See Figure 11.. When possible, limit the number of speed loops to eight per cabinet.

Junction Boxes

Also see chapter 6: COMMUNICATIONS for further information on junction boxes.

Junction boxes are located alongside the roadway adjacent to roadway loops. The loops are spliced in the junction box to shielded lead-in cable which then runs to the loop amplifiers in the cabinet. Junction boxes can also be used as "pullpoints".

Junction boxes should never be placed in the traveled roadway. When a junction box is placed in the shoulder in front of the barrier section where occasional traffic exposure occurs, a type L junction box should be specified with conduit sizes associated with type III junction boxes (see std. plan J-11a) and with the special lid. These type L junction boxes also have an advantage of side knockouts and straight entry conduits for long, straight pulls.

At the mainline loop locations, junction boxes shall be placed on both sides of the freeway (connected by conduit) to handle the mainline loops of that location. This way the entire roadway will not have to be closed for loop repair. See Figure 11.

Loop Detector Amplifiers

Loop detector amplifiers in the cabinet send out a voltage that runs through the roadway loops. The resulting inductance in the loops is affected by vehicle presence over the loops, which is detected by the amplifiers. The amplifiers amplify the signal returning from the loops, and output it to the detector display and controller panel.

Stopped Here

Detector Display Panel

Each roadway loop has a corresponding LED on the detector display panel. This LED lights when a vehicle passes over its corresponding loop. The detector display panel is used to verify loop-amplifier performance. It is also used to simulate traffic inputs to the controller, which is used to verify performance of the controller. The detector display panel outputs directly to the controller. See Appendix B.1.

Auxiliary Display Panel

An auxiliary display panel is used to indicate controller and communications status (green bulb on, communications to the central computer operative, detector failed, etc.) at the cabinet site. LED's light up to indicate the corresponding status. See Appendix B.1.

Output/Power Distribution Assembly (Power Panel)

Cabinet power supply converts 120 V to 24 V DC. Cabinets are served by various voltages which are transformed to 120 V. Circuit breakers, surge suppression for controller protection, a convenience outlet and other electrical equipment are included. For more information, see current specifications in Appendix B.1.

Service Drops for Electric Equipment Cabinets

If type B or D (120/240 VAC) services are used, the service drop should be within 500 feet of the cabinet containing the electronic equipment.

Distances greater than 500 feet should have a type C or E 480 VAC service installed. The 480 VAC should then be run to the electronic equipment cabinet and transformed to 120 VAC. A separate transformer cabinet is required because the transformer should not be mounted on or in the electronic cabinet.

Load Switches

Load Switches are switches used for opening and closing connections between the applied power and the traffic signals. Three are supplied and one is used for each metered lane. They are supplied for data stations as well as ramp meters. See Appendix B.1.

Current Monitor (Conflict Monitor)

One current monitor is required for each metered lane. The current monitor detects current flowing to the lamps in the signal head. By measuring current, the monitor can detect if a lamp is on. The 170 controller uses this information to detect lamp outages and conflicts. All existing cabinets use a state supplied current monitor. TSMC is searching for a new current monitor that can be vendor supplied. See Appendix B.1.

Meter Signal Display

The meter display varies depending on the on-ramp configuration. Each metered lane must have its own signal displays. A meter display consists of two 3-section signal displays mounted on one traffic signal pole. One is a 12 inch display, facing up the ramp, and the other is an 8 inch display, visible from the stop bar. However, a double mast arm may be used on a ramp with two metered lanes and no room for two signal poles. A meter display is supplied only for a ramp meter, not for a data station. Signal heads with louvers and/or visors will be used to prevent the signal head from being seen by the mainline traffic. See Appendix B.5.

Warning Sign and Flashing Beacon

POLICY STATEMENT ON ADVANCED WARNING FOR RAMP METERING

Ramp meter warning signs and flashing beacons shall be used to:

1) Provide motorists advanced warning that a ramp is being metered.
2) Provide motorists the option of using a ramp that is being metered.
3) Advise motorists of impending stops, due to ramp metering, on a ramp where sight distance concerns exist.

To provide advanced warning and the option of using a metered ramp, all ramp metered ahead signs shall be clearly visible from all approaches to the ramp. The advanced warning signs will be placed at the head of the ramp. If a decision point exists at a location other that the ramp entrance, the sign shall be placed so that it is clearly visible from that location.

To advise motorists of stops ahead on a limited sight distance ramp, a second advanced warning sign may be placed on the ramp. This sign should be approximately half the distance from the head of the ramp to the stop bar.

When metering is in effect, the beacons flash. All other times, the beacons are off. A warning sign is supplied only for a ramp meter, not for a data station. An aluminum NEMA 3R box, housing the flasher for the beacon, shall be installed on the sign pole over the handhole, approximately four feet above ground level, under the warning sign. See Appendix B.5.

Central Computer

The central computer, a Digital VAX system located at TSMC, receives and processes data from all data station/ramp meters simultaneously. Central also transmits ramp meter instructions to ramp meters. Ramp metering is controlled from central during remote metering operation.

Communications

See Chapter 6: Communications

Communications between the central computer and field located controllers are accomplished in one of five ways:

1) State owned fiber optic cable
2) State owned copper twisted pair cable
3) Leased telephone lines
4) Microwave transmission
5) Combinations of 1, 2, 3 & 4.

CLOSED CIRCUIT TELEVISION

General

For Closed Circuit Television (CCTV) specifications, see Appendix B.2.

CCTV is television coverage of WSDOT right of way or facilities. CCTV is primarily used for verifying highway incidents (accidents, disabled vehicles, or disturbances) and current traffic conditions. CCTV is also used for security surveillance of WSDOT facilities and fire control zones. The Washington State Patrol (WSP) and commercial television stations also pick up WSDOT CCTV to monitor traffic conditions. Color cameras are typically used.

Location

Finding the correct location for CCTV is extremely important. Locations should provide clear line of sight with minimal obstructions. Cameras used in low light conditions (such as tunnels or parking garages) should be located so that the main view will have the camera looking away from bright light. Looking into bright light from a low light condition causes washout of the video image. In the case of a tunnel camera, the first camera would ideally be located at the tunnel entrance facing into the tunnel.

CCTV cameras typically can turn 355 degrees. This 5 degree blind spot should be oriented at a location non-critical to viewing.

CCTV is located along the highway at a maximum distance of 1 mile between cameras. The cameras we use typically have a 10:1 zoom capability, which gives adequate monitoring capability up to about 2,500 feet.

Occasionally, this 1 mile spacing may be increased (such as for a long, straight stretch of highway with unobstructed views) with the use of a doubler. A doubler is a second lens used to double the magnification at the expense of light levels entering the cameras and focus quality.

A camera is typically located at each interchange. This allows monitoring of ramp metering as well as ramp queues. A minimum of two cameras should be placed at freeway-to-freeway interchanges (one to monitor each freeway).

Cameras should, where feasible, be located so that the message of an adjacent Variable Message Sign (VMS) can be read. This allows for visual verification of VMS status.

It is often desirable to locate cameras as high as possible over the roadway, to a maximum of 60 feet. The camera pole is typically between 30 and 50 feet tall. However, cameras mounted on retaining walls and under structures may not need a pole. In rare instances a 60 foot pole may be used, but only when

service access is located directly underneath, since the largest Northwest Region bucket truck reaches 65 feet.

The best camera location will often be on or next to an under crossing because of the increased altitude over the roadway or view of an interchange. If possible, the camera should be located off of the bridge structure. Vibration of the bridge can have an affect on camera reliability (usually this affect is minimal). Often however, because of obstructions such as trees, the bridge structure will clearly be the best place to install the camera. Headquarters Bridge Department must design a suitable foundation for this camera pole. Ideally this pole would be located above a bridge column or bent to reduce vibration. Headquarters Bridge Department should be notified early on in PS&E if a bridge will be affected.

A less desirable alternative to bridge placement is to place the camera adjacent to the roadway, a maximum of 10 feet from the bridge structure, and extending a minimum 30 feet above the top of the under crossing. The camera may then be serviced from the roadway on top of the under crossing.

Cameras are given preliminary locations before the design report phase of a project by the District ITS Planning Engineer. Once PS&E begins, the project office will request final locations from the ITS Planning Engineer. The Planning Engineer will then schedule the use of a bucket truck from District Signals Branch. **This is very important!** The roadway looks very different from 40 feet in the air than from down on the ground. An extra 10 feet of pole height can mean the difference between a sign bridge blocking 50 feet of roadway view or 1,000 feet.

CCTV System Components

Most CCTV components, except for cabinets and twisted pair cable, will be obtained under sole source requirements. Please see Appendix C for sole source justification and Appendix B.2 for CCTV specifications. CCTV components (the first 3 listed are located on the camera pole) are as follows:

Camera

The camera captures the video image for transmission. The camera must be equipped with a sun/rain visor to protect the video image from sun glare, rain, and bird droppings (cameras are favorite perches for birds). The camera can remotely zoom for magnification, open or close the iris for light control, and focus the video image. Northwest Region uses COHU brand cameras, Model 8212-1000/P10J-ER4226K-ER4565E-ER4841A for 10:1 zoom capability.

Pan/Tilt Unit

The pan/tilt unit is responsible for the movement of the camera. The pan/tilt unit requires 120 volts AC for power. Northwest Region uses a Pelco brand pan/tilt unit, Model PT1250P/PPT.

Junction Box

This junction box is located at the top of the camera pole below the pan/tilt unit. Control cable goes into the junction box and is terminated on terminal strips, from which the appropriate cables go to either the camera or the pan/tilt unit. Coaxial cable leaving the camera goes into the junction box on its way to the camera cabinet.

Control Receiver

The control receiver gets control signals over 4 wire twisted pair wire or over multimode optical fiber, from its associated communications hub, for the pan/tilt unit and the camera. Control cable leaves the control receiver on its way to the camera pole junction box. Northwest Region uses a COHU brand, Model MPC-D-111/51 control receiver.

Coaxial/Fiber Optic Converter

This device converts the video image coming from the camera over coaxial cable to an image carried over multimode fiber optic cable. The coaxial/fiber optic converter requires 12 volts DC for power. Northwest Region Optelecom Inc. brand coaxial fiber optic converters for new installations and has some America Fibertek converters at many existing camera locations.

Camera Cabinet

The camera cabinet houses the control receiver, the coaxial/fiber optic converter, and the power distribution panel. The camera cabinet requires 120 volts AC for power, which may be stepped down from 480 volts AC if needed. The cabinet should be large enough to provide adequate air circulation for cooling. The camera should be clearly visible from the camera cabinet location.

Communications

Camera control signals are carried from the TSMC over singlemode fiber optic cable. The signal is put on multimode fiber optic cable at the communications hub closest to the camera. The multimode cable carries the signal from the hub to the control receiver in the camera cabinet. A control cable connects the control receiver to the junction box and camera.

The video signal leaves the camera via coaxial cable to the junction box, and on to the camera cabinet. The coaxial/fiber optic converter in the camera cabinet puts the signal onto multimode fiber optic cable. The multimode fiber optic cable goes through the camera cabinet to the cable vault, then back to the closest communications hub. The multimode signal is then converted to a singlemode signal at the hub and carried back to the TSMC via singlemode fiber optic cable.

VARIABLE MESSAGE SIGNS

General

For VMS specifications, see Appendix B.3.

Variable Message Signs (VMS) are capable of displaying different messages remotely from the TSMC or a gate control cabinet (such as for reversible lanes). VMS can also be operated locally. Trailer mounted signs are operated locally in District 1, although they are capable of being operated by cellular phone.

VMS are used to give motorists information on accidents, incidents, construction and maintenance activities, reversible lane status, and traction device requirements. Public information notices are also displayed on a limited basis. Road condition information is not displayed because of liability issues.

VMS letters are typically formed by pixels (dots or disks) arranged in a 5 wide by 7 tall matrix. VMS letters are typically 18 inches tall for mainline freeway applications, which gives minimum readability distances of 800 feet.

Many VMS messages are two phase (a phase is the particular part of the message displayed on the sign at that time). A message phase typically lasts between 1.5 and 2 seconds. A car traveling 60 mph has about 9 seconds to read the message on the VMS (if the motorist starts reading at 800 feet), which gives the motorist time to read a 2 phase message under ideal conditions. Because the motorist has other distractions to deal with while driving (including steering), a good location is very important.

Location

The ideal location for a VMS is on a minimum 800 foot section of straight roadway, since the motorist must pay more attention to the road when negotiating a horizontal curve. Permanent VMS should be mounted over a freeway, on a structure or sign bridge.

Sign spacing is also important in VMS visibility. Sign spacing for a VMS should be per other freeway guide signs in the MUTCD.

Technologies

VMS technology can be divided into 3 categories commonly used in the United States: flip (reflective) disk, light-emitting, and light-emitting/flip disk hybrid. The flip disk VMS is the oldest technology, and uses reflected light off of a 2" disk to form the pixel. The light-emitting VMS uses an optical fiber or Light-Emitting Diode (LED) to form the pixel. The hybrid uses a flip disk in combination with light-emitting technology to form the pixel.

The light-emitting and hybrid signs are newer, still-developing technologies that are becoming increasingly popular in the United States because of their increased visibility. Northwest Region has a policy of specifying hybrid or light-emitting technology for new permanent installations. The following is a synopsis of VMS technologies:

Flip Disk

Flip disk VMS are an older technology that uses a 2" yellow/green reflective disk to form a pixel. The reflective disk pivots on its axis by a hinge mounted across its backside. When a blank space is to be shown,

the disk magnetically pivots 180 degrees revealing its matte black backside.

The pixel can be illuminated with a fluorescent or black light. Even with this illumination, though, flip disk signs have notoriously poor visibility at night. On the plus side, flip disk VMS have good visibility (about 800 feet) with the sun shining on them and are the most economical VMS to buy and operate.

Flip disk VMS have proven to be a reliable technology. Northwest Region currently has 26 permanently-mounted flip disk VMS as well as a number of trailer-mounted signs. T-S Systems Inc. and Matrix Media have supplied the vast majority of flip disk VMS in Northwest Region.

LED/Flip Disk Hybrid

This technology forms a pixel by shining a small cluster of LEDs (about 7) through a hole in the reflective disk. When a blank space is to be shown, the disk magnetically pivots 180 degrees and the LED cluster is switched off.

LED/flip disk VMS are very visible day or night (about 1,000 feet), and bright sun will not wash the message out because of the reflective disk. A dimming system should be built into the LED cluster for low light conditions.

This technology is well suited for retrofitting existing flip disk signs. Northwest Region has retrofitted one VMS with this technology and plans to retrofit more. Matrix Media Inc. makes the LED/flip disk VMS.

Fiber optic/Flip Disk Hybrid

This technology forms a pixel by shining a halogen-fed fiber optic light source through a hole in the reflective disk. When a blank space is shown, the disk magnetically pivots 180 degrees and the light is shuttered by a tab on the back of the disk, such that no light escapes.

The fiber optic/flip disk VMS is also very visible in the day or night (at least 1,000 feet). An overbright setting on the dimming control combines with the reflective disk to keep the message from washing out in bright sunlight.

This technology can be retrofitted onto existing flip disk VMS. Northwest Region has retrofitted a VMS with this technology and plans to retrofit more. T-S Systems Inc. and Matrix Media Inc. make fiber optic/flip disk VMS.

Fiber optic

This technology forms a pixel via a pair of halogen bulb-fed fiber optic light sources placed next to each other. When a blank space is shown, the light sources are shuttered so that no light escapes.

The fiber optic VMS is also very visible in the day or night (at least 1,000 feet). These signs are more expensive than flip disk or hybrid signs. An overbright setting on the dimming control keeps the message from washing out in bright sunlight.

District 3 is planning to install some of these signs in the near future. Fiber optic Display Systems (FDS) Inc. are makers of this type of VMS.

LED Cluster

This technology forms a pixel via a cluster of LEDs (usually about 60). When a blank space is shown, the LED is switched off.

The cluster can be composed of red, green or amber LEDs which can be combined to form different colors. This technology is still not developed to the point where uniform combining of LEDs occurs, due to different light levels and light degradation of the LEDs.

The LED cluster VMS is very visible at night but can washout under direct sunlight. Also, cooling systems must be included in the VMS housing due to the heat the clusters generate (which also contributes to the light degradation).

Northwest Region currently has no plans to install any LED cluster VMS until the technology develops further. Ledstar Inc. is among the manufacturers of LED cluster VMS.

Location

The ideal location for a VMS is on a minimum 800 foot section of straight roadway, since the motorist must pay more attention to the road when negotiating a horizontal curve. Permanent VMS should be mounted over the freeway on a structure or sign bridge.

Sign spacing is also important in VMS visibility. Sign spacing for a VMS should be per other freeway guide signs in the MUTCD.

The brighter fiber optic/flip disk hybrid should be specified when the South, East or West sky is visible behind the sign. The LED/flip disk hybrid is more suited for applications where the North, or no sky, is visible behind the sign.

VMS System Components

VMS communication has never been standardized throughout the industry. This means that every sign manufacturer has their own control system. To be compatible with the Northwest Region VMS control system, the VMS controller (a F-P Displays model 1001 or 2001) must be sole sourced. Please see Appendix C for sole source justification, installation diagram and component specification. VMS components are as follows:

Control Cabinet

The VMS cabinet houses the controller, modem, and associated electrical and climate control equipment. The VMS requires 120 volts AC (VAC) for power, which may be stepped down from 480 VAC if needed. The cabinet should be large enough to provide adequate air circulation for cooling. The cabinet is usually mounted to the outside of the VMS support (i.e. sign bridge)

Modem

The modem converts a twisted pair copper data signal to a signal useful to the controller. The modem is 1200 baud.

Controller

The controller locally controls the message display functions of the sign.

Sign Housing

The sign housing contains the display modules, drivers, and air circulation and climate control equipment. A display module consists of one or more 5 by 7 matrix of pixels which form one character.

The sign housing is a rain tight, vented enclosure with a polycarbonate lens in front of the modules. Amber beacons that alternately flash on selected messages are located on top of the housing. Adequate catwalks, tie-offs, and sign access must be provided for maintenance.

Communications

VMS control signals are carried from the TSMC to the communications hub over singlemode fiber optic cable. The signal is put on a 25 twisted pair cable at the communication hub closest to the VMS. A 6 twisted pair lateral cable (2 pairs required) carries the signal from the closest cable vault to the modem and controller. The status signals returning to the TSMC go in the reverse order.

HIGHWAY ADVISORY RADIO

General

For HAR specifications, see appendix B.4.

Highway Advisory Radio (HAR) is used as a driver information system to warn motorists via their car radio of construction and maintenance roadway closures, and major traffic incidents. HAR has an advantage over Variable Message Sign (VMS) in that more detailed information can be relayed to the motoring public, giving them the chance to use alternate routes. Both the Radio Shop and the TSMC should be included in any plan review involving HAR.

Restrictions on Message Content

HAR message content is restricted by federal regulations. WSDOT restricts HAR messages to non-commercial voice information pertaining to traffic and road conditions, major incidents, traffic hazards and travel advisories.

BASIC OPTIONS

All HAR systems contain the following three components: a modulating source, a transmitter, and an antenna system. In the simplest configuration, the modulating source and transmitter are located in pole-mounted weatherproof enclosures at a single site.

MAJOR COMPONENTS OF HAR SYSTEM

HAR SIGNS

HAR signs tell the motorists to tune to the HAR broadcast when beacons above the sign are flashing. HAR signs are typically located on the approaching legs of a major freeway interchange, to give the motorist an alternate route to avoid an incident or closure. Signs should be located far enough from the alternate route to give motorist time to locate radio channel (15-20 seconds), listen to message twice (approx. 60 seconds), and divert to alternate route.

The distance from sign to alternate route on a 55 mph freeway should be approximately 1 1/2 to 2 miles. The distance from the HAR transmitter to its HAR sign should not exceed 2 miles. Existing sign spacing standards should be used when placing HAR sign, except the motorist should not have to take their attention from a difficult stretch of roadway (sharp curves, merges, etc.) to tune radio. HAR signs should be located within sight of a CCTV to visually confirm status of flashing beacons.

Existing HAR sign flashing beacons are controlled by radio signals from the TSMC. When the beacons are turned on or off, a confirmation

DTMF tone signal is returned back to TSMC. A disadvantage to radio control is lack of reliability. If there is radio traffic when the sign is being turned on, or the operator uses the wrong frequency or code, the sign will not be activated. Mainline cable or leased telephone lines should be used in future projects, if feasible, for sign control.

The current standard is **"TRAFFIC ADVISORY/TUNE 530 AM/WHEN FLASHING"**, a 7' by 15', black on yellow, see Figure 28.

B) EXTERNAL ILLUMINATION AND FLASHING BEACONS

These are activated, either remotely or from sign, when there is a HAR broadcast to be heard. We use 8 inch amber flashing beacons with cadet visors. For sign illumination, see standard specification 9-28.16, and Figure 28.

C) ANTENNA AND MOUNT (radio controlled signs)

We use a 3 element beam antenna capable of transmitting and receiving at 151.025 MHz. The antenna is fastened to a sign post with a mast mount.

D) CONTROL CABINET

The control cabinet is a rain proof, lockable enclosure, anodized aluminum, NEMA type 3R with a hinged door, accessible from ground level. Former control cabinets were located high up on the sign, accessible only with a bucket truck. These cabinets are being switched to ground level.

E) TRANSMITTER/RECEIVER

The transmitter/receiver is located in the control cabinet and must be capable of transmitting and receiving at 151.025 MHz.

F) ENCODER/DECODER

The encoder/decoder is located in control cabinet. This units encodes and decodes DTMF tones and reports back to TSMC and on/off status of the HAR sign when external relay is tripped. All of our current HAR signs use Zetron brand encoder/decoders. Zetron should be specified for compatibility with our existing system and reliability.

G) RELAY PANEL AND POWER SUPPLY

The relay panel and power supply are located in control cabinet. The HAR sign uses a 20 amp power supply, fed by 120 volts AC with an output of 12 volts.

H) KEY SWITCH

The key switch allows for control at the HAR sign and is mounted below the sign on a sign post. The key switch has three positions: "manual on" for control of beacons at the HAR sign, "off" to turn the signs beacons and equipment off, and "auto on" to remotely control the sign. The switch shall use an "E 10" key, which is compatible with existing HAR signs.

2) HAR TRANSMITTER

The HAR transmitter is usually located at the interchange that the HAR signs are covering. Typically the transmitter is located within the open area within a loop ramp, since the transmitter's antenna requires a 100 foot minimum radius on the ground. The HAR transmitter should be located on the highest ground possible, to aid reception of the transmission.

The HAR transmitter is controlled remotely from the TSMC, via phone lines or (preferably) mainline cable. The maximum transmitter output is 10 watts.

A HAR transmitter setup consists of the following components:

A) ANTENNA

The antenna is center or top loaded vertical featuring a low-loss, embedded, weatherproof loading coil (similar to a Model SF Morad antenna). The antenna system includes a ground plane consisting of #8 non-insulated copper conductors placed in a horizontal plane a minimum of 100 feet in radius from the antenna.

B) CONTROL CABINET

Control cabinet is an anodized aluminum, weatherproof enclosure, typically NEMA type 3R. The cabinet should be lockable using Design-Builder supplied construction CX series cores and keys.

C) AM TRANSMITTER

The transmitter is located in the control cabinet. The amplitude modulated transmitter must be FCC type accepted, equivalent to an Audiosine brand model AM10WS AM.

D) VOICE STORAGE UNIT

Voice storage unit is located in control cabinet. The voice storage unit shall digitally store 60 seconds of message (input over phone lines or mainline cable). The voice storage unit should be equipped with DTMF control capability. The Zetron model 20 should be specified for it's proven reliability, and compatibility with our existing system.

E) RELAY PANEL AND POWER SUPPLY

Relay panel and power supply are located in control cabinet. The power supply must be capable of operating on 120 volts AC with an output of 12 volts.

CHAPTER 6

COMMUNICATIONS

GENERAL

For specifications, see Appendix B.5.

The Traffic Systems Management Center (TSMC) employs various methods of communication from its central VAX computer to ITS components in the field. Voice, data and video communications are used by TSMC.

TSMC communicates to ITS devices through fiber optic cable, copper twisted pair cable, leased telephone lines and microwave transmission. These communication lines are housed and protected by support structures.

COMPONENTS

Components must be selected as to ensure continuity throughout the ITS system. For this reason, some items may have to be sole sourced, see Appendix B.5 for current specifications and Appendix C for sole-source justification.

Support Structure

The support structure is that which is used to mechanically accommodate the components of the TMS. Hubs, cable vaults, junction boxes, pull boxes, terminal cabinets, conduits and inner ducts are defined as support structures.

Hubs

Communication hubs are used as information gathering points in the field. Data from the field devices is transmitted to a local hub via twisted pair copper and multimode fiber optic cables. This data is converted to a single mode optical fiber and sent to TSMC where it is compiled for immediate use and stored for future use.

Hubs are located throughout the ITS system. Currently the ITS system extends on I-5, from Federal Way north to Lynnwood, along I-405, on SR 520, from I-5 east to I-405, and on I-90, from I-5 east to Issaquah. Hubs are typically spaced at ten mile intervals, and at major interchanges, to facilitate redundant communication links.

Cable Vaults

See Figure 29 for a typical cable vault detail.

Cable vaults are used as pull points, splice locations, if approved, and where the mainline conduit has major changes in direction. They are also used whenever mainline communications conduit changes from PVC to GRS and visa versa, i.e. when the conduit is attached to a bridge. At least 50 feet of cable should be coiled and racked at all cable vaults.

Pull Boxes
See Figure 30 for a typical pull box detail.

Pull boxes are typically spaced at 1000 foot intervals along mainline conduit runs. Pull boxes, as their name implies, are used as intermediate pull points where cable vaults are not needed. Pull boxes are generally smaller than cable vaults. Pull boxes may be used in jacking operations. Splices are not allowed in pull boxes.

Junction Boxes
See Standard Plan J-11a for typical junction box details.

Junction boxes can be used as "pullpoints" for copper twisted pair. Type 2 should be used as a minimum for mainline communication cables. The loops are spliced in the junction box to shielded lead-in cables which runs to the loop amplifiers in the cabinet.

Junction boxes used for lateral cable runs may be type 2 or 3, with a special lid when there may be traffic on the box. This may be different if there is either no traffic or continuous traffic on the junction box. See Standard Plan J-11a.

Generally, in grade junction boxes are sized following standard Plan J-11a:

Conduit Diameters	Junction Box Type
>0" to 6"	1
>7" to 12"	2
>13" to 18"	3
>18"	see district electrical inspector

All sizing of junction boxes, whether in grade or structure mounted, shall also meet the requirements of the National Electrical Code, Section 370-18.

Terminal Cabinets
Terminal cabinets shall be anodized aluminum NEMA type 3R. Terminal cabinets are splice points for the mainline twisted copper communication cable, when a camera control cabinet is not used as such. Terminal cabinet spacing is based on the distance the cable can physically be pulled, generally taken to be 1600 to 1800 feet. Terminal cabinets shall not be placed at a low point in the roadway alignment, unless the conduits can be drained prior to entering the cabinet. (Std. spec 9-29.25 - Sizes Terminal Cabinet). All splices to the twisted copper communication cable are done above ground in a terminal cabinet. See Figure 3.

Terminal cabinets should be sized depending on how many cables and what type of equipment will be housed inside, i.e. camera line amplifiers, number of terminal blocks, etc. Therefore, there is no standard size terminal cabinet, however, continuity throughout a job should be considered.

A terminal cabinet is also used to connect the mainline twisted copper communications cable with a controller, via a lateral communications cable. This lateral will range in size from a 6 to 12 pair cable, each pair is copper #22 AWG (same as mainline cable). Lateral size depends on how many pairs are needed at the controller cabinet. Spare pairs should be included. See Figure 3, 13, 14 and 15.

Conduit

Conduit is used to protect communication cables. Our mainline communications use 2-four inch conduits. The conduit is either buried in a trench or attached to structures, such as bridges. When buried, schedule 40 PVC conduit is encased in red tinted concrete and buried in a trench with fiber optic warning tape and a #4 insulated THWN-XHHW location wire. When attached to structures, Rigid Galvanized Steel, RGS, must be used along with approved mounting brackets. The WSDOT headquarters bridge section may have to be contacted when planning to attach conduit to a bridge. It is suggested that this be done early in the PS&E stage. All mainline communication conduit is to have four-1.12 inch factory silicon lined and installed, smooth walled, inner ducts.

Communication Lines

The TSMC communicates to field devices through fiber optic cable, copper twisted pair cable, leased telephone lines and microwaves.

For fiber optic specifications, see Appendix B.5.

Fiber optic cable is able to carry large quantities of data on a single fiber. Fiber optic cable is used for its communication efficiency and to avoid the use of a bulky mainline copper twisted pair communication cable.

Single mode fiber optic cable is used for mainline long-haul communications from hubs to the TSCM. Multimode fiber optic cable is used for short-haul communications, from the hubs to the field devices. Copper twisted pair is also used to communicate from hubs to field devices.

Leased telephone lines are used when a field device is placed where no other communication options are available. They are also used for temporary communications until normal communications can be restored or brought to that location. A request for phone lines is made to Utilities during the PS&E stage of a project. Provisions need to be made during design to allow phone hookup, i.e. conduit to the nearest phone box, pull wire, etc.

Microwave is used on SR 520 to relay video from the CCTV's on the east side of Lake Washington to TSMC. Microwave is used because currently no coaxial or multimode cable spans across Lake Washington. Once fiber spans the lake, the CCTV microwave communication will be replaced with fiber optics.

Examples of a combination of mainline communication cable and leased telephone lines and a combination of a mainline communication cable and fiber optics are shown in Figures 13 and 14.

In Figure 14, leased telephone lines are brought into a cabinet dedicated as a communication cabinet. This communication cabinet is a relay point from all connecting data station/ramp meters to TSMC. Since the data station/ramp meters transmit with modems, modems are not required in this communication cabinet, only terminal blocks for connection with phone company interfacing equipment. This communication cabinet should be large enough to house all phone company equipment needed. The mainline cable and laterals then continue the communications out to the controller cabinets.

In Figure 15, the mainline cable brings the data from the controllers and camera cabinets (Chapter 3: CCTV) on twisted pairs and coaxial cable back to a communications hub . This data is then put onto singlemode fiber and sent to the TSMC.

Figure 14.

Figure 15.

LOOP NAMING

LOOP NAMING SCHEME

A loop name contains exactly seven characters. The underscores are considered characters and are therefore necessary. A loop name is found by selecting one item from each column in table #1 (Roadway, Direction, Lane Type, and Lane Number). These items are then concatenated into a loop name. The correct item is found by following the conventions in the list of rules below. Special loops that need to be identified to the 170 are shown in table #2.

Speed loops must also be identified to the 170. These loops are identified by XXXXXSX. To find the corresponding loop for the trap, match each X in XXXXXSX to each X in XXXXX_X.

Table #3 shows some loop name examples from Figure 16.

TABLE #1

ROADWAY	DIRECTION	LANE TYPE	LANE NUMBER
_M - Mainline	S - Southbound (SB)	_X - Exit-Ramp	_1
_C - Collector/Distributor	N - NB	_O - On-Ramp	_2
_R - Reversible	E - EB	RA - Right Advanced Queue	_3
AM - Auxiliary Mainline	W - WB	LA - Left Advanced Queue	_4
AC - Auxiliary C/D		_Q - Queue Loop	_5
AR - Auxiliary Reversible		_I - Intermediate Queue Loop	_6
MM - Metering Mainline		_D - Demand Loop	_7
MC - Metering C/D		_P - Passage Loop	_8
MR - Metering Reversible		HX - HOV Exit Ramp	_9
		HO - HOV On-Ramp	S1 Speed Loop L-
		HD - HOV Demand Loop	S2 Speed Loop L-
		HP - HOV Passage Loop	S3 Speed Loop L-
		H_ - HOV Mainline	S4 Speed Loop L-
		___ - Mainline	S5 Speed Loop L-
			S6 Speed Loop L-
			S7 Speed Loop L-

S8 Speed Loop L-8

S9 Speed Loop L-9

TABLE #2 (170 Control Loops)

Function Name	Lane 1	Lane 2	Lane 3
Passage	XXX_P_1	XXX_P_2	XXX_P_3
Demand	XXX_D_1	XXX_D_2	XXX_D_3
Inter. Queue	XXX_I_1	XXX_I_2	XXX_I_3
Queue	XXX_Q_1	XXX_Q_2	XXX_Q_3
Adv. Queue Right	XXXRA_1	XXXRA_2	XXXRA_3
Adv. Queue Left	XXXLA_1	XXXLA_2	XXXLA_3
Station Loops	MXXXXXX	Same as 1	Same as 1
HOV Demand	XXXHD_1	XXXHD_2	XXXHD_3
RED CURRENT	Pin 75 (Det 35)	Pin 63	Pin 78 (Det 38)
YELLOW CURRENT	Pin 76 (Det 36)	Pin 64	Pin 79 (Det 39)
GREEN CURRENT	Pin 77 (Det 37)	Pin 65	Pin 80 (Det 40)

NOTES: X = DON'T CARE
Pin refers to the pin number in the 170 C1 connector

TABLE #3 (SAMPLE NAMES, SEE FIGURE 16.)

ES 10R 5 45 Ave NE - NB

DETECTOR	LOOP NAME
1	_ M N H _ _ 3
2	M M N _ _ _ 2
3	M M N _ _ _ 1
4	_ M N _ P _ 1
5	_ M N _ D _ 1
6	_ M N _ I _ 1
7	_ M N _ Q _ 1
8	_ M N R A _ 1
9	_ M N L A _ 1
10	_ M N _ X _ 1

Figure 16.

NAMING RULES:

1. All loops of similar type are named from upstream to downstream.

2. All multi-lane roadways will be named from right to left while looking downstream. If one or more lanes are HOV, the lanes will be numbered the same as if they were a general purpose lane.

3. Each HOV lane bypass will have the same lane number as ramp lane number that it bypasses.

4. Speed loops will have an "S" before the lane number.

5. Ramp meter lanes will be named from right to left and upstream to downstream. All existing ramp meter lanes are numbered "2".

DIRECTION RULES:

1. All loops will have a direction code "N" for Northbound, "S" for Southbound, "E" for Eastbound, and "W" for Westbound.

2. Reversible roadways will use the direction of increasing milepost. The I-5 Express lanes would be considered as Northbound.

ROADWAY NAMING RULES:

1. Each cabinet is assigned a principle roadway. If a cabinet on I-5 (principle roadway) has loops on I-90, then the I-90 loops are consider auxiliary and have a roadway type beginning with "A". In the case of on-ramps and exits, the principle name will prevail. If a loop could be called an exit from I-90 and an on-ramp to I-5, then it would be called an on-ramp.

2. Loops that are to become part of a ramp metering station will have a roadway type beginning with "M", including speed loops. HOV lanes **do not** have the roadway type beginning with an "M".

3. All loops must have a roadway type. On-ramps and exits will have the roadway type that enter or leave.

LANE TYPE NAMING RULES:

1. All loops will have one lane type.

2. Each metered lane can have two advanced queue loops, one right movement and one left. 'RA' and 'LA'. If no movement is associated with the advanced queue loop, then use 'RA'.

3. Each metered lane can have up to two queue loops and two intermediate queue loops, depending on the ramp length. The queue loops and intermediate queue loops will be evenly spaced, 200 feet to 500 feet apart, again depending on the ramp length.

4. Use '_X' for exit ramps and '_O' for on-ramps, that are not metered.

5. HOV loops have an 'H' as the first lane type character.

6. Metered Loops:

'RA'	Advanced Queue Right
'LA'	Advanced Queue Left
'_Q'	Queue
'_I'	Intermediate Queue
'_D'	Demand
'_P'	Passage

7. Use '_ _' or '_ H' for mainline loops.

STATION NAMING SCHEME

1. All station names will contain a roadway and direction type followed by either _Stn or HStn.

2. This naming scheme will only work for mainline, collector, reversible lanes and HOV lanes on these roadway types.

CURRENT SPECIFICATIONS

I. SPECIFICATIONS FOR RAMP METERING/DATA STATIONS

These specifications shall be used if expansion and/or retrofitting of a ramp meter or data station is specified on a project.

Model 170 Controller

Each controller unit furnished shall meet the requirements specified in Chapter 2 of the Type 170 Traffic Signal Control System Hardware Specification, FHWA IP-78-16, as currently amended and modified as follows:

1. Model 412C PROM modules shall be provided. The PROM modules shall have 4 kB of zero power RAM addressed at 7000-7FFF and 32 kB of 27256 EPROM addressed at 8000-FFFF.

2. The 170 controller shall have 2 kB of battery backed static RAM on the motherboard addressed at 0000-07FF.

3. The system PROM module shall utilize INTEL 27256 EPROM chips, or equal. Three blank 27256 EPROM chips shall be provided on the system PROM module.

4. A minimum of 8,000 bytes of RAM memory (with battery support) shall be provided.

5. Furnish a second asynchronous communication interface adapter (ACIA) located on the same board as the CPU. Set the second ACIA to transmit at 19,200 bits per second. Set the first ACIA to transmit at 1200 bits per second.

6. Each controller shall have an ACIA C20 wrap-around, meeting the requirements of the step test.

7. Provide a hardware reset button mounted on the front panel or just behind the front panel with each controller. If installed behind the front panel, the button shall be readily accessible when the front panel is opened.

8. In addition to the field side Model 400 modem provided with each controller, furnish a second office side Model 400 modem separately for the TSMC.

Model 334 cabinet

Each ramp meter/traffic data station controller cabinet furnished shall meet the requirements specified in Chapter 12 of the Type 170 Traffic Signal Control System Hardware Specification, FHWA IP-78-16, as currently amended except as modified by the following:

Cabinet Construction

1. The cabinet shall be fabricated from anodized sheet aluminum.

2. Each cabinet door shall be provided with a Design-Builder supplied spring-loaded construction core lock, with one master and one core key per cabinet, capable of accepting a Best Lock Company CX series core furnished by others.

3. The visual alarm light shall not be provided.

4. The alternate raceway as specified in the addendum to Chapter 18 will not be allowed.

5. Field wire terminals shall be labeled in accordance with the ITS Field Wiring Chart.

6. Two shatterproof fluorescent interior cabinet lights with self-starting ballast, one fixture mounted on the rear rack near the top and the second mounted at the top of the front rack shall be furnished. Door switches shall automatically turn on both lights when either door is opened.

7. One controller unit shelf which attaches to the front rails of the EIA rack shall be provided in lieu of the two controller unit support angles. The shelf shall be fabricated from aluminum and shall be installed such that it does not interfere with access to any terminal block. The shelf shall contain a roll-out flip-top drawer for storage of wiring diagrams and manuals.

Cabinet Ventilation and Heating

A disposable paper filter element of at least 30 square inches shall be provided in lieu of a metal filter.

Cabinet Accessories

1. Each Model 334 cabinet shall be equipped with a type 170 controller. The 170 controller shall have 2 kB of battery backed static RAM on the mother board and addressed at 0000-07FF.

   Model 412C PROM Module shall be provided and shall have 4 kB of zero power RAM addressed at 7000-7FFF and 32 kB of EPROM (27256) addressed at 8000-FFFF.

2. Two input files, each using 5.25 inches of rack height, shall be supplied.

   Model 222 amplifiers shall be provided, one for every two loops or a total of eight, whichever is greater.

3. Power Distribution Assembly

   The power distribution assembly shall be PDA #3 as detailed in the January 1989 CALTRANS amendment to the FHWA specification.

   The PDA #3 shall contain three Model 200 Load Switches.

   A transient voltage protection device, which plugs into the controller unit receptacle and in turn accepts the controller plug and meets the electrical requirements of Section 9-29.13(7)B(3)f, shall be provided.

   A second transfer relay, Model 430, shall be mounted on the rear of the PDA #3 and wired as shown in the Plans.

   Terminal block T1 and T4 shall be labeled as follows:

T1-1	571	Neutral
T4-1	611	Lane 1 - Red
T4-2	612	Lane 1 - Yellow
T4-3	613	Lane 1 - Green
T4-4	621	Lane 2 - Red

T4-5	622	Lane 2 - Yellow
T4-6	623	Lane 2 - Green
T4-7	631	Lane 3 - Red
T4-8	632	Lane 3 - Yellow
T4-9	633	Lane 3 - Green

4. Police Panel

The police panel shall contain only one DPST toggle switch. The switch shall be labeled "POLICE CONTROL", "ON-OFF".

5. Display Panel

General One display panel shall be furnished with each cabinet. The panel, showing and providing detection for inputs and specified controller outputs, shall be mounted at the top of the front rack above the controller unit. The display panel shall be constructed according to the detail in the Plans.

Text All text on the display panel shall be silk screened directly to the panel except the phenolic detector and cabinet nameplates. These nameplates will be engraved with a 0.25 inch nominal text according to the ITS Field Wiring Chart. One nameplate shall be provided for each loop shown in the ITS Field Wiring chart. The nameplates shall be semi-permanently affixed to the display panel.

LEDs The LEDs for the display panel shall meet the following specifications:

Case size	T 1-3/4 inches,
Viewing angle	50 degrees minimum,
Brightness	8 milli-candelas.

LEDs with RED, YELLOW or GREEN as part of their labels shall be red, yellow or green in color. All other LEDs shall be red.

Detector Display Control Switch One detector display control switch shall be provided on the panel with labels and functions as follows:

ON
Detector display LEDs will operate consistent with their separate switches.

OFF
All detector indicator LEDs shall be de-energized. Detector calls shall continue to reach the controller.

TEST

All detector indicator LEDs shall illuminate and no calls be placed to the controller.

Advance Warning Sign Control Switch One advance warning sign control switch shall be provided on the panel with labels and functions as follows:

AUTOMATIC
Sign Relay shall energize upon ground true call from controller.

SIGN OFF
Sign Relay shall de-energize.

SIGN ON
Sign Relay shall energize.

Sign Relay The sign relay shall be plugged into a socket installed on the rear of the display panel. The relay shall be wired as shown in the plans. The relay coil shall draw (or sink) less than 50 milliamperes from the 170 controller and have a DPDT contact rating not less than 10 amperes. A 1N4004 diode shall be placed across the relay coil to suppress voltage spikes. The anode terminal shall be connected to terminal #7 of the relay as labeled in the plans. The relay shall energize when the METERING indicator LED is lit.

Detector Input Indicators One display LED and one spring-loaded 2-position SPST toggle switch shall be provided for each of the 40 detection inputs. These LEDs and switches shall function as follows:

TEST
When the switch is in the test position a call shall be placed to the controller and the associated LED shall be energized. The switch shall automatically return to the run position when it is released.

RUN
In the run position the LEDs shall illuminate for the duration of each call to the controller.

Controller Output Indicators The display panel shall contain a series of output indicator LEDs mounted below the detection indicators. The layout shall be according to the detail in the Plans. These LEDs shall illuminate upon a ground true output from the controller via the C5 connector.

The output indicator LEDs shall have resistors in series to drop the voltage from 24 volts DC to their rated voltage and limit current below their rated current. The anode connection of each LED shall be wired to +24 VDC through the resistor.

Connectors Connection to the display panel shall be made by three connectors, one male (labeled P2) and one female (labeled P1) and one labeled C5. The P1 and P2 connectors shall be 50 pin cannon D-series, or equivalent 50 pin connectors, and shall be compatible such that the two connectors can be connected directly to one another to bypass the input detection. Wiring for the P1, P2 and C5 connectors shall be as shown in the Plans.

6. Connectors

Connectors P1, P2, C1P, C2, C4, C5 and C6 shall be furnished. These connectors shall be wired according to the pin assignments noted in the Plans.

7. Cabinet Wiring Diagram

One reproducible drafting film and two non-fading copies of the cabinet wiring diagram shall be furnished with each cabinet.

Cabinet Wiring

1. Cabinet wiring shall conform to the details and diagrams in the Plans. Wiring shall be trimmed to eliminate all slack and shall be laced or bound together with nylon wraps or equal. All terminals shall be labeled. The cabinet shall be completely wired so that the only requirement to make a field location completely operational is to connect field, power and ground wires to appropriate terminals.

2. Terminal Block

Terminal blocks TB1 through TB9 shall be installed on the Input Panel. Layout and position assignment of the terminal blocks shall be as noted in the Plans.

Terminals for field wiring in traffic data and/or ramp metering controller cabinets shall be numbered and connected in accordance with the following:

Terminal and Wire Numbers	Terminal Block Pos.	Connection Identification
501-502	TBS	AC Power, Neutral
T1-1	571	Neutral
T4-1	611	Lane 1 - Red
T4-2	612	Lane 1 - Yellow
T4-3	613	Lane 1 - Green
T4-4	621	Lane 2 - Red
T4-5	622	Lane 2 - Yellow

T4-6	623	Lane 2 - Green
T4-7	631	Lane 3 - Red
T4-8	632	Lane 3 - Yellow
T4-9	633	Lane 3 - Green

Loop lead-in cables shall be connected to cabinet terminals according to Field Detector Number below and the cabinet details. Loop lead-in cables and engraved phenolic detector nameplates shall be labeled as specified under Detector Label.

SAMPLE CABINET CHART ONLY

Cabinet chart for:

ES -XXXX - Location
MP X.XX

DETECTOR	LOOP NAME
1	_ M S _ _ _ 1
2	_ M S _ _ _ 2
3	_ M S H _ _ 3
4	_ M S _ _ S 1
5	_ M S _ _ S 1
6	_ M S H _ S 3
7	_ M N _ _ _ 1
8	_ M N _ _ _ 2
9	_ M N H _ _ 3
10	_ M N _ _ S 1
11	_ M N _ _ S 2
12	_ M N H _ S 3

Amplifier, Transformer, and Terminal Cabinets

Designer Note:
It is the responsibility of the designer to properly size all cabinets and provide proper power requirements.

Terminal cabinets furnished for this contract shall be of the pedestal type fabricated in accordance with Section 9-29.25 except:

1. The cabinet shall be fabricated from anodized sheet aluminum.

2. Nominal cabinet dimensions shall be 10.5 inches wide by 7.5 inches deep by 43.75 inches high.

3. The cabinet shall have:

a. Two hinged and gasketed front doors with spring loaded locks. Best CX series cores will be supplied and installed by others.

4. One or more Type R66B quick connect terminal blocks, as necessary to accommodate the cables, shall be mounted on a backboard in the cabinet.

a. Each block shall contain 50 rows with six clips each.

b. Each row shall be clearly and permanently marked with the number of the cable pair which is attached.

c. Within each row, the clips shall be electrically connected within the block so as to form two sets of three adjacent clips.

d. A special press-on tool which is used to attach field wires to the clips shall be furnished with each cabinet.

5. Barrier-type terminal block(s) shall also be furnished and mounted to the backboard.

Power Transformer and Cabinet - ITS
Description
The Design-Builder shall install transformers and cabinets at the locations shown in the plans.

Materials
Transformers
The transformers to be general purpose, totally enclosed, non-vented, resin encapsulated, two wire, 60 Hz, 480/120 volt, single phase with two 5 percent full capacity taps below normal on primary windings. The transformers shall be indoor/outdoor type dry transformers rated at 5 and 3 kVA.

Transformers shall be UL listed for indoor/outdoor mounting and designed for a maximum temperature rise of 115 degrees Celsius above a 40 degree Celsius ambient.

All transformer coils, buss bar and all connections shall be copper.

A service ground rod shall be installed at each transformer location.

Transformer Cabinet
The transformer cabinet shall be fabricated from anodized sheet aluminum and shall be a NEMA Type 3R. The cabinet shall be a 48-inch high by 22-inch wide by 16-inch deep nominal size. It shall be a single door enclosure. All seams shall be continuously welded. All exterior hardware shall be stainless steel. A drip shield shall be provided. A solid neoprene gasket shall be used to provide a watertight seal around the doors. Louver type vents shall be furnished to provide a minimum of 9 square inches for ventilation.

Inside the cabinet there shall be two separate compartments, one for the transformer and one for the power distribution circuit breakers. Each compartment shall be enclosed with a dead front to completely isolate and protect the live parts of the assemblies. The dead fronts shall have labels attached to identify the circuits that each breaker controls.

The cabinet door shall be provided with a stainless steel hinge and a two position door stop assembly. A waterproofed wiring diagram for the installation shall be attached to the inside of the door.

Traffic Signal Standards
Traffic signal standards shall be furnished and installed in accordance with the methods and materials noted in the applicable Standard Plans, pre-approved plans, or special design plans.

Type 1 traffic signal standards shall conform to Standard Plan J-7a with the following modifications:

1. The base plate and slip base assembly shall conform to details on Standard Plan J-1b except the base plate and slip base assembly shall be fabricated from 1-inch A 36 plate; clamping bolt torque and anchor bolt torque shall be 50 foot pounds and the radius of the center hold in the base plate and slip base assembly shall be 2 inches.

2. All cables entering the standard shall be fitted with fused in-line quick disconnects.

Construction Requirements
Section 8-20 is modified by the following:

Existing Conduit
The Design-Builder shall install new electrical conductors in existing conduits.

All existing conduits shall be cleaned with an approved cleaning and sizing mandrel prior to pulling in new wire.

Where existing conduit runs contains wire that is of short length, the Design-Builder may leave existing wiring in place, using a fish tape or other method approved by the State's Engineer to install the new wires. If the Design-Builder encounters difficulty in accomplishing this, the Design-Builder shall remove the existing conductors, clean the existing conduit with an approved cleaning and sizing mandrel and reinstall the existing wires together with the new wires.

Conduit

All lateral conduit shall be hot-dip galvanized steel conduit.

The Design-Builder shall install conduit in paved shoulder or roadway areas by jacking, drilling or the use of an air ram. Open cutting of the pavement for any reason shall not be allowed.

All conduit shall employ cast malleable iron fittings that are hot-dip galvanized after fabrication.

Wiring
Lateral Control Cable
The Design-Builder shall pull continuous lengths of lateral control cable in existing and new conduits between field cabinets and terminal cabinets to connect field mounted equipment with mainline communication cable as shown in the Plans

The Design-Builder shall identify and label the lateral communication cables in all terminal and field cabinets installed by this contract. Labeling of the cables shall consist of affixing a wrap type tag within 1 foot from the end of the cable jacket such that cable identification can be made from within the cabinet. This tag shall indicate the cabinet number (e.g. ES 089D) to which the cable is running.

Lateral Control Cable Test
The Design-Builder shall test each pair of 25 TWP cable and 6 TWP cable installed. The tests shall include continuity, signal-to-noise, and loss at 1 kHz, from hub to end of mainline pairs and hub to end of lateral pairs. The Design-Builder shall repair or replace any cable segment containing any pairs exhibiting discontinuity. Signal-to-noise measurements shall be better than 55 dB, and 1 kHz signal loss measurements shall be less than 2 dB per mile.

Induction Loop Vehicle Detectors - General
Induction loops shall meet the requirements of Sections 8-20.3(14C and D, except as supplemented or modified below).

The Design-Builder shall first mark loop positions at the stations shown in the Plans. Sawcutting shall begin only after these locations have been verified by the State's Engineer.

Sawcuts shall be constructed using a self-propelled power saw equipped with a diamond or abrasive blade. The saw shall be equipped with a depth gauge and horizontal guide to assure the proper depth and alignment of the cut.

Sawcuts shall be smooth continuous ducts, free of projections and rough edges. All corners shall be rounded using a file or other appropriate method to prevent damage to the conductor insulation during installation.

Loop wire shall be installed in a manner to avoid abrading or otherwise damaging the insulation. To further reduce the chance of damage, the loop wire shall be taped a minimum of two turns at each sawcut corner.

The State's Engineer will inspect all loop wire installations prior to the application of sealant.

Measurement
No specific unit of measurement will apply.

Payment
All costs for traffic data station/ramp metering, traffic data station - revised, lateral control cable, conduit, and junction boxes, shall be included in the lump sum contract price for "Traffic Data Accumulation and Ramp Metering System".

Figure 17.

Figure 18.

Figure 19.

Figure 20.

Figure 21.

Figure 22.

II. SPECIFICATION FOR CLOSED CIRCUIT TELEVISION

These specifications shall be used if expansion and/or retrofitting of the closed circuit television (CCTV) surveillance system is specified on a project.

A. VIDEO DISTRIBUTION SYSTEM

Description

This work consists of providing and installing a video distribution system for carrying CCTV video signals over multimode fiber optic cable (62.5/125 um) up to 5 miles. This system shall equip or retrofit each camera control cabinet, or camera location, with a fiber optic video transmitter for conversion of the video signal to an optical signal and transmission over multimode fiber optic cable to the associated video hub. The system shall also equip each video hub with a corresponding fiber optic video receiver to receive and convert the optical signal back to a video signal. At the communications hub, the fiber optic receiver shall be installed in the Design-Builder provided shelves.

If the models specified have been superseded by a product that is interchangeable, the new product shall be provided. If the product is no longer available, and has no replacement, the Design-Builder shall propose a different product meeting the performance and material specifications of the discontinued product.

The Design-Builder shall provide any attenuators on the shorter links.

Materials

Video Distribution System Cabling

The Design-Builder shall utilize multimode fiber optic cable for the transmission medium in this item.

The Design-Builder shall provide and install all required equipment interconnection cabling to include RG-59 video coaxial cables, for runs up to 1000 feet, or RG-11 video coaxial cables for runs from 1000 to 2500 feet, power cables, ancillary cables, and connectors as recommended by the equipment vendor.

Optical Transmitter and Optical Receiver

For CCTV locations where camera control is via 6 pair copper. the video transmitter and receiver system shall be manufactured by American Fibertek, Inc. This equipment shall transmit video one way at 1300 nm over multimode fiber optic cable.

1. Model Numbers:

Video Transmitter	MT-130
Video Receiver	RR-130
Shelf	SR-20/1

2. Manufacturer:

American Fibertek Inc.
1662 63rd St.
Brooklyn, NY 11204
Telephone (718)236-1797

For CCTV locations where camera control is via multimode optical fiber, the video transmitter and receiver system shall be manufactured by Optelecom, Inc. This equipment shall transmit video one way at 1300 nm over multimode fiber optic cable.

1. Model Numbers:

Video Transmitter	3710AT-L-ST-L-62
Video Receiver	5710AR-L-ST-L-62
Shelf	System 5000 Chassis
Power Supply	5031/4D
Adapter	5005G

2. Manufacturer:

Optelecom, Inc.
9300 Gaither Rd.
Gaithersburg, MD 20877
Telephone (301)840-2121

If the models specified have been superseded by a product that is interchangeable, the new product shall be provided. If the product is no longer available, and has no replacement, the Design-Builder shall propose a different product meeting the performance and material specifications of the discontinued product.

Measurement
No specific measurement will be made.

Payment
The lump sum contract price for "Video Distribution System" shall be full pay for performing the work as specified.

B. CLOSED CIRCUIT TELEVISION SYSTEM

Description

This work consists of providing for the expansion and retrofit of television surveillance to include provision and installation of camera assemblies (camera, lens, and housing), pan and tilt drives, camera control receivers, and other equipment necessary to provide a complete and operable fiber optic-based closed circuit television (CCTV) system.

If the models specified have been superseded by a product that is interchangeable, the new product shall be provided. If the product is no longer available, and has no replacement, the Design-Builder shall propose a different product meeting the performance and material specifications of the discontinued product.

The transmitter and receiver shall be compatible with EIA 250B long haul specifications.

The transmitter and receiver shall be capable of video transmission over multimode fiber over a 1300 nm wavelength.

The transmitter and receiver shall meet technical specifications as detailed in the Plans.

Materials

Conductors, Cables
The Design-Builder shall supply and install cables between the receiver and the camera, the camera lens, and the camera pan-and-tilt units, at the top of the pole, to the field equipment located in the associated field cabinet. These cables shall be MPC-CA-236 for the camera and MPC-CA-238 for the pan and tilt unit.

Television Camera Assembly
The television camera assembly shall consist of a color camera, camera housing, pan-and-tilt unit, motorized zoom lens, camera control and video cables, and pole mounted junction box described as follows.

Pole Mounted Junction Box
A 10-inch by 8-inch by 4-inch weatherproof NEMA 4X junction box shall be installed at the top of the pole as detailed in the Plans.

Television Camera
Television cameras shall be by COHU and shall be equipped with a multi-line programmable alpha-numeric identification character generator and a rain/sun shade that extends a minimum of 4 inches beyond the camera housing.

1. Equipment Model Numbers:

COHU Camera	8215-1000, with
10:1 Zoom Lens	P10J
Programmable Source Identification Generator	ER4226K
Environmental Enclosure	ER4565E
Camera Control	ER4841A

2. Manufacturer:
   COHU
   5755 Kearny Villa Road
   P.O. Box 85623
   San Diego, CA 92138-5623
   Telephone (619) 277-6700

Pan and Tilt Drive

The Design-Builder shall provide and install weatherproof heavy duty pan and tilt drive assemblies as shown in the Plans.

Pan and tilt drive shall be by Pelco.

1. Equipment Model Numbers:

   Pan and Tilt PT1250P/PPT

2. Manufacturer:

   Pelco
   300 West Pontiac Way
   Clovis, CA 93612-5699
   Telephone (209) 292-1981
   (800) 421-1146

The pan and tilt drives shall meet the specified performance requirements within the field operating ambient temperature range as specified in the Special Provisions.

The pan and tilt drives shall be capable of remote control from the TSMC when used with the specified control receiver (COHU Model MPC-D-111/51, ER4226B, ER1074C).

The pan and tilt drives shall be capable of simultaneous pan and tilt movement and preset positions.

The pan and tilt drives shall be capable of meeting specifications when mounted outdoors in an inverted position.

The pan and tilt drives shall be capable of horizontal panning of 355 degrees. Externally adjustable limit stops shall be provided to permit smaller angles of horizontal movement.

The pan speed when loaded with the specified camera assembly shall be at least 5 degrees/second.

The pan and tilt drives shall utilize main worm gears to prevent overshoot.

The pan and tilt drives shall be capable of providing a vertical tilt of at least +90 to -90 degrees from a level position. Externally adjustable limit stops shall be provided to permit smaller angles of vertical movement.

The tilt speed when loaded with the specified camera assembly shall be at least 2.5 degrees/second.

The drives shall have a minimum torque of 50 ft-lbs.

The Design-Builder shall adjust the limit switches for each pan and tilt drive as designated by the State's Engineer.

Dynamic braking shall be provided for each pan and tilt drive to prevent drift and large worm gears shall be used to minimize backlash.

The exterior finish shall be suitable for an outdoor environment.

The cable from the camera shall be attached to the pan and tilt drive in accordance with the camera manufacturer's specifications.

The pan and tilt drives shall operate on the 120 VAC from the control receiver. The drives shall be powered and controlled through a multi-pin weather-resistant connector attached to the base section of the unit and which remains stationary when the top section pans and tilts. The unit shall incorporate electrical filtering to minimize interference. Grounding shall be provided by the manufacturer.

Camera Control Receivers

The control receivers shall be provided and installed by the Design-Builder and shall be by COHU. Firmware for the control receiver shall be programmed specifically for the specified pan and tilt drive.

1. Equipment Model Numbers:

   Camera Control Receiver MPC-D-111/51, ER4226B, ER1074C

2. Manufacturer:

   COHU
   5755 Kearny Villa Road
   P.O. Box 85623
   San Diego, CA 92138-5623
   Telephone (619) 277-6700

The camera control receiver shall support the following:

1. RS422 programmable camera identifier.

2. Preset positioning of the pan and tilt and the lens.

3. RS422 command control signals from TSMC to the COHU master.

The control receivers shall be installed in the camera cabinets as shown in the Plans.

Field Camera Support - TV Camera Pole

TV camera poles shall be fabricated and installed as specified in the Plans.

The poles shall be field painted as follow:

The primer shall meet the requirements of Federal Specification TT-P-641, Primer Paint, Zinc Dust, Zinc Oxide, Type III.

One primer coat of 3-mil wet thickness shall be applied.

The finish coats shall be State Standard formula C-9-86, Phenolic Finish Coat for Steel.

Finish coats shall be pigmented to match color chip number 37056, Federal Standard Number 595 A.

Two finish coats of 3-mil wet thickness each shall be applied.

Fiber optic Interface Equipment
The Design-Builder shall provide equipment for this item which has been made by one of the following manufactures:

1. Catel Telecommunications, Inc.
2. American Fibertek, Inc.
3. Math Associates, Inc.

Field Cabinets
The Design-Builder shall provide and install field cabinets at the locations and as detailed in the Plans.

Each cabinet shall be equipped with a Design-Builder-provided, flush, spring-loaded construction core lock, with one master and one core key per cabinet, capable of accepting a Best Lock Company CX series core.

Cabinets shall be constructed of anodized sheet aluminum

Drawings
Shop drawings of the following items shall be submitted for review and approval prior to fabrication of the controller cabinets:

One Line Diagrams
Panel Layout Drawings
Panel Detail Drawings
Panel Terminal Assignments
Internal Wiring Diagrams
Equipment Schedule

Construction Requirements

Cable Installation
The Design-Builder shall submit to the State's Engineer the method that is intended to be used to install the various cables. Any cable runs which have damaged jackets or do not pass the appropriate test will be rejected and shall be replaced by the Design-Builder at no additional cost to the State.

Shielded cables terminated at a cabinet shall have their shields grounded at the cabinet at one end and insulated at the other. Insulated spade type terminals shall be used when connecting wire to terminal blocks.

Cables at the camera end shall be soldered to the connectors provided with the equipment using established techniques.

The rear connection area shall be filled with RTV silicon rubber compound. The cables to the camera shall be encased in a flexible sheath to form one cable between the camera and the local junction box cable grips.

All cables shall be tagged with permanent markers of PVC identifying their use. Cables shall be tagged at both ends and at every junction box location.

Television System Performance Test
The Design-Builder shall provide all required test equipment and shall carry out the test as specified in the Plans. The Design-Builder shall provide camera

control switches and portable control console for functional testing, which will become property of the State.

This test shall be started after all of the following conditions are met:

1. Installation of the television system is completed as specified.

2. All field located equipment and hardware checked by the State and found in compliance with the specified requirements.

The Design-Builder shall notify the State's Engineer in writing 10 working days prior to starting the test. The State's Engineer will inspect the physical system and notify the Design-Builder, in writing, if the Design-Builder is to proceed.

The test shall be carried out from the TSMC at Dayton Ave. for each camera in the presence of the State's Engineer. The following steps shall be taken:

1. Turn on the camera.

2. Check the pan and tilt and lens for preset positions.

3. Using camera control switches, check pan and tilt movements. Check lens controls for zoom in and out, focus near and far.

4. Check on-off control for camera.

5. Verify that the correct camera identification marker appears on the monitor as the camera is selected.

Measurement

No specific unit of measurement shall be made.

Payment

All costs for installing conduit, wire or cable, junction boxes, and concrete foundations for more than one of the below listed systems shall be included in the lump sum contract price for the appropriate system according to the following priority:

1. Traffic Data Accumulation/Ramp Metering System
2. Closed Circuit Television System
3. Swing Gate and Sign Control System

The cost of providing electrical cables or conductors for a particular system shall be included in the lump sum contract price for the respective system.

The lump sum contract price for "Closed Circuit Television System" shall be full pay for construction of the complete system as shown in the Plans. This includes excavating, backfilling, concrete foundations, conduit, wiring, restoring facilities destroyed or damaged during construction, salvaging existing materials, and for making all required tests.

Figure 23.

Figure 24.

Figure 25.

Figure 26.

III. SPECIFICATION FOR VARIABLE MESSAGE SIGNS

These specifications shall be used if expansion and/or retrofitting of the variable message sign (VMS) system is specified on a project.

Description
The Design-Builder shall design, furnish, and install a complete variable message sign (VMS) in accordance with these Special Provisions, the Plans, and the Standard Specifications. The sign shall be installed with a maintenance walkway on either an existing sign bridge or a new sign bridge.

Designer Note:
The VMS may be part of a multi- member sign composed of this VMS, overhead neon signs, and/or fixed message panels. The VMS housing shall be designed and fabricated such that when attached to each other, the signs present the appearance of an integrated unit.

Materials And Sign Display

The following features shall be provided:

The sign face for the VMS sign shall be capable of displaying messages on a horizontal line composed of a fixed matrix field. The fixed matrix field shall be formed by modules. The modules are formed by pixels (dots or disks) arranged in 5 wide by 7 tall matrix.

Designer Note:
The designer is responsible for determining which technology is used and providing the appropriate specifications. An 18 inch high matrix is required for mainline freeway applications.

The configuration of the VMS will vary depending on the technology used and the signs application. WSDOT District 1 utilizes four different sign configurations:

1. *2 line by 22 module overhead,*
2. *2 line by 21 module overhead,*
3. *2 line by 15 module overhead,*
4. *3 line by 8 module post or trailer mounted.*

The 2x22 overhead sign shall be used when flip disk or LED/Flip Disk Hybrid technology is applied. The 2x21 overhead sign shall be used when Fiber Optic/Flip Disk Hybrid technology is applied. The 2x15 overhead sign shall be used when Flip Disk or LED/Flip Disk Hybrid technology is applied for a reversible lanes information sign. The 3x8 post or trailer mounted sign shall be used when flip disk or LED/Flip Disk Hybrid technology is applied for either a temporary post mounted or a portable trailer mounted sign.

Messages displayed on the sign face shall be readable from a minimum of 800 feet, for the 18 inch matrix. The sign face shall be capable of a character change rate of not less than forty-eight per second. The sign face shall be perpendicular to the roadway.

Flip Disk VMS
The sign face shall use pixels using electromagnetic, two-state technology to form alpha-numeric symbols.

Each pixel shall be comprised of a 2-inch, two-sided disk. The two-sided disks shall consist of a highly reflective fluorescent yellow mylar material on one side, and flat black on the other side to match in with the flat black of the sign face. The pixel shall be internally illuminated with a black light, for signs not employing LED/Flip Disk or Fiber Optic/Flip Disk technology.

LED/Flip Disk Hybrid VMS
The sign face shall use pixels combining electromagnetic, two-state technology and Light Emitting Diodes (LEDs) to form alpha-numeric symbols.

Each pixel shall be comprised of a disk and a cluster of high intensity LEDs shining through a hole in the disk. The LEDs shall have a half life of luminous intensity of 3 candela per pixel The LEDs shall have a half-life of luminous intensity of 50,000 hours. The LEDs shall have dimming capabilities for nighttime operation.

The two-sided disks shall consist of a highly reflective fluorescent yellow mylar material on one side, and flat black on the other side to match in with the flat black of the sign face.

Fiber Optic/Flip Disk Hybrid
The sign face shall use pixels combining electromagnetic, two-state technology and a halogen-fed fiber optic light source to form alpha-numeric symbols.

Each pixel shall be comprised of a disk and a small cluster of high intensity, halogen-fed fiber optic fibers shining through a hole in the disk. The light intensity shall be at least 27 candela per pixel. The light shall be completely shuttered when the blank face of the pixel is shown. The fibers shall be high quality glass fibers and shall have a dimming control for the light source with a minimum of three dimming levels, (night, normal and overbright).

Each halogen light source shall feed a maximum of three modules. If a halogen light source fails, the VMS shall continue to display a discernible message.

Sign Mounting Hardware
For VMS that are installed on an existing sign bridge, a new maintenance walkway allowing access from over the roadway shoulder shall be constructed. For a new VMS and sign bridge, a maintenance walkway will be included in the construction. The sign housing shall be provided with all necessary hardware including sign mounting beams, vertical and horizontal brackets, maintenance walkways and all related hardware to install the VMS.

The maintenance walkway shall be a minimum 5 feet wide and be equipped with a folding handrail on the front edge of the walkway and either a safety chain or rail between the handrail and the sign. The maintenance walkway shall be mounted a minimum of 18 inches below the bottom of the sign. All mounting hardware shall be hot-dip galvanized steel and shall conform to the G series Standard Plans, the Standard Specifications and the Bridge Plans.

Sign Housing
The sign housing shall be constructed of galvanized steel and shall have a neat, uncluttered appearance. The housing shall be provided with 120 VAC power.

The housing shall be designed to withstand wind velocities of 80 mph with 30 percent gust factors, be constructed as an environmentally controlled cabinet with a clear polycarbonate front face.

All components of the VMS shall operate without degradation due to vibrations caused by traffic and wind.

The interior sides of the sign housing, excluding the sign face, shall be covered with insulation rated at R-6. The sign housing shall be able to drain water that might permeate or condense within the sign.

The VMS exterior shall be shop painted with the following coats of paint as a minimum in the order that follows:

One coat of primer, State Standard Formula No. A-7-70 (red).

Two finish coats of paint, State Standard Formula No. C-9-86 (matte black).

The interior of the VMS shall be shop painted with the following coats of paint, as a minimum, in the order that follows:

One coat of primer, State Standard Formula No. A-7-70 (red).

One coat of paint, State Standard Formula No. C-9-86 (matte black).

All steel components, which are not stainless steel, shall be galvanized prior to painting.

Paint damaged from shipping or installation shall be repaired according to Section 8-20.3(12), at no additional cost to the State.

The Design-Builder shall submit final color samples to the State's Engineer for approval.

All coats of paint shall be at least two mils thick.

Corrosion protection between dissimilar metals shall be provided.

The dead load of the VMS sign shall not exceed 2,500 pounds.

Sign Features
The sign housing shall have adequate thermostatically controlled, filtered, forced ventilation. The ventilation system, with the use of blowers or fans, shall be capable of two volume changes of the VMS housing per minute. A manual override timer switch shall be located in the local sign control cabinet at the base of the sign bridge. The override timer switch shall be capable of turning on the ventilation system for up to one hour, in one minute increments. Filters for the ventilation shall be on the intake and exhaust. The filters shall be standard size and type, and easy to replace.

The sign housing shall have one thermostatically controlled 500-watt heater. A manual override timer switch shall be located in the local sign control cabinet. The override timer switch shall be capable of turning on the heaters for up to one hour, in one minute increments. The ventilation and heating systems shall have separate thermostats and override timer switches, which shall be clearly marked as to which system they control.

The cabinet shall be provide with one 20 amp, 120 VAC duplex receptacle, conveniently placed inside the cabinet. The cabinet shall open from the front, have stainless steel hinges, and a two-position stop assembly.

The sign face shall be modular in design such that the display units can be easily removed and installed by the use of a screwdriver. Wiring for each display unit shall employ connectors for ease of unit replacement. The connectors shall provide a positive latch that locks the cable to the display unit.

Communications

Designer Note:
Communications between the sign controller and the Traffic System Management Center (TSMC) shall be either direct, dedicated telephone lines or 22 AWG Twisted Pair (TWP) to the fiber optic hub and singlemode fiber optic cable to the TSMC. The copper twisted pair from the sign to the fiber shall be 4 wire E&M cards supplied under Communications Distribution System. All new communication equipment required for the local controller to properly communicate with the existing VMS central control system at the TSMC, shall be Design-Builder provided and installed. This includes, but is not limited to, modems, receivers and transmitters, multiplexers, connectors, splices and optical cables.

Control
The VMS and sign controls supplied under this contract shall be fully compatible with and capable of being operated by the State's existing Digital VAX computer system. The sign control computer shall be a Ferranti-Packard Model 2001 manufactured by Ferranti-Packard Electronics Ltd..

Local control shall be provided for the sign. Local control includes equipment in a cabinet at the base of the supporting sign bridge where the sign is located to allow sign message selection and operation from or near the roadway shoulder.

While actual equipment within the cabinetry varies with suppliers, the following functions shall be capable of being performed from the local control panel:

Power to the sign shall be selectable by an ON/OFF switch.

The LEDs shall have an automatic, adjustable dimming feature.

A minimum of 16 messages shall be selectable for display on the sign. A visual indication shall denote which message is being displayed on the sign.

The ability to run test patterns on the sign to test every disk element in the sign face.

Selectivity whether to have the sign face blank in the event of a power failure or loss of communications, or to have the last message displayed.

VMS housing ventilation and heating override time switches.

All items associated with the local control shall be installed in the cabinet in a neat and orderly manner. Access to terminal boards shall be provided without moving any equipment. Wiring in the cabinet shall be bound in a neat manner.

Local Control Cabinet
The local equipment shall be provided with a new sign control cabinet. This cabinet shall be fabricated of anodized sheet aluminum meeting NEMA 3R specifications.

The cabinet door shall employ closed cell neoprene gasketing plus drip shield to assure a weatherproof enclosure. The door shall be held by a vertical stainless steel hinge and be provided with a two position stop assembly. The cabinet doors shall be provided with spring loaded construction core locks capable of accepting a Best Lock Company CX series core. The Design-Builder shall provide one Best "R" construction core with two keys per cabinet. The locks shall not protrude beyond the front of the doors. The cabinet door shall be able to swing 180 degrees. The cabinet shall be equipped with mounting pans and terminal strip boards as required. An incandescent or fluorescent light shall be mounted in the cabinet and activated by a door switch. The cabinet shall be provided with a thermostatically controlled fan and associated vents.

Control System
The VMS control system shall include all excavation, backfill, conduit, wiring, and all hardware associated with providing power and control between the local controller and the sign. It shall also include writing, providing, and installing all software and any needed hardware to ensure the VMS is fully compatible with and completely capable of being operated by the State's existing Digital VAX computer system, while requiring no additional software be installed in the State's VAX.

Construction Requirements

Sign Installation
The VMS shall be installed on the sign support structure at the location and as shown in the Plans.

New Conduit
All conduit shall be hot-dip galvanized. All conduit shall use hot-dip galvanized fittings and couplings and shall be attached to the sign structure with stainless steel straps.

Junction boxes for the VMS system shall have the letters V.M. brazed onto the lid. Letter sizing for the various sizes and types of boxes shall be submitted to the State's Engineer for approval.

Designer Note:
The local control cabinet shall be installed on: 1) the sign bridge, if appropriate, and if the VMS is located on a sign bridge, or 2) on a concrete foundation, in close proximity to the sign, as designated in the Plans. The control cabinet must be in a location that is easily accessible by maintenance personnel.

Sign Transportation and Delivery
The VMS, local control cabinet, and components shall be packed and loaded for shipping so no damage will occur during shipping and storage. The Design-Builder shall notify the State's Engineer of sign delivery 5 days prior to delivery.

Shop Drawings and Documentation
Shop Drawings

The following shop drawings shall be submitted to the State's Engineer for approval prior to sign fabrication. State's Engineer approval normally takes 30 days. If the drawings are returned without approval another 30-day approval period will occur after resubmittal for approval:

1. Parts list

2. Sign housing and local control cabinet fabrication details

3. Equipment layout within the sign housing and control cabinet

4. Details of mounting hardware and mounting method

5. Electrical schematics of the sign housing and control cabinet

6. The actual dead load of the sign shall be noted

Documentation
The following documentation shall be supplied with each sign.

1. Sign technical description and operation principle.

2. Parts list including manufacturer description and part number.

3. Maintenance schedule including component testing and replacement procedures.

4. Schematic and diagrammatic wiring drawings.

Testing
The VMS will be tested in order to check the operation of the sign. The Design-Builder shall designate qualified representatives for the test.

This test shall be conducted immediately following the complete installation of the VMS. The Design-Builder shall demonstrate that all functions of the sign and local controller are operational. This test shall be conducted in the presence of the State's Engineer. The light levels of the light-emitting VMS shall be adjustable so that night and day levels are acceptable, as determined by the State's Engineer.

Upon satisfaction of the State's Engineer that all functions of the system are operational, a 20-day trial period of continuous operation shall begin. The sign shall operate without major breakdown or interruption of operation as a system due to any fault of the equipment provided for this project. The following shall be observed during the test period:

It is assumed that all equipment shall be in working order at the beginning of the test. Therefore, adjustment or replacement of components shall be considered as a malfunction and cause for termination of the test period.

The test period shall be started on a date mutually agreeable to the State and the Design-Builder.

The system shall operate for 20 consecutive days without malfunction.

Although it is not necessary for the Design-Builder to provide personnel to be in attendance during the 20-day testing period, upon being informed of a malfunction, the Design-Builder shall respond with a representative who is thoroughly familiar with the operation of all parts of the system.

Upon detection of a malfunction, the test and test time shall be stopped and the malfunction corrected. If the malfunction is determined by the State's Engineer to be a major breakdown or interruption of operation, the test time will be reset to start the 20-day trial period again. If the malfunction is considered to be minor by the State's Engineer the test time will continue when the problem is corrected.

Warranty
The Design-Builder shall provide a warranty period of 6 months from the date that the VMS (including local control cabinet and equipment) successfully completes the system acceptance test. This quality assurance shall cover each piece of equipment and shall be provided by the manufacturer or agent of said equipment.

The warranty period shall apply to all components of the VMS provided under this contract and shall include the following:

Replacement of parts used during this warranty period shall be by the Design-Builder at no cost to the State.

Regularly scheduled preventative maintenance every 3 months for the 6-month period (two times).

Emergency repair shall commence within 24 hours of notification by the State.

Upon acceptance of the VMS, one reflective disk/LED module shall be furnished for the sign. This module shall be delivered to the State's Engineer.

Measurement
VMS will be measured per each.

When described in these Special Provisions as "Warranty - Variable Message Sign", no specific unit of measurement shall apply, but measurement shall be for the sum total of all items required to provide the warranty as so stated and specified.

Payment
The unit contract price per each for "Variable Message Sign" shall be full pay for performing the work as specified, including maintenance walkways, control system, local control cabinet, field located communications equipment, coordination of wiring and related work between the local control cabinet and the VMS, including installation, documentation and shop drawings.

The lump sum contract price for "Warranty - Variable Message Sign" shall be full pay for all costs related to the warranty as specified. Half of this item will be paid at the completion of the first preventative maintenance service, and the second half paid at the completion of the second preventative maintenance service.

Figure 27

NOT YET INCORPORATED

IV. SPECIFICATIONS FOR THE HIGHWAY ADVISORY RADIO (HAR) SYSTEM

Description
The intent of the Highway Advisory Radio (HAR) System is to advise motorists, via their car radios, of construction activities and major incidents which may adversely impact travel through the construction corridor.

The Design-Builder shall furnish, install and successfully test the sign and beacon assemblies at the location shown in the Plans.

Because of its importance to construction traffic coordination, the sign and its associated transmitter shall be installed and made operational within the first 60 working days of this project.

Materials
Each HAR sign and beacon installation shall consist of the following:

Sign Assembly
The HAR sign shall be fabricated from materials meeting the requirements of Section 9-28 and the Special Provision PERMANENT SIGNING. Sign size, legend, and colors shall be as detailed in the Plans.

Flashing Beacons
Two 8-inch amber beacons shall be provided with each sign assembly. The signal display shall meet the requirements of Section 9-29.16. The flashing beacon control shall meet the requirements of Section 9-29.15. The beacons shall flash alternately.

Sign Lighting Luminarie
The sign lighting luminaire shall be as per standard specification 9-28.16. Each sign shall be provided with three luminaires.

Sign Control Equipment and Cabinet
Control Equipment
1. The sign shall be controlled over telephone lines via a remote function controller (Zetron Model 1512 or approved equal). The remote function controller shall turn the beacons and sign lighting luminaries on and off using DTMF tones. The controller shall also report sign status (OFF or ON) to TSMC.

2. The sign shall have a three position key switch attached to the outside of the cabinet for manual control of the sign. The legend plate shall have the markings:

MANUAL to the left (sign lights and flashing beacons are ON and controller is OFF).

OFF in the center (sign lights and flashing beacons are OFF and controller is OFF).

AUTO to the right (sign lights and flashing beacons are controlled by controller)

There shall be 60 degrees of throw between each switch position. The key shall be removable in all three positions. Two keys shall be provided for each sign and shall match the keys for the existing HAR signs (E 10 keys).

The key switch shall have a NEMA type, oil tight, vertically mounted cast aluminum or stainless steel enclosure.

The contact blocks shall be rated at 600 volts at 10 amps minimum.

Cabinet
Sign control equipment shall be housed in a NEMA Type 3R anodized sheet aluminum cabinet. The cabinet design shall be such that no more than 60 percent of the cabinet volume is used. The cabinet shall be provided with a hinged door capable of accepting a Design-Builder supplied Best Lock Company CX Series construction core.

The Design-Builder shall furnish catalog cuts and shop drawings to the State's Engineer for approval.

Conduit, cable and junction boxes installed as part of the HAR system shall meet the requirements of Section 8-20 and the Special Provision **ILLUMINATION, SIGNAL SYSTEM AND ELECTRICAL.**

Construction Requirements
The Design-Builder shall be responsible for installation of the following:

Sign Assembly
Each sign shall be installed on three 6 inch by 8 inch wood posts at the location staked by the TSMC Engineer. Mounting shall be as shown in the Plans.

Flashing Beacons
The beacons shall be installed as shown in the detail in the Plans. The flasher units shall be housed within the sign control cabinet.

Sign Lighting Luminaire
The luminaire shall be installed as shown in the Plans.

Sign Control Cabinet
The control cabinet shall be installed as shown in the Plans.

Measurement

Measurement will be by the lump sum for a complete system to be furnished and installed.

Payment

The lump sum contract price for "Highway Advisory Radio System" shall be full pay for providing, installing, and connecting all required equipment to provide for an operational highway advisory radio system as specified.

Figure 28.

V. COMMUNICATIONS

COMMUNICATION SYSTEM CABLES

Description

The work specified in this section shall include the furnishing and installation of communication system cables and associated components in accordance with the Contract Plans. These specifications define the types of communication system cables and interface equipment that shall be implemented on projects containing ITS communications.

The Design-Builder shall provide materials, equipment, and the expertise required for the installation of fiber optic, copper, camera and power cables as components of the TMS.

Designer note:
The designer is responsible for determining which communication setup is being considered. The designer should then decide which specifications are appropriate to use.

Submittals

With a minimum of 30 calendar days prior to anticipated construction, the Design-Builder shall provide all documentation, pertaining to the materials and method of execution proposed to satisfy the requirements of this section. The State Engineer's approval is required prior to the committing of any materials or the commencement of any work.

The State's Engineer will either approve or disapprove each submitted item within 30 calendar days of submittal. Actual time for the State Engineer's review is dependent upon the completeness and appropriateness of the documentation being submitted. Any deficiencies will require additional time for approval. Any delays caused by such deficiencies will not be eligible for extension of project time consideration. The Design-Builder shall anticipate review intervals to ensure project progress in accordance with Section 1-08.3.

The State Engineer's approval of any submitted documentation shall in no way relieve the Design-Builder from compliance with the safety and performance requirements as specified herein.

Submittals required by this item shall include but not be limited to the following:

1. A material staging plan, should the Design-Builder propose State owned property as a staging area.

2. The manufacturer's specifications for all communication system cables and associated components.

3. The manufacturer's specifications for optical fiber splice enclosures.

4. A detailed fiber optic cable installation procedure including the following:

a. Fiber optic cable cutting lengths reflecting the cable order and reel allocations.

b. Cable pulling plan comprising the exact operation methods with the physical locations, equipment setup and type.

c. Exact splice points as provided for herein.

d. Manpower proposed for all equipment, safety, and manual assist operations.

e. Traffic and right-of-way control with respect to public safety.

Cable Installations
The Design-Builder shall determine a suitable cable installation method to allow all cable installation requirements to be met in all the conduit sections. All work shall be carried out in accordance with the highest standards of craftsmanship in the communication industry with regard to the electrical and mechanical integrity of the connections, the finished appearance of the installation, and the accuracy and completeness of the documentation.

The Design-Builder shall survey the project site and establish the exact cable routing and cutting lengths prior to the commencement of any work or committing any materials. The Design-Builder shall submit a detailed installation procedure for approval by the State's Engineer, which shall address the issues listed above, under submittals.

All work areas shall be made clean and orderly at the completion of the work and at times required by the State's Engineer during the progress of work.

Quality Assurance
All work described in this section shall meet or exceed the applicable provisions of the following documents:

1. Standard Specifications

2. EIA 455-1-5 (addenda 1 through 5) Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices

3. EIA 27A, Method for Measuring (Uncoated) Diameter of Optical Waveguide Fibers

4. EIA 455-28A, Method For Measuring Tensile Failure Point of Optical Waveguide Fibers

5. EIA 455-34, Interconnection Device Insertion Loss Test

6. EIA 455-46, Spectral Attenuation Measurement For Long Length Graded-Index Optical Fibers

7. EIA 455-51, Pulse Distortion Measurement of Multimode Glass Optical Fiber Information Transmission Capacity

8. EIA 455-52, Method for Measuring Temperature Dependence of Attenuation for Optical Waveguide Fibers

9. EIA 455-53, Attenuation by Substitution Measurement for Multimode Graded-Index Optical Fibers or Fiber Assemblies Used in Long Length Communications Systems

10. EIA 455-89, Fiber Optic Cable Jacket Elongation and Tensile Strength

11. EIA 455-95, Absolute Optical Power Test for Optical Fibers and Cables

12. EIA 455-103, Buffered Fiber Bend Test
13. EIA 359-A-1, Special Colors

14. ANSI, C8.47-1983 American National Standard for Polyolefin-Insulated Thermoplastic-Jacketed Communication Cables.

15. REA, PE-39, Twisted Pair Copper Cables

Materials
The Design-Builder shall provide all products and materials required for the installation and splicing of the specified communications cables and power cables and associated interface devices.

Communication Cables
Communication cables are defined as 8.3/125 um single mode, 62.5/125 um multimode, #22 AWG twisted pair copper, and multiconductor camera cables. Optical fiber dimensions shall be in compliance with the methods for measuring as established in EIA, 455-27A.

FIBER OPTIC CABLE

GENERAL

Fiber Optic Cable Description

The Design-Builder shall provide certified documentation or test results that demonstrates that all fiber optic cables meet the specified optical and mechanical performance criteria.

All optical fibers shall be identifiable by standard color codes as defined in EIA 395-A.

All cables shall be free of material or manufacturing flaws and dimensional non-uniformity's which would:

1. Interfere with the cable installation using accepted cable installation practices,

2. Degrade the transmission performance and environmental resistance after installation,

3. Inhibit proper connection to interfacing elements, and

4. Otherwise yield an inferior product.

Fiber Optic Cable Mechanical Performance Requirements

The following defines the physical and environmental requirements for completed fiber optic cable(s):

Designer note:
The designer is responsible for determining the number of optical fibers needed, and shall adjust the specifications accordingly. (i.e. 48, 36, 24, etc single mode fibers, 24, 12, 2, etc. multimode fibers)

Single mode cables shall be comprised of optical fibers in a loose tube buffer design of industry standard construction for underground conduit installations and of dielectric construction.

Multimode cables shall be comprised of optical fibers in a tight tube buffer design. Each multimode optical fiber shall be contained in a breakout style cable, with core locked elastometric 2.0 mm subcables. The 2.0 mm subcables shall be comprised of 900 um multimode fibers surrounded by aramid strength fibers and elastomer to form a nominal 2.0 mm outside diameter.

Single mode and multimode fiber optic cables shall be capable of withstanding a 2,700 Newton (600 pounds) pull force during installation.

Fiber optical cables shall be constructed in accordance with EIA 455.

The completed cables shall have sequentially numbered length markers, in a contrasting color to the cable jacket, at regular intervals of not more than one meter along the outside of the jacket. Stamped on the jacket shall be the cable

code to identify the number and type of fibers, the manufacturer's name and the sequential length markings.

The cables shall be capable of being stored, installed, and operated at the temperature range of -55°C. to +85°C.

The cable(s) shall be able to withstand bending to a minimum radius of 10 times the cable outer diameter without tensile load applied, and of 20 times the cable outer diameter with maximum load applied (during installation),without damage to the cable components or degradation of the optical fiber performance. The fiber optic cables shall withstand at least 20 cycles at a minimum bend radius without damage to the fiber optic cable components or degradation of the optical performance. The cyclic flexing test shall be in accordance with EIA 455.

The minimum crush resistance of the fiber optic cable shall be greater than 2200 Newton's/cm without damage to the cable components or degradation of the optical performance.

The fiber optic cables shall be capable of withstanding 2500 impacts, at 5 newton-meters force without damage to the fiber optic cable components or degradation of the optical performance. The impact resistance test shall be in accordance with EIA 455.

The single mode fiber optic cables shall be tested for the ability of the gel filling compound in the interior of the inner jacket and buffer to resist flow at the above mentioned temperature range in accordance with EIA 455.

The fiber optic cable shall be capable of preventing the entry and axial migration of 9 psi pressurized water when subjected to fluid penetration testing in accordance with EIA 455.

Fiber Optic Cable Factory Acceptance Test
The Design-Builder shall provide factory acceptance test data sheets for each reel of fiber optic cable delivered. These shall be performed by the factory and shall include both-way OTDR traces and test data for each fiber used in the cable. The State reserves the right to witness factory acceptance tests of the fiber optic cables. The Design-Builder shall perform OTDR tests on each fiber cable after delivery and just prior to installation of the cable.

The Design-Builder shall supply the factory test results documenting that the cables meet EIA specifications as specified in these Special Provisions. The Design-Builder shall submit a 1 meter sample of each type of cable to the State Engineer for approval.

Fiber Optic Cable Installation
Fiber optic cables shall be installed in continuous lengths without intermediate splices throughout the entire project, except at the location(s) specified in the Plans. The cable installation personnel shall be familiar with the cable manufacturer's recommended procedures including but not limited to the following:

1. Proper attachment to the cable strength elements for pulling during installation.

2. Cable tensile limitations and the tension monitoring procedure.

3. Cable bending radius limitations.

The Design-Builder shall comply with the cable manufacturer's specifications at all times.

To accommodate long continuous installation lengths, bi-directional pulling of the fiber optic cable is approved and shall be implemented as follows:

From the midpoint, pull the fiber optic cable into the conduit from the shipping reel in the usual fashion. When this portion of the pull is complete, the remainder of the cable must be removed from the reel to make the inside end available for pulling in the opposite direction. This is accomplished by hand pulling the cable from the reel and laying into large figure eight loops on the ground. The purpose of the figure eight pattern is to avoid cable tangling and kinking. The loops must be laid carefully one upon the other (to prevent subsequent tangling) and must be in a protected area. The inside reel end of the cable is then available for installation. In some cases, it may be necessary to set up the winch at an intermediate cable vault. The required length of cable is pulled to that point, and brought out of the cable vault and coiled into a figure eight. The figure eight is then turned over to gain access to the free cable end which can then be reinserted into the duct system for installation into the next section.

Installation shall involve the placement of the fiber optic cables in a specified innerduct or conduit as defined in the Plans. The Design-Builder shall ensure that innerducts are secured to prevent movement during the cable installation.

The pulling eye/sheath termination hardware on the fiber optic cables shall not be pulled over any sheaves.

When power equipment is used to install the fiber optic cables, it must be designed to be used with fiber optic cable. Low speeds shall be used, not to exceed 30 meters per minute. The equipment must show the rate of pull, tension and automatically shut down if any cable pulling parameters are exceeded. The tensile and bending limitation for fiber optic cables shall not be exceeded under any circumstances. The use of large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the appropriate bending radius. Tension monitoring shall be accomplished using commercial dynamometers or load-cell instruments.

Fiber Optic Cable Splicing

This section describes minimum requirements for splicing and connecting of the specified fiber optic cables. The single mode cables are the only fiber optic cables that shall contain intermediate splices.

All splicing equipment shall be in good working order, properly calibrated, and meet all industry standards and safety regulations. Cable preparation, closure installation, and splicing shall be accomplished in accordance with accepted and approved industry standards.

Upon completion of the splicing operation, all waste material shall be deposited in suitable containers, removed from the job-site, and disposed of in an environmentally acceptable manner.

The Design-Builder shall use the fusion method with local injection and detection for all fiber optic splicing.

The average splice loss of each fiber shall be 0.15 dB or less. The average splice loss is defined as the summation of the attenuation as measured in both directions through the fusion splice, divided in half.

No individual splice loss measured in a single direction shall exceed 0.25 dB.

Splices shall be contained in a re-enterable splice case designed for use on fiber optic cables in a manhole environment where total and continuous submersion in water is to be expected.

At all fiber optic splice locations, the Design-Builder shall neatly coil and secure 50 feet of fiber optic cable in a manner that is consistent with optical fiber specifications, including minimum bend radius.

SINGLEMODE OPTICAL FIBER

Single Mode Optical Fiber Mechanical Requirements

Single mode fibers shall have a nominal core diameter of 8.3 um.

The mode field diameter for all single mode fibers shall be 10 um nominally, with no variation greater than 1.0 um when measured at 1300 nm.

Single mode fibers shall be contained in a loose buffer tube and multimode fibers shall be constructed with a tight buffered jacket. These configurations shall be dimensionally sized to minimize local stresses and microbend losses in compliance with EIA 455-103. The interior of the buffer tube shall be filled with a compound of suitable viscosity to dampen fiber vibrations and prevent the ingress and migration of water.

Void areas around the individual buffer tubes in single mode cables shall be filled with a moisture resistant filling compound as a block against moisture migration.

A reinforcing layer of aramid strength fibers shall be applied as an inner jacket to provide additional cable strength and protection.

An outer jacket of UL rated Optical Fiber Non-conductive Riser (OFNR) PVC shall be applied over the reinforcing material to provide mechanical protection, and to serve as the primary moisture barrier for the single mode cables. The PVC shall be core locked to the tight buffered jackets in the multimode cables. The cable sheaths shall be designed to meet or exceed the tensile criteria defined in EIA 455-89.

The single mode fiber cladding shall have a nominal diameter of 125 um, with no variation greater than 3 um. The non-circularity of the cladding surface shall be less than 2 percent. Cladding non-circularity is defined as the difference between the longest and shortest chords each passing through the center of the cladding and connecting points on the outer cladding surface, divided by the average diameter of the cladding surface.

The core cladding offset shall be less than 1.0 um. The core cladding offset is defined as the distance between the core center and the cladding center.

The coated single mode optical fibers shall have a nominal outside diameter of 500 um, with no variation greater than 15 um and a minimum coating thickness at any point not less than 50 um. Single mode optical fibers shall, as a minimum

provide industry standard levels of tensile strength, in accordance with EIA 455-28A.

Single mode optical fibers shall be 100,000 psi glass.

Fibers shall contain no factory splices.

Single Mode Optical Fiber Performance
The maximum attenuation of each 8.3/125 single mode fiber at the temperature range of -55°C to +85°C shall be no greater than 0.40 dB/km at 1,310 nm nominal, and 0.30 dB/km at 1,550 nm nominal. The attenuation shall be measured on a completed reel length of cable then normalized to a length of 1 km. The measurement method shall be in accordance with the manufacturer's recommended procedure.

All fibers shall be free from imperfections and inclusions that would prevent them from meeting the transmission and mechanical requirements of this specification. All anomalies shall be kept to a minimum, and in no case shall be in excess of 0.20 dB.

The maximum dispersion at 68°F shall be 2.6 ps/nm-km over the range of 1,225 to 1,330 nm, and 17-20 ps/nm-km over the range of 1,525 to 1,575 nm.

The cutoff wavelength shall be 1,200 um nominal, and shall have no variation greater than 70 um.

Singlemode Fiber Optic Cable Mechanical Performance Requirements

The following defines the physical and environmental requirements for completed singlemode fiber optic cable(s):

Single mode fiber optic cables shall be capable of withstanding a 2,700 Newton (600 pounds) pull force during installation.

Singlemode fiber optic cables shall be constructed in accordance with EIA 455.

MULTIMODE OPTICAL FIBER

Multimode fibers shall be constructed with a tight-buffered, breakout-style design.

Multimode Optical Fiber Mechanical Requirements
Multimode fibers shall have a nominal core diameter of 62.5 um, with no variation greater than 3 um. The non-circularity of the cladding surface shall be less than 6 percent. Core non-circularity is defined as the difference between the longest and shortest chords each passing through the center of the core and connecting on the core/cladding interface, divided by the average core diameter.

The multimode cladding shall have a nominal outside diameter of 125 um with no variation greater than 3 um. Non-circularity of the cladding surface shall be less than 4 percent. Cladding non circularity is defined as the difference between the longest and shortest chords, each passing through the center of the cladding and connecting points on the outer cladding surface, divided by the average diameter of the cladding surface.

The concentricity error for multimode optical fibers shall be less than 6 percent, where the error is the distance between the core and cladding centers divided by the average core diameter.

The acrylate coated multimode optical fibers shall have a nominal outside diameter of 500 um, with no variation greater than 15 um and a minimum coating thickness of 50 um. The acrylate coated multimode fibers shall be covered with an elastometric buffer brining the total outside nominal diameter to 900 um. The multimode optical fibers shall be 100,000 psi glass.

The multimode optical fibers shall, as a minimum, provide industry standard levels of tensile strength in accordance with EIA 455-28A.

Fibers shall contain no factory splices.

Multimode Optical Fiber Performance
The maximum attenuation for each 62.5/125 multimode fiber at the temperature range of -55°C to +85°C shall be no greater than 3.0 dB/km at 850 nm nominal and 1.0 dB/km at 1,300 nm nominal. The attenuation of multimode optical fibers shall be determined by EIA 455-46.

The information transmission capacity (bandwidth) of each multimode optical fiber shall be 600 MHz-km at 1300 um. The information capacity of each fiber shall be measured in the time domain environment and the result shall be expressed in terms of -3 dB (Optical power) frequency. The method to determine the pulse distortion shall be EIA 455-51.

Multimode Fiber Optic Cable Mechanical Performance Requirements

Multimode fiber optic cables shall be capable of withstanding an 2700 Newton (600 pounds) pulling force during installation.

COPPER CABLE

Copper Cable Description
Copper cables shall contain 25, or as noted in the Plans, twisted #22 AWG copper pairs. All pairs shall be color coded using standard North American communication industry colors to uniquely identify each pair in the cable. Copper cables shall be constructed for installation in an underground conduit environment, with a sheath consisting of a double coated aluminum shield over which a medium density polyethylene jacket is extruded,.

All cables shall be filled with a gel compound to resist water penetration and migration.

All copper cables shall be constructed in accordance with REA, PE-39.

Copper Cable Performance
Copper cables shall contain no faulty pairs and shall be capable of the transmission of 9,600 b/sec data circuits over distances of 5 miles.

Twisted Pair Copper Cable Installation
The Design-Builder shall install the 25-pair OSP cable and associated terminal blocks and splice case.

Where cables are terminated at terminal blocks in terminal cabinets, the same pair assignment shall be maintained from existing to new pairs.

The cable shall be terminated in the cable vault in a water-proof re-enterable splice case. The cable and splice case shall be racked in the cable vault and sealed after completion of cable testing.

Twisted Pair Copper Testing
Upon completion of installation, the following tests shall be conducted:

> Each pair of 25 TWP cable and 6 TWP cable installed shall be tested. The Design-Builder shall test for continuity, signal-to-noise ratio, and loss at 1 kHz, from the hub end of the mainline pairs to the hub end of lateral pairs. Any cable segment containing a pair or pairs exhibiting discontinuity shall be repaired or replaced. Signal-to-noise measurements shall be better that 55 dB, and 1 kHz signal loss measurements shall be better than 2 dB per mile.
>
> Tip-to-tip and ring-to-ring continuity and color sequence continuity shall be measured and recorded. This test shall be conducted for each twisted pair within each cable section.

Copper Cable Splice Cases
The Design-Builder shall provide and install re-enterable waterproof copper cable splice case enclosures suitable for a cable vault environment and capable of a branch splice of 25 pairs as shown in the plans.

Copper Cable Protector Block
The Design-Builder shall provide and install a combination protector block/punch-down terminal block for the protection and termination of a 25-pair OSP cable. 25 protector units of the low voltage heat coil and gas tube type, with gold pins, shall be provided and installed with the protector block. The block shall be equipped with punch-down terminals for both input and output cable pairs.

Copper Cable Termination Blocks
The Design-Builder shall provide and install cable terminations on blocks that are 25-pair Type 66 punch-down blocks. Connectorized Type 66 blocks shall be used for 24 AWG ISP cables. Unconnectorized Type 66 blocks shall be used for 22 AWG OSP and riser cables. Connectorized and unconnectorized blocks shall have six columns of terminal pins, with the left three in each row connected and the right three in each row connected, and capable of through connections using removable bridge clips in each row.

CAMERA CABLE

Camera Cable Description
Camera cables shall extend from the camera control receiver to the camera and pan/tilt drive unit. These cables shall provide camera power, environmental housing heater power, pan/tilt drive power and controls, camera lens controls, and additional wires for preset positioning of pan/tilt and lens. The number and size of wires required in the camera cable is dependent upon the vendor selected for pan/tilt drives. The Design-Builder shall provide camera cables with the proper type and quantity of conductors to enable connection as recommended by the selected vendors.

The Design-Builder shall install the camera cables and connectors as shown on the Plans and as required to provide for proper operation of the closed circuit television system.

Camera Cable Performance
Camera cables shall be designed for long life operation under adverse weather conditions. Cable connectors at the camera housing and pan/tilt drive shall be waterproofed in accordance with vendor recommendations. Camera cables shall be terminated on terminals in the camera pole NEMA box on one end and terminals in the camera control cabinet on the other end.

POWER CABLE

Power Cable Description
Power cables shall extend from the State-provided power source to the Design-Builder-provided local power transformer. Power cables must also be installed to provide power to specified devices, via the Design-Builder provided local transformer. Power cables shall consist of #3c-8 AWG and #3c-10 AWG as shown in the Plans.

Power Cable Performance
Mechanical and performance characteristics of the power cables shall be in accordance with the Section 9-29.3.

CABLE VAULTS

Cable Racking in Cable Vaults
After the cables are installed and spliced, cables, and innerducts shall be racked with spare conduits and innerducts sealed. Since there is substantial risk of damage to optical fibers by careless handling of the cables, much care shall be exercised, especially with regard to observing the minimum bending limitations.

Lateral cables shall be placed behind the main cables when changing levels. Cables or innerducts shall be secured in racked position with Ty-Raps or approved equivalent.

Identification/warning tags shall be securely attached to the cables or innerducts in at least two locations in each cable vault or pull box.

All coiled cable shall be suitably protected to prevent damage to the cable and fibers. Racking shall include securing cables or innerducts to brackets (racking hardware) that extend from the side walls of the cable vault or pull box.

When all cables or innerducts at each cable vault and pull box are securely racked, all unused conduits and innerducts, and the void areas around the conduits containing cables or innerducts shall be sealed using sealing materials meeting or exceeding industry standards.

See Figure 29 for cable vault details.

Junction Boxes

See standard specification j-11a.

In-grade junction boxes shall be placed on a 6-inch cushion of crushed surfacing top course. Boxes shall be installed behind barriers except as otherwise shown

in the Plans. Boxes shall be installed flush with the paving in shoulder areas and shall be supported by base materials adequate to sustain slow moving H-20 design loads. Boxes shall be installed as close and as practical to barriers on paved shoulders.

Surface mounted junction boxes shall be rated NEMA 4X and shall be properly sized per the NEC. Installation of the junction boxes shall be in a manner approved by the State's Engineer.

Communication System Cable Testing and Acceptance
Fiber Optic Cable Testing

Upon completion of the fiber optic cable installation (and splicing) the following tests shall be performed. Prior to performing these tests, the Design-Builder shall notify the State's Engineer 10 days in advance so that they may be witnessed.

A recording optical time domain reflectometer (OTDR) shall be utilized to test for end-to-end continuity and attenuation of each optical fiber. The OTDR shall be equipped with a 1,300 nm and 1,550 nm light source for single mode optical fibers and an 850 nm and 1,300 nm light source for multimode optical fibers. The OTDR shall have an X-Y plotter to provide a hard copy record of each test measurement. The OTDR shall be equipped with sufficient internal masking to allow the entire cable section to be tested. This may be achieved by using an optical fiber pigtail of sufficient length to display the required cable section, or by using an OTDR with sufficient normalization to display the required cable section. A hard copy X-Y plot shall be provided for all fiber optic attenuation tests.

The OTDR shall be calibrated for correct index of refraction to provide proper length measurement for the known length of reference fiber. The Design-Builder shall provide the OTDR after type approval by the State. After fiber testing has been completed, the OTDR will become the property of the State.

Each single mode and multimode splice shall be tested for optical loss using an OTDR. Measure each splice in both directions, at 1300 nm for single mode splices and 850 nm for multimode splices. An X-Y plot, from the OTDR, shall be provided for each splice measurement. Splice loss shall meet or exceed the requirements of the Special Provisions. Splices to existing fibers shall also be measured and recorded.

A transmission test shall be performed with the use of a stabilized light source and an optical power level meter. Each single mode fiber, including those splice to existing single mode fiber, shall be measured at both 1300 nm and 1550 nm, in both directions, subsequent to field and pigtail splicing. Each multimode fiber shall be measured at both 850 nm and 1300 nm, in both directions, subsequent to fiber connectorization. The light source shall be at the field end and the power level meter at the communications hub. Relative calibration between the two power meters must be checked against the same source at both the beginning and end of each session. Fiber loss shall meet or exceed the requirements of the Special Provisions.

Upon completion of the above mentioned tests all fiber optic cable coils shall be secured with ends capped to prevent intrusion of dirt and water.

Power Cable Test
All power cables shall be tested in accordance with the Standard Specifications.

Installation of all communications system cable interface equipment shall be in accordance with the manufacturer's specifications and the transmission equipment requirements. For specific locations and cable/wire connectivity, refer to the Plans.

Testing
Tests shall be performed on all interface equipment that shall demonstrate compliance with the transmission equipment requirements (or power transformation equipment).

Optical fiber connectors and jumpers shall be measured at the fiber optic termination panel, in accordance with tests defined in EIA 455-34.

Induction Loop Detectors
Section 9-29.18(1) shall be supplemented as follows:

Amplifiers shall be capable of generating a continuous output to the controller when a loop or lead-in failure occurs.

Detector Loop Sealant
As an alternate to the sealant material noted in the Standard Specifications, loop sealant can be one of the following:

1. Gold Label Flex
2. Bondo P-606
3. MSI

Installation shall conform to manufacturer's recommendations. Installation of detector rope is not required if MSI sealant is used.

Measurement
This item is shown as lump sum in the Plans and in the Special Provisions. No specific unit of measurement will apply, but measurement will be for the sum total of the installed and operational communication system cable. The following major components of communication system cable shall be included in this bid item:

1. Single Mode Fiber Optic Cable
2. Multimode Fiber Optic Cable
3. Copper Twisted Pair Cable
4. Camera Cable
5. Power Cable
6. Power Transformers
7. Traffic Detector Loops

Payment
The lump sum contract price for "Communication System Cables" shall be full pay for performing the work as specified.

All additional materials and labor, not shown in the Plans or called for herein and which are required to complete the communication system cables, shall be included in the lump sum contract price for "Communication System Cables".

SOLE SOURCE JUSTIFICATION

JUSTIFICATION FOR ITS COMPONENTS

PURPOSE:

The purpose of this document is to provide justification for the sole source procurement of certain communication components for the expansion and retrofit of the ITS system. This information should suffice to convince FHWA and WSDOT Headquarters of the need to include sole source specifications in future ITS contracts. This document may not suffice for a blanket approval, but the information should be helpful in requesting sole source approvals.

GENERAL:

All of the equipment to be discussed is electronic in nature and was originally supplied by competitive bids on previous projects. The need to sole source future purchases is based on the requirements of electrical and mechanical compatibility. Electrical compatibility means that a component on one end of a circuit can send and receive data to an electrical component on the opposite end of the circuit. (A circuit maybe comprised of either copper wire or glass fiber.) Mechanical compatibility means that a module (or plug-in card) can plug into a rack of modules and operate correctly.

FLUOR DANIEL PRELIMINARY ENGINEERING REPORT:

The report for district-wide ITS communications clearly states the needs for sole source procurement of certain communication system components. This is found on page 98. A word-for-word excerpt follows:

To facilitate a total system compatibility requirement, it is recommended that certain systems, equipment, and material be provided by sole source procurement. This recommendation concerns those systems, equipment, and material which has been selected by bidding in the SR 90 Communication Project.

This recommendation also includes the vendor equipment which has been justified because of its ability to perform a needed task which cannot be done by any other equipment.

The reasons for this recommendation are as follows:

* *Equipment standardization by vendor and model makes it easier for WSDOT to maintain and operate the TMS, including simplification of logistic procedures, maintenance and operations, procedures, training, and warehousing of spare parts.*

* *The communication equipment plug-in slots are not common between vendors. It would not be possible to transfer plug-in units from the equipment of one vendor to the equipment of another, even though the units perform the same functions.*

Section 7.2 of The Fluor Daniel Report is a little vague in explaining why certain system components must be sole sourced. In the following sections the reasons for each component are explained in detail.

SONET DIGITAL TRANSMISSION SYSTEM:

SONET is an acronym for Synchronous Optical NETwork. It is the first real attempt at a compatibility standard for fiber optic communications. This standard only covers the optical interface and the protocol for the data streams. Alarm and network control functions are not covered in the present SONET standard. Expansion of an existing SONET system will require that the expansion modules match the existing equipment. This requires that they be made by the same manufacturer.

A new fiber hub could use equipment from a different vendor. However, the SONET system will require re-configuring each time a new hub is added to the system. This re-configuring requires that some modules be moved from one hub to another, if different vendors were used, we would have to purchase additional modules. This will be an added cost that we did not plan for, and probably would require a communication expert to re-engineer the communication system for each new hub.

If the SONET equipment varies from hub to hub there will be no way to monitor the system from a network manager terminal. This due to the fact that there are no standards for the network interface. If we allowed different vendors, it would be difficult to specify which modules to buy in a future contract. Some contracts are being designed with the intentions of expanding a hub that hasn't been built. For the design to work we must know what vendor will be used in a hub before the contract is bid. Without strict vendor standards it will be impossible to design a system that will work as planned.

The bottom line is that if the future purchases of SONET equipment are not sole sourced, functionality of the system will suffer, design, maintenance and future expansions will cost more.

The Dayton Avenue Communication Extension (contract 4009) supplied Alcatel Model ADM 50 OC-1 SONET equipment. This vendor was the only one that supplied equipment which can swap DS 0 channels between T1 carriers. This allows TSMC DAYTON to use a single channel bank to support multiple field hubs and thus saving rack space at TSMC.

PCM DS 2 DATA TRANSMISSION SYSTEMS:

This equipment already exists but will require some expansion in existing hubs. Also, this type of equipment will be used in the non-SONET hubs. We must sole source Telco Systems "FOX 2R" as the vendor or replace a large part of the system with each expansion. Different vendors would require the use of extra fibers and thus reduce the future expandability of the ITS system. Each new vendor will require a doubling of the spare parts and training requirements. There is a possibility that WSDOT may want to contract for system maintenance, different vendors will make contract maintenance a costly option.

TELCO SYSTEMS CHANNEL BANKS:

These channel banks hold cards that accept audio and digital inputs from ITS equipment such as ramp meters, data stations, weather stations, VMS, and CCTV receivers. The channel bank combines the cards into a single, high-speed data stream. This data stream is called "T1" and is then sent to TSMC on the SONET system and/or the DS 2 FOX 2R system. Any expansion to existing channel banks will require Telco systems cards. The district-wide plan calls for moving some of the channel cards from one hub to another as new hubs are added to the system. If a different vendor was used at a new hub, new cards would have to be purchased rather than moving the old ones. Each vendor's equipment has different termination's and wiring requirements. Using different vendors will require that each hub be unique, making design, contract inspection, and maintenance cost more. The chance that there will be disastrous incompatibilities will increase. These incompatibilities will force expensive change orders or State Force work after contract completion.

VOICE AND DATA DISTRIBUTION SYSTEMS:

MODEM BELL 202

All modem expansions to existing hubs will require the use of Universal DATA SYSTEMS Model UDS202T modem cards. The only option would be to add another modem rack to accept the new vendor's modems. The new rack would increase the cost of the installation, and possibly require an expansion of the hub itself (i.e. adding a new cabinet). New hubs could use a different vendor's equipment, however this will increase the cost of the spare parts inventory, maintenance and design. We are considering using the FHWA-IP-78-16 Model 400 modems for future hubs. This is the same modem used in a 170 controller. They would not have to be sole source.

RS-232/422 Converters

All converter expansions to existing hubs will require Ark 422/232 cards. The reasons are the same as for the modems above. Future hubs may not require converters because the T1 Telco Systems channel banks might use cards that support RS 422 circuits. We are also attempting to send camera control signals

over fiber for new installations. If this new technique works we will not use or require new ARK 422/232 cards.

VIDEO TRANSMISSION SYSTEMS:

The I-90 project supplied Catel as the vendor. Any expansions to existing hubs must use Catel equipment or will require replacement of that TSMC to hub system. If new hubs use different vendors it will be impossible to construct a redundant video system. Route diversity (see Fluor Daniel report) will require that alternate routes use the same vendor. As each new hub is added to the system, existing fiber equipment will have to be moved from one hub to another. With different vendors, more new equipment would have to be purchased rather than just relocate some of the old.

CCTV CONTROL SYSTEM:

COHU CAMERAS

These cameras were selected based on advanced features which are remotely adjustable through the receivers described below. They are also the only camera made in America. If a different vendor was used, camera functionality would suffer. We would not be able to remotely change camera identifier labels, and nighttime color and brightness sensitivities.

The cameras use special plugs to connect the lens and control lines to the camera control receivers. These connections are not common among vendors. This means that maintenance must stock spares for each vendor. Wiring could not be included in contracts since it would depend on which vendor was used by the Design-Builder.

COHU CONTROL RECEIVERS

These receivers are used to control the cameras and the pan/tilt units. TSMC software can only control COHU receivers. If another vendor was used the system simply would not work. This is due to the fact that the control protocol is different among vendors.

PELCO PAN/TILT UNITS

Pelco pan/tilt units are required for plug compatibility. This means that we can include exact wiring diagrams in the contracts. These units are the most durable and easiest to repair. They also support the preset positioning features of the COHU receivers.

MULTIMODE FIBER LINKS:

These fiber connections carry the video pictures from the camera to the fiber hub. Since each link is point to point they would not have to be sole sourced for

new hubs. All expansions to existing hubs will require sole source because the fiber receivers are cards that mount in a card rack. As stated before, cards from one vendor will not work in the rack of another.

For design and maintenance concerns it would be better that all multimode fiber transmitters and receivers be sole source and that the vendor be American Fibertek.

MISCELLANEOUS EQUIPMENT:

Sole source procurement of the following items will allow designers to use "canned" wiring details in future contracts. The Design-Builder will not be required to submit technical proposals and WSDOT will not have to pay a communications consultant to review them.

The equipment is used mainly for protection and troubleshooting. If different vendors are allowed, maintenance and repair operations will require more time. This means that the TSMC system will be less reliable.

SieCor	Fiber Termination Panels
Telect	DSX-1 Jackfields VF JackfieldsNote: VF Jackfields are no longer required Fuse Panels
Ratelco	48 V dc Power Supplies

SUMMARY:

There are many reasons for sole source procurement of electronic equipment and only a few have been listed. If more justification is required for a particular device, in a particular installation, TSMC will provide any required information upon request. Contact Michael Forbis at 440-4475.