APPENDIX G INFRASTRUCTURE DESCRIPTION

For the purposes of this appendix, ODOT's existing and planned ITS devices are divided into nine broad categories[1]:

- data collection,
- traffic management,
- incident detection,
- incident management and response,
- pre-trip traveler information,
- en-route traveler information,
- commercial vehicle operations,
- communication systems, and
- maintenance coordination.

Each device's operations will be briefly described, as well as its integration with or similarity to, if any, other ITS devices. An estimate of the existing and planned deployment schedule is provided. Finally, there is a brief discussion of each device's maintenance needs.

G.1 Data Collection

Many of ODOT's ITS devices are designed to gather data about traffic and weather conditions for reporting into other systems. Eight such devices are discussed in this section.

G.1.1 Automatic Traffic Recorders

Automatic traffic recorders (ATRs) are used to record traffic volumes at fixed locations throughout the state. These are often, but not always, deployed in response to federal regulations. They consist of a vehicle detection device (usually an inductive loop detector), a controller that records detector actuations, and a controller cabinet. ATRs are connected by telephone line, so that their operation can be verified remotely.

	Region					State
	1	2	3	4	5	Total
Existing	26	26	26	23	26	127
STIP	1	4	2	1	0	8
Existing + STIP	27	30	28	24	26	135
Strategic Plan	2	16	3	2	3	26
Existing + Strategic Plan	29	46	31	26	29	161

Table G-1: Deployment Schedule for Automatic Traffic Recorders.

As Table G-1 shows, ODOT currently has about 130 ATR stations located throughout the state, with a fairly even distribution across the five ODOT regions (71). Several more are currently under construction as part of the STIP, and there are many more proposed sites for ATRs that might be constructed after the current STIP.

---

[1] There may be some devices that could be classified as ITS devices that are not included in this plan. It is assumed that maintenance procedures for these devices are already adequate.

Maintenance procedures for ATRs have been established and followed by the Transportation Data Section (TDS); therefore, specific maintenance needs for these devices will not be discussed. It should be understood, however, that as the number of ATR sites in Oregon increases, there would be a corresponding increase in the need for device maintenance, based on the procedures that are already in place.

G.1.2 Speed Zone Monitoring Stations

Similar in technology to ATRs, speed zone monitoring stations are used to measure traffic speeds at fixed locations throughout the state. They consist of a pair of inductive loop detectors, a controller that records detector actuations and calculates vehicle speed, and a controller cabinet. As Table G-2 indicates, ODOT currently has a fairly even distribution of speed zone monitoring stations across the state (72). No additional installations are currently planned in either the STIP or the Strategic Plan.

	Region					State Total
	1	2	3	4	5	
Existing	4	8	4	9	9	34
STIP	0	0	0	0	0	0
Existing + STIP	4	8	4	9	9	34
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	4	8	4	9	9	34

Table G-2: Deployment Schedule for Speed Zone Monitoring Stations.

Because there is currently no active federal regulation for speed zone monitoring stations, maintenance of the speed zone monitoring stations has been a lesser priority than for the ATRs. The similarity of technology between the two types of devices means that the maintenance needs of speed zone monitoring stations will be similar. TDS has been responsible for maintenance and upkeep of speed zone monitoring stations, and has established repair procedures. Consequently, specific maintenance needs for these devices will not be discussed.

G.1.3 Closed-Circuit Television Surveillance

One effective tool for traffic monitoring is a system of closed-circuit television (CCTV) cameras set up along major travel routes and high-accident locations. CCTV enables ODOT operators to have additional "eyes" in the field to verify where traffic problems are occurring and how they may be cleared. The cameras may be operated remotely from the TOC to pan, tilt and zoom for different perspectives from the same fixed point.

Table G-3 shows the current and future deployment of CCTV by ODOT. The Transportation Management Operation Center (TMOC), the TOC for Region 1, has a long-term goal of locating cameras at one-mile intervals along the freeway system. For other regions, cameras are being located in high-accident or other critical areas.

There are two basic different camera configurations that ODOT uses. Figure G-1 shows the standard, still camera configuration that is typically used for rural locations. This configuration takes still camera images and melds them with weather data. The weather data and camera image are fed into a character generator before feeding into the RealCam 5000. The RealCam captures

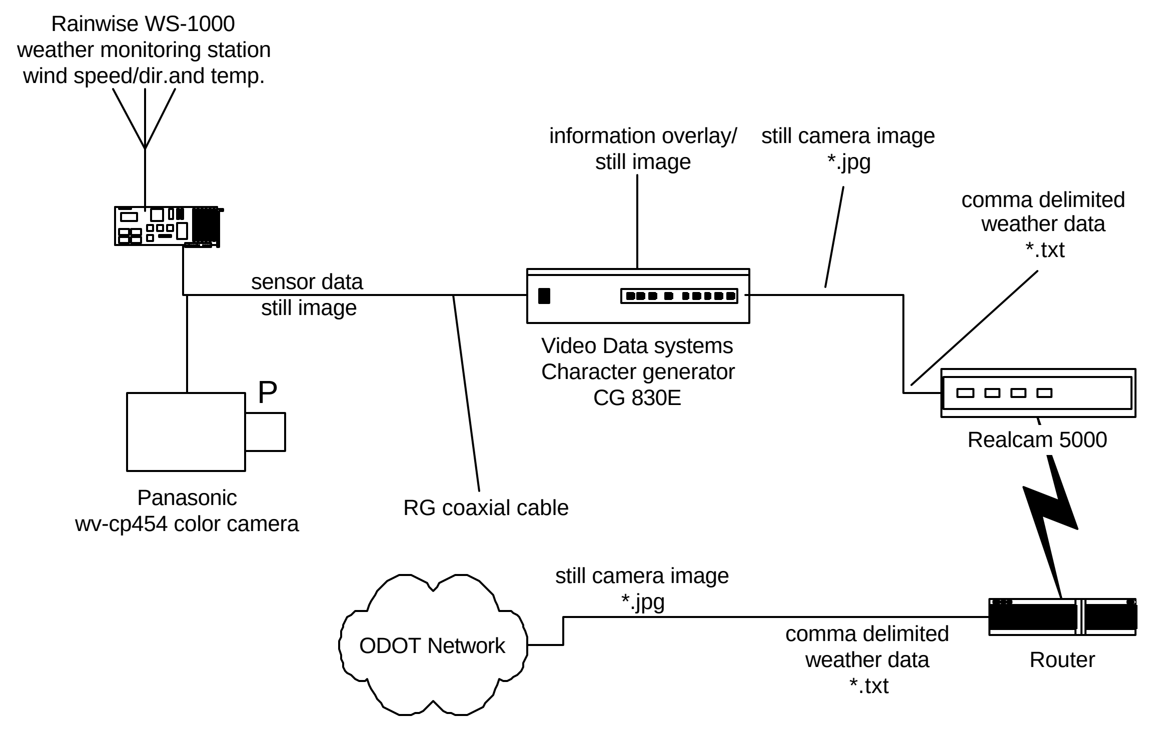

Figure G-1: Architecture for Still Camera.

(Source: ODOT)

the camera image, compresses it into a JPEG format file, and prepares it to be downloaded via a phone line (73) to the wide-area network. Normally, camera images are downloaded every few minutes.

The second configuration, which uses live camera images, is used exclusively in Region 1. Figure G-2 shows how the system architecture is set up. The TMOC uses video switching to alternate images viewed at the TMOC between different camera locations. This allows operators to more efficiently view locations that require TMOC intervention. These camera images do not include weather data.

Recent improvements in camera technology have significantly reduced the need for repair maintenance of the cameras themselves. In Region 1, where the newest generation of cameras is deployed, TMOC staff reports that equipment is generally upgraded before repair maintenance is necessary. Older generations of cameras, deployed in other parts of

	Region					State
	1	2	3	4	5	Total
Existing	39	5	1	10	1	56
STIP	7	2	0	5	17	31
Existing + STIP	46	7	1	15	18	87
Strategic Plan	73	38	40	25	13	189
Existing + Strategic Plan	119	45	41	40	31	276

Table G-3: Deployment Schedule for Closed-Circuit Television Cameras.

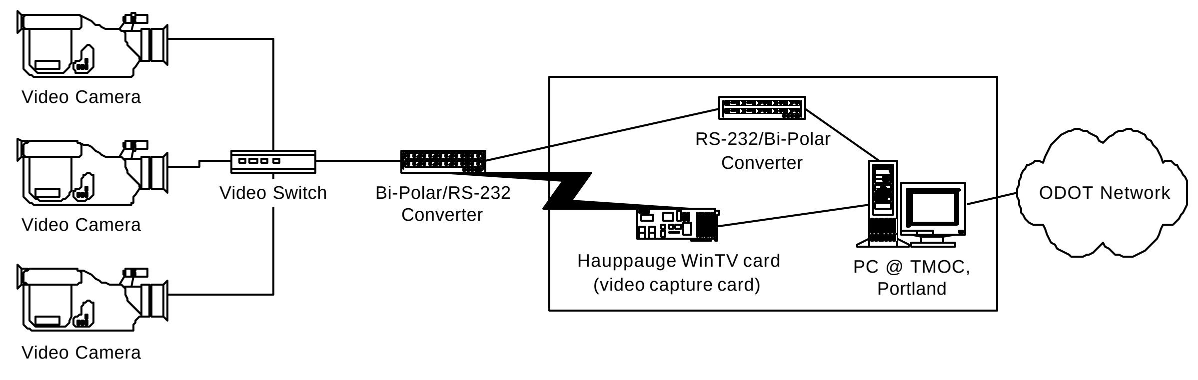

Figure G-2: Architecture for Real-Time Cameras in Region 1.

(Source: ODOT)

the state, have had problems with weather exposure to cables, which require on-site repair work. The Rainwise weather units, according to the manufacturer, require little maintenance which ODOT staff can perform (74).

There are many communication media that are used to transmit camera images to the TOCs, depending upon the location. The fiber optics backbone, which will connect the field cameras in Region 1 to the TMOC, will be shared by several ITS devices; its maintenance needs will be addressed in section G.8.1. The radio communications system, which is used for locations for which telephone access is difficult, was provided by ODOT prior to the implementation of ITS. It is assumed that there are negligible marginal maintenance costs associated with the additional radio traffic. ODOT also uses microwave relay through a cable television company as well as landline communications provided by the telephone company. In both of these cases, maintenance is outside of ODOT's jurisdiction.

Several solid-state pieces of equipment, such as modems, routers and packet radio transmitters, are required to convert and transmit the camera image over the communications media. There are other solid-state devices used in conjunction with cameras in Regions 1 and 4, including the video switch mentioned in Region 1, which are located indoors. Preventative and repair maintenance needs for these components are typically low (75), and often repairs cannot be done by ODOT staff due to the specialized nature of the components (76).

In Region 1, there are other components in the CCTV system which are necessitated by the use of real-time video. A camera server is used to take "snapshots" of the various camera locations and transmit them to ODOT's Web page. The server will need regular re-booting and system maintenance in order to ensure it operates efficiently. A software package installed in Region 1 allows the operators to use the video switch to select which cameras to view. The software will need to be updated or upgraded periodically. Finally, there is also a wall of video monitors in Region 1 used to show, at a glance, dozens of camera images from around Region 1. These monitors will need repair every few years.

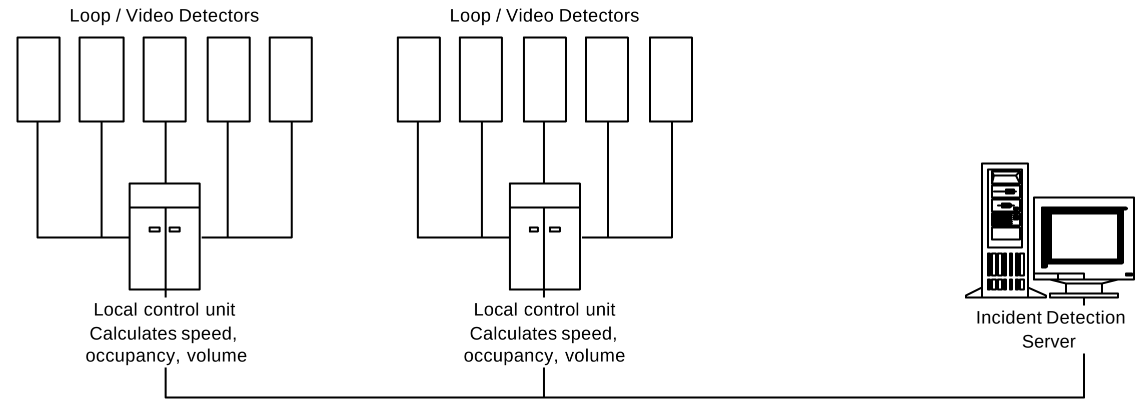

Figure G-3: Proposed Architecture for Regionwide Video Detection.

G.1.4 Video Detectors

Additional video detection equipment may be installed beyond a system of remotely controlled CCTV cameras. The purpose of this detection equipment would be to detect traffic flow parameters such as volume, speed and occupancy.

There are two different architectures that may be used for video detection, depending upon the end purpose. Figure G-3 shows how video detection would be used on a systemwide deployment. In this case, multiple video detectors throughout the region are continually collecting images from the field. Field processors interpret the images to determine traffic flow characteristics such as speed, occupancy and volume. The traffic flow data is sent to a central server at the TOC, where the data is analyzed.

Alternatively, video detection may be used in an intersection-based application, as is currently done in Valley Junction and is proposed in the STIP, to identify the presence of vehicles. In these cases, it may serve as a substitute for inductive loops or other detection technologies at a semi-actuated or fully actuated traffic signal, as shown in Figure G-4. In this case, actuations from the detector would go into a signal controller located in the field, which might influence signal timing patterns.

	Region					State Total
	1	2	3	4	5	
Existing	0	4	0	0	0	4
STIP	0	1	0	1	0	2
Existing + STIP	0	5	0	1	0	6
Strategic Plan	100	0	0	0	0	100
Existing + Strategic Plan	100	5	0	1	0	106

Table G-4: Deployment Schedule for Video Detectors.

Table G-4 shows the existing and planned deployment of video detection systems in ODOT. Currently, there are video detectors set up on Interstate 5 in Salem and on Oregon Route 18 in Valley Junction on an experimental basis. There are two short-term projects for video detection, one in Region 2 on Oregon Route 22 and in

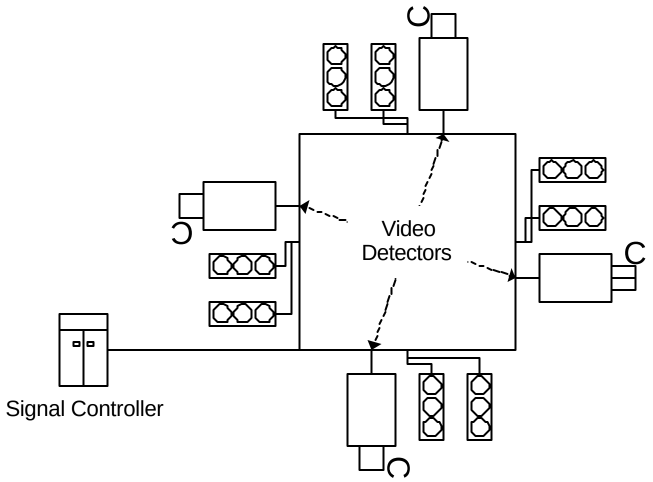

Figure G-4: Proposed Architecture for Intersection Video Detection.

Region 4 in Bend. There are long-term plans for regional installation of video detection in Region 1. This system of detectors would serve primarily as a data source for regionwide incident detection, which is discussed in section G.3.3.

According to one video detection system manufacturer, maintenance needs for video detection systems have proven very minimal. The customer may perform annual lens cleanings, but it is recommended that the vendor perform most major maintenance (77). Repair maintenance should be necessary only rarely, such as in cases of lightning or knockdowns.

G.1.5 Road and Weather Information System

Road and weather information systems (RWIS) are used to gather key meteorological data near major roadways. Data collected by RWIS may have several applications, including expediting decisions on weather-induced closures or detours, providing pertinent traveler information, and assisting in deployment of roadway maintenance vehicles. In rural areas, RWIS can provide an initial warning about potentially hazardous conditions, giving TOC operators the ability to respond to conditions more quickly.

	Region					State Total
	1	2	3	4	5	
Existing	6	4	1	8	1	20
STIP	3	5	3	7	19	37
Existing + STIP	9	9	4	15	20	57
Strategic Plan	5	15	20	22	9	71
Existing + Strategic Plan	14	24	24	37	29	128

Table G-5: Deployment Schedule for Road and Weather Information System Stations.

Table G-5 shows ODOT's existing and planned deployment of RWIS. RWIS are currently located on a limited basis, primarily in Regions 1, 2 and 4. ODOT is planning to deploy RWIS more aggressively in the future, especially in the more rural parts of the state.

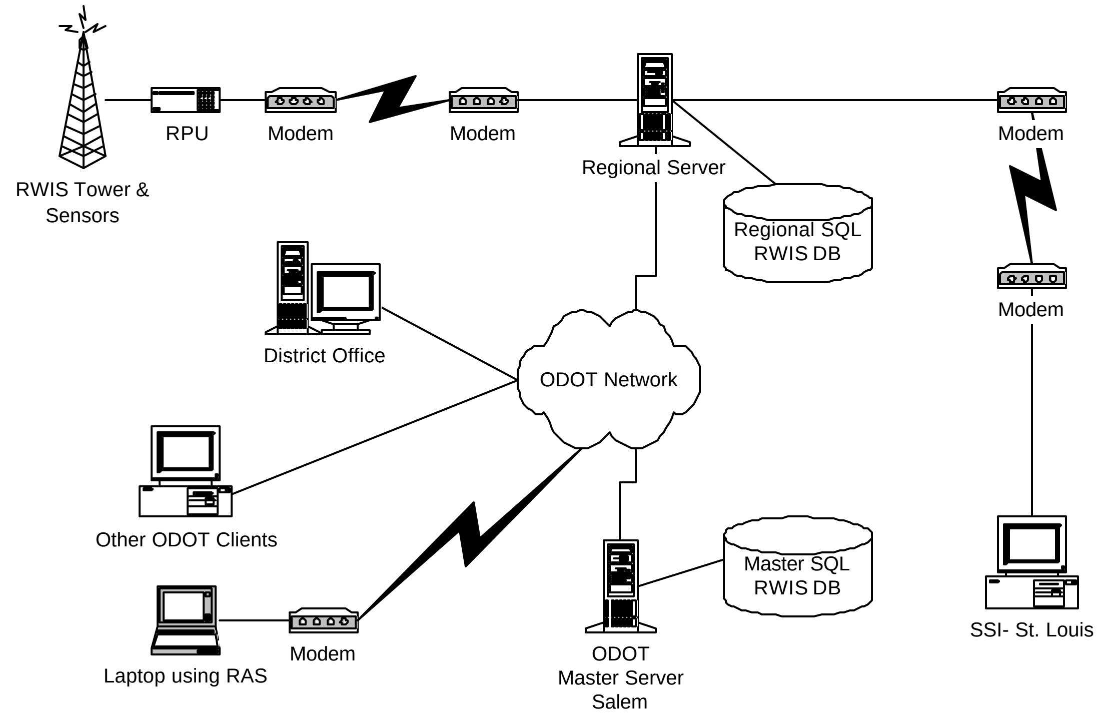

Figure G-5: Architecture for RWIS Configuration with SSI Stations.
(Source: ODOT)

ODOT has used several different architecture configurations to support RWIS, based on the RWIS vendor's technology as well as the availability of communications infrastructure. The vendor most often used by ODOT for RWIS installations currently is Surface Systems Incorporated (SSI). A typical SSI architecture is shown in Figure G-5. Field sensors collect atmospheric data relating to temperature, wind speed and direction, relative humidity, and precipitation. In addition, sensors are embedded in the roadway to measure road surface temperature and moisture to help identify precursors to icy conditions. The sensors continuously collect data, which is stored on a remote processing unit collocated with the sensors. In addition to remote weather sensors, there are regional RWIS servers located in each of ODOT's regions. The regional servers use software developed by SSI to poll each RPU every ten minutes to extract the latest weather data. Once the measurements from each of the RPUs are loaded onto the regional servers, the data is sent to three different locations. First, the data is sent via modem to SSI in St. Louis for commercial applications. Second, the data is replicated into a regional database. Third, the data is sent to the ODOT wide-area network, where it is put onto a central RWIS server. The central server has its own database, so that there is a duplicate of the databases stored at the regions. Once the RWIS data is on the ODOT network, ODOT has developed several database queries to extract and display weather data from the vendor-supplied database. SSI maintains ownership over many maintenance aspects of the system, including the polling software and the databases (78), while ODOT is responsible, in general, for field sensors and associated equipment, as well as regional and central servers.

The second vendor used by ODOT for RWIS installations is Texas Weather Instruments (TWI). As shown in Figure G-6, data collected from the servers is again transmitted to a central

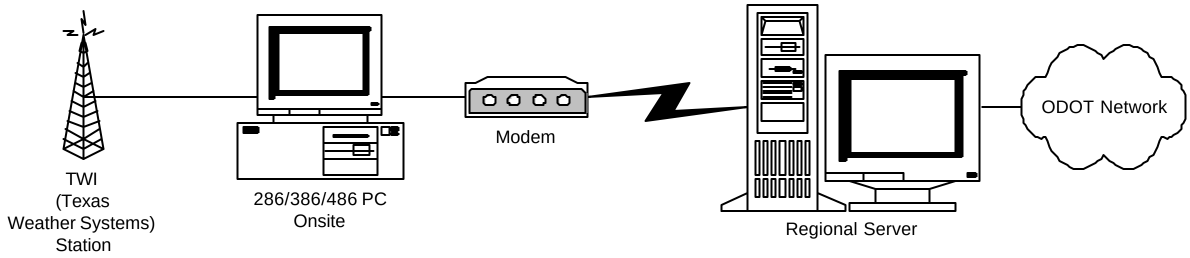

Figure G-6: Architecture for RWIS Configuration with TWI Stations.

(Source: ODOT)

regional server. The regional server transmits the information to ODOT's wide-area network, where the data may be disseminated. The TWI installations differ from the SSI installations primarily in that the TWI stations do not use pavement sensors.

Recommendations for sensor equipment maintenance vary between the two manufacturers. For SSI, annual cleanings of the various sensors are recommended (66). TWI recommends monthly cleaning of the rain collector equipment (79); however, since ODOT does not appear to use data on precipitation accumulation as a part of its RWIS information given to the public, it may be adequate to visit these sites annually as well. The remote servers are expected to have similar maintenance needs whether it is a SSI or a TWI system, with the need for regular visual inspection and re-booting.

Like CCTV, RWIS utilizes many different communications systems in order to attempt to reduce operations costs. Many sites use landline telephone communications. Where telephone service is either not available or would require long-distance toll charges, ODOT utilizes a couple of different systems. For some TWI stations, ODOT uses its radio system to transmit data. This requires the use of special packet radio devices that convert data between a text file format and a format that can be transmitted via radio. For some SSI stations, ODOT has used some dial-up routers that have proven to be very sensitive to the quality and level of power supplied (78). Based on field experience in Oregon, the most persistent communications problem for RWIS is associated with these dial-up routers. ODOT is in the process of replacing these routers, which will reduce the associated maintenance needs.

The RWIS system is very data-intensive and relies on the integrity of several servers and their respective databases. Maintenance on these servers is focused primarily on preventative maintenance, primarily performing regular re-booting and diagnostic checks.

G.1.6 Travel Time Estimation

Obtaining real-time estimates of travel time through a corridor would allow the notification of emergency response crews in the event of non-recurring congestion as caused by a roadway incident or accident, and the dissemination of real time travel information to assist in en-route route choice. There are several methods available for estimating travel time. ODOT is investigating deploying a system in metropolitan Portland that would calculate travel times based on when the same vehicle license plate number passes two or more video checkpoints. It has been recommended that checkpoints would be spaced between one and three miles apart (80). Based on readers spaced at two-mile intervals aimed in each direction, Table G-6 provides an estimate for the number of checkpoints that would need to be deployed.

	Region					State
	1	2	3	4	5	Total
Existing	0	0	0	0	0	0
STIP	0	0	0	0	0	0
Existing + STIP	0	0	0	0	0	0
Strategic Plan	80	0	0	0	0	80
Existing + Strategic Plan	80	0	0	0	0	80

Table G-6: Deployment Schedule for License Plate Readers for Travel Time Estimation.

The basic components of a travel-time estimation system using automated license plate readers, shown in Figure G-7, are as follows.

- Camera. The camera is used to capture the image of the vehicle's license plate as it passes the system installation point. Just about any type of camera can perform this function, from monochrome to color or digital to normal. A digital color camera is the most recommended because of the increased speed of data transfer and assistance in plate identification.

- Light source. A light source is required, depending on the type of camera, to allow for operation at night and in poor visibility conditions. The light is typically timed to turn on at the same time as the camera to save energy and avoid too much motorist distraction. Infrared lighting is the most common light source used. It is undetectable to the human eye but most cameras will pick it up.

- Triggering mechanism. The triggering mechanism is intended to fire the image-capturing components (i.e., the camera and light source) of the license plate reader when a plate is within the camera's field of view. The two types of triggering

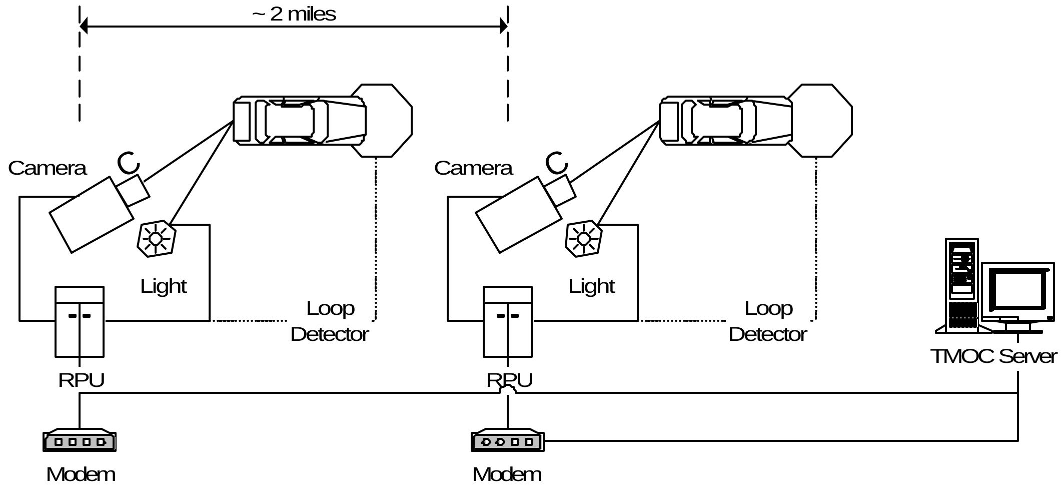

Figure G-7: Proposed Architecture for Travel Time Estimation.

mechanisms available are external and internal. An external trigger causes an image to be captured when a vehicle is detected by a sensor on the road surface. Internal triggers within the reader itself require an image processing algorithm to recognize when a plate enters the camera's field of view.

- Image processing algorithm. The image processing algorithm is used to identify the plate within the captured image, identify its state of origin and read its alpha-numeric code. The types of processing algorithms used are decision trees and neural networks.
- Remote processing unit. To control the triggering mechanism, run the image processing algorithm and transmit the plate identification to the TOC, it will be necessary to have "intelligence" in the field in the form of a remote processing unit. This would simply be an environmentally hardened microcomputer.

To measure travel times will require real-time communication from each of the checkpoints to a central server. This will be provided by the same fiber optics network used by the Region 1 CCTV cameras. The server will match observations collected at different checkpoints to identify vehicles that have passed between two or more checkpoints. After the server calculates average travel times, this information could be transmitted to the public through a variety of means, including the Internet, commercial radio, or other en-route traveler information systems.

The primary maintenance need of the travel time estimation system is the proper upkeep of the remote processing units at each checkpoint. In addition to the preventative maintenance needs typical for a field computer, there is the possibility of cabinet knockdown due to the proximity of the cameras to the roadway. According to one vendor of such systems, maintenance needs have proven to be very minimal (81). The travel time server is also expected to need regular re-booting and database pruning in order to ensure the system operates efficiently and effectively during times of peak congestion.

G.1.7 Automatic Vehicle Location

Automatic vehicle location (AVL) is a technology by which information about a vehicle's location may be transmitted automatically to a remote destination. For this technology to be implemented, vehicles are equipped with an in-vehicle unit that integrates a global positioning system (GPS) receiver, a modem, a display unit and a simple keypad. The in-vehicle unit is, in turn, connected with sensors on the vehicle that may characterize the vehicle's activity. A computer receiver records vehicle locations and then transmits this information to the appropriate operator.

In ODOT's ITS Strategic Plan, it was originally intended that AVL would be used as a system for regionwide estimation of travel times in Portland (3). ODOT is no longer looking at using AVL for that type of application; instead, the following two applications are being examined for AVL:

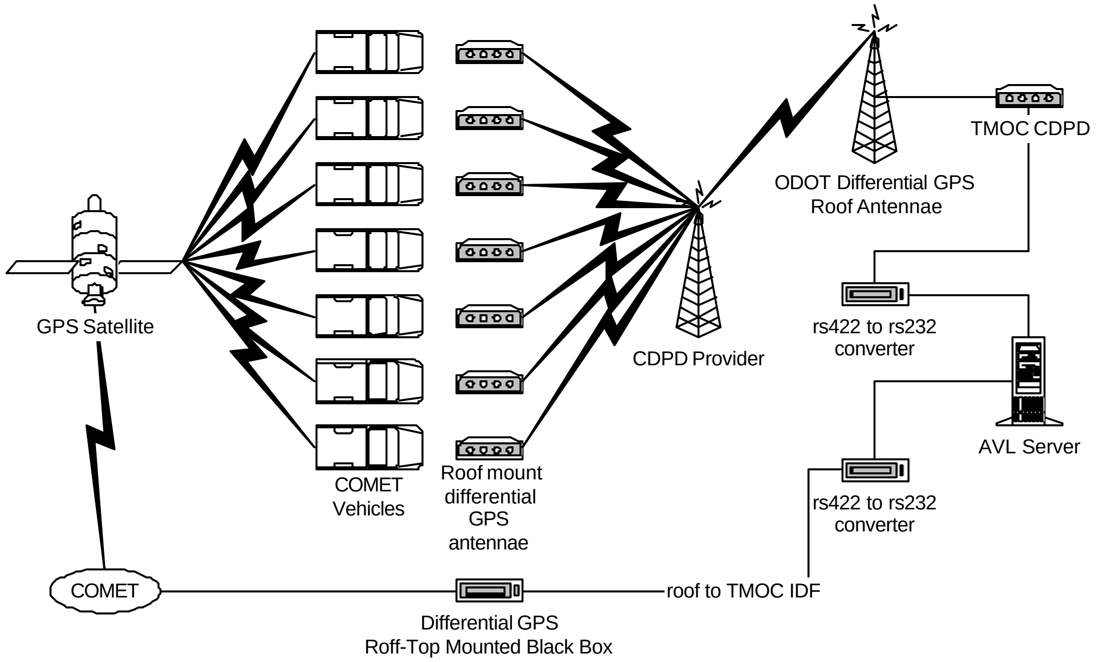

Figure G-8: Architecture for Automatic Vehicle Location.

- Incident response vehicles. AVL is currently in use on the seven incident response vehicles[2] in Region 1. The AVL system currently in use on these vehicles is shown in Figure G-8. Vehicle locations are identified through the use of satellites and roof-mounted, magnetic differential GPS antennae on the top of each vehicle. The vehicles communicate via cellular digital packet data (CDPD) radio modems to a roof antenna located at the TMOC. Information from the vehicles is combined with information from the satellite to determine vehicle locations. Having AVL enables the TMOC to dispatch vehicles more efficiently to incidents when they have been identified through CCTV, police reports or other means. For AVL, on-board sensors can indicate information such as whether the on-board VMS is activated or whether the vehicle's doors are open or closed.

- Maintenance vehicles. ODOT is testing the use of AVL to assist in highway maintenance in Region 4. This type of application would enable a maintenance district office to direct maintenance vehicles to restore roadways to normal operations more efficiently during inclement weather. Sensors can indicate whether the plow is raised or lowered, whether the spreader (for salt or sand) is on or off, and what the spreading rate is. The primary difference between the architecture used to support this AVL application and the architecture used to support incident response vehicles in Region 1 is that CDPD has limited coverage in rural regions. Consequently, low-band radio would likely be used for vehicle-to-center communications under a maintenance vehicle management program.

---

[2] These vehicles will be discussed in detail in section 3.2.4.2.

	Region					State Total
	1	2	3	4	5	
Existing	7	0	0	0	0	7
STIP	0	4	0	40	0	44
Existing + STIP	7	4	0	40	0	51
Strategic Plan	100	100	100	60	100	460
Existing + Strategic Plan	107	104	100	100	100	511

Table G-7: Deployment Schedule for Vehicle Probes.

Table G-7 shows the deployment schedule for AVL in Oregon. The STIP includes four additional incident response vehicles in Region 2 – one for each district – each of which is assumed to be equipped with AVL. Provided the AVL field test in Region 4 is successful, it is anticipated that about 100 maintenance vehicles per region will be equipped with AVL.

Much of the maintenance of the system is – and will continue to be – handled by the vendor. The vendor is responsible for the in-vehicle units, which seldom have significant maintenance problems and require no preventative maintenance. According to one vendor, the most significant maintenance concern with the vehicle component of AVL has been the performance of the in-vehicle sensors, which are typically not provided by the vendor (82). These sensors may need regular inspection and testing to ensure they are working properly (83). ODOT's maintenance responsibility is currently limited to maintaining the AVL servers, located in each region. Low-band radio, if ODOT does use this as the communications media for AVL, would also become ODOT's maintenance responsibility. The vendor is responsible for providing the satellite system that supports the GPS, the in-vehicle probes, as well as the center-based software. Because the AVL support software has become somewhat mainstream, no special training or vendor involvement is required for software upgrades (82).

G.2 Traffic Management

The purpose of traffic management devices is to allow operators, especially at the Transportation Operation Center (TOC) level, to make better use of the existing transportation infrastructure to meet the public's needs.

G.2.1 Traffic Signals

Traffic signals represent one of the oldest ITS devices. Traffic signals may be installed not only for safety reasons – i.e. to better manage conflicting movements at intersections – but also to improve mobility for traffic on side streets trying to cross or access a major arterial. ODOT has many traffic signals under its jurisdiction, although the organization tries to delegate the maintenance responsibility for these signals to municipalities or counties where possible.

Traffic signals have well-established maintenance procedures, not only relating to how staff are summoned to diagnose and repair a malfunctioning signal, but also relating to logging and tracking the repair process.

G.2.2 Ramp Metering

Ramp metering systems are essentially traffic signals governing a one-legged approach onto an expressway. They are a relatively older technology designed to improve expressway capacity and safety by controlling the rate at which vehicles enter the flow of traffic. Most metering systems are operated during peak-period conditions when mainline volumes are heaviest. A typical ramp metering system consists of vehicle detectors on the ramp and possibly on the mainline, a traffic signal, a local traffic signal controller, and communications links between these components.

Table G-8 shows the existing and future deployment of ramp metering systems in Oregon. These systems are currently exclusively located in the Portland metropolitan area due to the severity of peak-period traffic congestion. The Strategic Plan includes a more ambitious implementation of ramp meters, with all entry ramps in Portland eventually being metered, and as many as one hundred additional ramp meters to be installed between the Eugene, Salem and Medford metropolitan areas.

	Region					State
	1	2	3	4	5	Total
Existing	64	0	0	0	0	64
STIP	26	0	0	0	0	26
Existing + STIP	90	0	0	0	0	90
Strategic Plan	60	65	35	0	0	160
Existing + Strategic Plan	150	65	35	0	0	250

Table G-8: Deployment Schedule for Ramp Metering.

To improve the effectiveness of ramp metering systems, they are typically connected to a central operating center. In Region 1, existing ramp meters will be connected to the fiber network, which will allow the TMOC to adjust ramp metering timings in real-time based on local traffic volumes, incidents, special events, and other factors. Future installations in the other regions will likely have similar connections to the respective region’s TOC.

Because of the similarities between ramp meters and traffic signals, maintenance procedures and requirements for each of these classes of devices are handled in the same way. The maintenance needs of the fiber network required to support ramp metering systems will be discussed in Section G.8.1.

G.2.3 Traffic Signal Preemption for Emergency Vehicles

Many traffic signals have special equipment that temporarily alters the intersection’s signal timing to allow an emergency vehicle to pass through. The equipment interfaces with conventional Type 170 traffic signal controllers. ODOT has emergency vehicle preemption in use at hundreds of traffic signals across the state, as shown in Table G-9 (84).

An architecture schematic for this technology is shown in Figure G-9. An emergency vehicle has an in-vehicle device that communicates its presence to the intersection signal controller through a detector. Once the detector is activated, a signal is sent to the controller to bypass its current timing sequence and give green to the direction from where the emergency vehicle is coming for a pre-determined length of time. Once the green time passes, the intersection resumes its normal signal timing pattern. ODOT uses optical-based detection with an in-vehicle strobe light used to send light to an optical detector mounted on the signal mast (84).

ODOT will continue to use this technology in the future by both retrofitting existing intersections and installing the equipment at new signals. Maintenance for both special controller cards like emergency vehicle preemption and the optical detection equipment is covered under existing procedures.

	Region					State Total
	1	2	3	4	5	
Existing	206	104	59	51	23	443
STIP	0	0	0	0	0	0
Existing + STIP	206	104	59	51	23	443
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	206	104	59	51	23	443

Table G-9: Deployment Schedule for Emergency Vehicle Signal Preemption.

G.2.4 Preferential Traffic Signal Treatment for Transit Vehicles

Traffic signals may also be programmed to provide preferential treatment to transit vehicles. Region 1 uses preemption equipment for light rail transit vehicles, giving the light rail system right-of-way over other vehicle traffic, so traffic signals at any at-grade intersections will be turned to red when a light rail train is passing through.

Traffic signal prioritization may also be used in order to improve on-time performance and reduce travel times for transit. Like signal preemption, the technology involves communication between a transit vehicle and the intersection signal controller via detection equipment. Instead of automatically giving green to the transit vehicle, the prioritization card in the controller will merely extend green time to the direction the vehicle is coming from if the light is currently green. In this way, the transit vehicle will be able to clear the intersection without having to wait

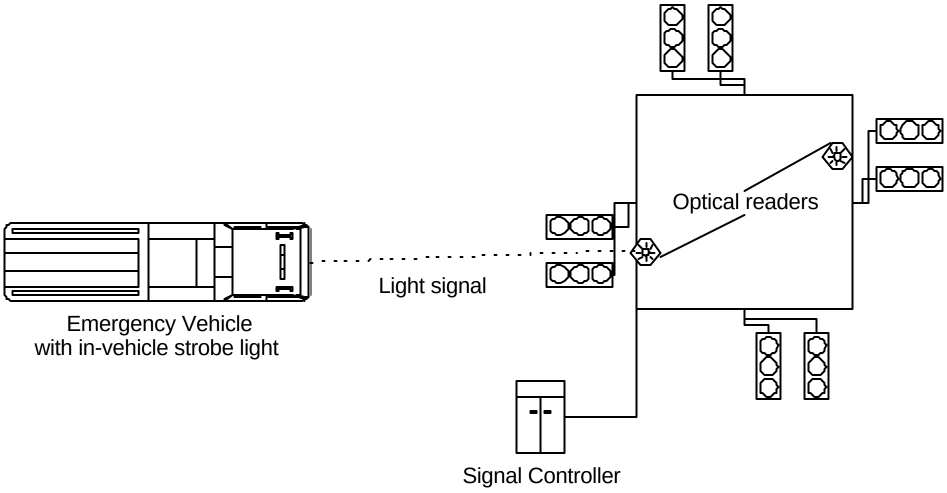

Figure G-9: Architecture for Signal Preemption.

an additional cycle.

Preferential signal treatment for transit vehicles is currently limited in application to Region 1, as shown in Table G-10. The table includes only preemption equipment used in connection with light rail transit (84). In addition, the Strategic Plan includes funding for prioritization equipment at 100 intersections outside of metropolitan Portland. The two transit systems with the largest fleets after Tri-Met are in Region 2 – in Eugene and Salem (85) – so it is assumed that all 100 equipped intersections would be in Region 2 as well.

	Region					State
	1	2	3	4	5	Total
Existing	17	0	0	0	0	17
STIP	0	0	0	0	0	0
Existing + STIP	17	0	0	0	0	17
Strategic Plan	0	100	0	0	0	100
Existing + Strategic Plan	17	100	0	0	0	117

Table G-10: Deployment Schedule for Preferential Signal Treatment for Transit.

Maintenance for these devices is covered under existing procedures.

G.2.5 Advanced Traffic Management System

An Advanced Traffic Management System (ATMS) is a system that is concerned with the overall management of traffic to improve network capacity, reduce user delays, and improve safety. To do this, an ATMS collects and analyzes field data on traffic conditions, and assists in assessing network congestion, adjusting traffic signal timing, providing drivers with real-time information on potential alternatives, and detecting incidents. For an urban TOC, the ATMS is a primary tool for managing regional traffic.

As Table G-11 indicates, ODOT's deployment goal for ATMS in the long-term is to have one operating system in each of ODOT's five regions[3]. The TMOC in Portland has installed ATMS software first developed for metropolitan Atlanta. The system is a UNIX-based network system with Windows NT interfaces for the operators. It is capable of interfacing with CCTV, VMS, ramp meters and other ITS systems in order to optimize the transportation system's operations. It is a scaleable system; therefore, it may be installed in a smaller version at ODOT's other TOCs at a future date.

	Region					State
	1	2	3	4	5	Total
Existing	1	0	0	0	0	1
STIP	0	0	0	0	0	0
Existing + STIP	1	0	0	0	0	1
Strategic Plan	0	1	1	1	1	4
Existing + Strategic Plan	1	1	1	1	1	5

Table G-11: Deployment Schedule for Advanced Traffic Management Systems.

For the purposes of this analysis, the ATMS is defined to include only the computer and communications equipment necessary to support ATMS functions. Region 1 was used as a

---

[3] This long-term goal assumes a new TOC is initiated in Region 5.

model for estimating maintenance needs in other regions because it has the most advanced ATMS deployment to date. Region 1 utilizes two servers – a graphical user interface (GUI) server and a database/communications server. Each of these servers will have regular preventative maintenance activities. There are approximately 20 workstations and/or laptops in Region 1 which are used by TOC staff in fulfilling the operation of the TOC, and hence should be considered as part of the ATMS maintenance needs (76). It is assumed that other regions would have fewer staff members, and consequently would not need as many computers. For the other regions, it is assumed that there would be two operator consoles, the two required server machines, and two machines for the TOC manager – one desktop and one notebook.

As ODOT deploys an increasing volume of technology and desires increased functionality, the ATMS software will need to be upgraded and updated. Because the software is written on a UNIX platform, it is anticipated that the software modifications will be developed centrally in Salem, where any ODOT UNIX expertise would reside. After testing of the software, upgrades would be installed at the other regions in the state to ensure consistency of operations across the state.

In addition to the maintenance needs associated with the computer hardware and software, there will be maintenance associated with communications inside the TOC. Failure of the local-area network due to worn cables could deactivate the ATMS, so regular inspection of the in-building communications is recommended.

G.3 Incident Detection

The Federal Highway Administration has estimated that at least 60 percent of highway congestion is caused by incidents (86). Therefore, one of the most important aspects of successful traffic management is being able to detect incidents quickly. ODOT is considering implementation of several ITS solutions that would expedite incident detection.

G.3.1 Callboxes

	Region					State Total
	1	2	3	4	5	
Existing	0	0	4	0	0	4
STIP	0	0	0	0	0	0
Existing + STIP	0	0	4	0	0	4
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	0	0	4	0	0	4

Table G-12: Deployment Schedule for Callboxes.

One incident detection mechanism used by many departments of transportation is emergency callboxes, located strategically along expressways to help motorists report incidents and breakdowns more quickly. In Oregon, as shown in Table G-12, callboxes have been installed only in Region 3. They were installed on the Medford Viaduct primarily because geometric constraints on the viaduct mean that incidents or breakdowns will more than likely be blocking travel lanes, creating an additional safety hazard.

ODOT's callboxes are environmentally sealed, heavy-duty, telephone handsets. They are hard-wired directly to a dispatch center at Central Point in Region 3 such that a motorist picking up the handset would be directly connected to the dispatch center in order to verbally report the incident. There are neither telephone keypads nor automatic call classification procedures associated with the callbox system.

The callboxes are currently being upgraded, with new field units to be deployed in the fall. The previous models were not very resistant to vandalism and were susceptible to environmental damage as well, requiring significant maintenance activities every 3 to 4 months. According to vendor recommendations, the new units should need little maintenance. Preventative maintenance, in the form of seeing if calls go through, is recommended every three or four weeks. Because of the sophisticated nature of the electronics within the call boxes, repair maintenance would need to be directed to the vendor (87).

G.3.2 Cellular Call-in

To expedite detection and reporting of incidents, many jurisdictions have worked with local cellular phone providers to provide a universal, cellular call-in telephone number. Calls to these telephone numbers are often the first reports of incidents (88). In one case study, response time to incidents was reduced by 10 to 15 minutes when the Massachusetts State Police developed a single statewide phone number for reporting incidents (89). As cellular phone market penetration increases, this could be an even more critical component to the quick detection and response to incidents. ODOT currently has telephone numbers available for reporting incidents that may be accessed by cellular phone users, but the telephone numbers change across jurisdictions and are generally not easy to remember.

To create a cellular call-in program, ODOT would coordinate with cellular phone providers to arrange for an easy-to-remember number (such as *999) to be made available on a statewide basis. As a public service, the cellular telephone companies may absorb the cost of creating the program (90). Once the program is in place, maintenance of the program would be minimal from ODOT’s perspective. ODOT would have maintenance responsibility over roadside signage that indicates the phone number; this maintenance could be included with other sign maintenance programs with negligible additional cost. Maintenance of the cellular phones and cellular phone transmitters would be the responsibility of the cellular phone companies and subscribers.

G.3.3 Automatic Incident Detection Systems

The previous two incident detection methods strive to reduce response time to incidents by making it easier for human observations to be provided to an operations center. An alternative to simply improving the channels for human reporting is to utilize technology to automatically identify incidents. Such systems may be called automatic incident detection systems.

The system’s functionality is based on the development of an algorithm that identifies incidents based on key traffic flow parameters such as occupancy, volume and speed. The algorithm reviews the data collected from the detectors and attempts to identify anomalies that might suggest the presence of an incident, such as sudden reductions in travel speed or volume. These algorithms are not faultless: an algorithm may sometimes identify an “incident” when actually there is none (i.e. a “false alarm”) or it may fail to identify an incident that has actually occurred. There is ongoing research to improve incident detection algorithms in order to reduce the number of “false alarms” and missed incidents.

	Region					State Total
	1	2	3	4	5	
Existing	0	0	0	0	0	0
STIP	0	0	0	0	0	0
Existing + STIP	0	0	0	0	0	0
Strategic Plan	1	0	0	0	0	1
Existing + Strategic Plan	1	0	0	0	0	1

Table G-13: Deployment Schedule for Regionwide Automatic Incident Detection Systems.

Incident detection systems have most commonly been used in metropolitan areas by relying on a system of field detectors. ODOT is looking to implement this type of application in Region 1, as shown in Table G-13. The architecture for this type of deployment was depicted in Figure G-3 in connection with the discussion on regionwide video detection. In order to be of value, the system requires continuous, real-time communications from the field detectors to the incident detection server. This would allow the server to poll the field units every 10 to 60 seconds to obtain the latest in traffic flow information. In Region 1, this would likely be provided by the same fiber optics network which is used by CCTV, ramp metering and other ITS devices.

ODOT is also looking to deploy, on a test basis, intersection-based incident detection. The architecture for this type of deployment is indicated in Figure G-10. For this type of system, a remote processing unit located in the field would execute the incident detection algorithm. When an incident has been identified, the field unit transmits a message to the TOC. Communication needs for this type of system are less demanding than a regionwide deployment because there is no need for continuous, real-time communications between the intersection and the TOC.

As Table G-14 indicates, ODOT is planning to test video-detection based incident

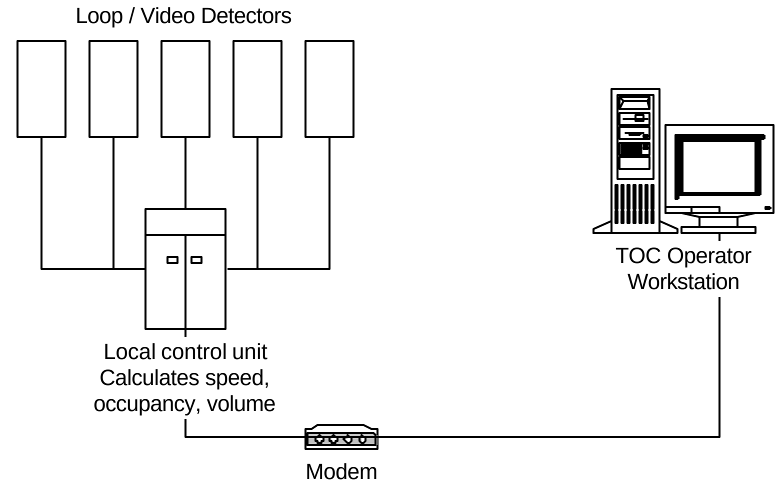

Figure G-10: Proposed Architecture for Intersection-Based Incident Detection.

detection at a couple of test high-accident locations using an intersection-based deployment.

	Region					State Total
	1	2	3	4	5	
Existing	0	0	0	0	0	0
STIP	0	1	0	1	0	2
Existing + STIP	0	1	0	1	0	2
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	0	1	0	1	0	2

Table G-14: Deployment Schedule for Intersection-Based Incident Detection Systems.

The automatic incident detection system relies upon accurate detector data; consequently detector maintenance, which was discussed in Section G.1.4, is a major priority. The software algorithm may need fine-tuning and upgrading every couple of years in order to incorporate the results of on-going research. The most significant maintenance issue with this system is likely the intelligence, either at the TMOC for regional incident detection or at individual intersections. These machines will need regular preventative maintenance (such as database management and re-booting) to ensure they are operating efficiently. The intersection-based computers should need little in terms of hardware upgrades. If detection points from major arterials in Region 1 are incorporated into the regional incident detection system, the incident detection server may need to be upgraded to handle the additional data processing requirements.

G.4 Incident Management and Response

In addition to detecting incidents, quick response to incidents is essential to aiding victims of incidents as well as restoring the transportation capacity of the network. Several systems may assist in expediting incident management and emergency response.

G.4.1 Computer-Aided Dispatch

Computer-aided dispatch (CAD) assists in dispatching police and emergency personnel to various calls for help. It is primarily a database system that records the calls as they come in, giving the location, type of call, and other pertinent information.

The system is designed primarily around the needs of the Oregon State Police (OSP), which supports the CAD mainframe and network connections to the TOCs. The TOCs may use information from the CAD system for a variety of incident management and response purposes, including dispatching incident response vehicles, providing information to motorists both pre-trip and en-route, and dispatching repair services for potential malfunctioning equipment.

All of the TOCs except for the TMOC are collocated with the OSP dispatch functions. In Portland the TMOC's ATMS, along with information provided by surveillance cameras, enables them to provide additional information to OSP on incident location and severity.

The CAD database and system is maintained and updated by the OSP. ODOT's maintenance responsibilities for the system are limited to the CAD terminals used by ODOT staff, and all the communications within the dispatch center to link the terminals to communications from the central CAD database (91).

	Region					State Total
	1	2	3	4	5	
Existing	0	5	2	2	0	9
STIP	0	0	0	0	0	0
Existing + STIP	0	5	2	2	0	9
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	0	5	2	2	0	9

Table G-15: Deployment Schedule for Computer-Aided Dispatch Stations.

Table G-15 indicates the number of ODOT workstations on which CAD is operated. These workstations will need maintenance typical for any computer. Because ODOT has limited in-house expertise in CAD diagnostics, however, repair maintenance needs often require more time than for other computer systems in order to include travel time from Salem.

G.4.2 Incident Response Vehicles

One effective tool in reducing both the safety hazard and time delay caused by incidents or stalled vehicles is to have a fleet of vehicles ready to assist in clearing disabled vehicles from the roadway. ODOT's best-established program for incident response is Portland-based COMET, which stands for CorridOr ManagEment Team. COMET vehicles regularly patrol major travel routes to keep them free from major obstructions, to provide emergency motorist assistance, and to improve on-scene incident management (92). Each COMET vehicle is equipped with several ITS devices, including:

- an automatic vehicle location (AVL) in-vehicle unit;
- a laptop computer;
- cellular phone communications;
- high-band and low-band radio communications; and
- on-board variable message signs.

	Region					State Total
	1	2	3	4	5	
Existing	7	0	0	0	0	7
STIP	0	4	0	0	0	4
Existing + STIP	7	4	0	0	0	11
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	7	4	0	0	0	11

Table G-16: Deployment Schedule for Incident Response Vehicles.

As shown in Table G-16, the TMOC currently has seven COMET vehicles. The STIP includes provision for one additional incident response vehicle for each district within Region 2.

Maintenance for the vehicles themselves would be considered as part of traditional fleet maintenance activities. The ITS devices on-board the incident response vehicle have unique maintenance activities. For truck-mounted VMS, maintenance needs are typically relatively low, focusing on sign cleaning. Many of the vehicles currently employ flip-disk matrix VMS, which have the tendency to stick or change during travel. Moreover, these signs have often had power supply problems. These VMS are being upgraded to displays using light-emitting diode (LED) matrices, which are more stable during transit and have more reliable power (93). Wireless communication systems, such as cellular phone and radio equipment, are maintained through the private sector and OSP respectively. The vehicles' laptop computers typically are used for incidental activities, such as assisting in record keeping or in providing additional messages to the on-board VMS beyond the messages which are already programmed (76). Consequently, maintenance needs for the laptop computers will be fairly low. Maintenance of the in-vehicle AVL equipment was discussed in Section G.1.7.

To preserve the effectiveness of the incident response vehicles, their down-time must be minimized. To help in this effort, regular inspection and testing is recommended to ensure that, as a minimum, the VMS, AVL and on-board communications systems are functioning effectively. It is envisioned that preventative maintenance activities for all of the ITS devices on the incident response vehicles would be performed in the same time frame in order to minimize down-time. Because maintenance of many components, such as the in-vehicle AVL units and cellular phones, are provided through vendors or contractors, the on-board VMS will be ODOT's most significant maintenance concern. Repair needs for the VMS should decrease in frequency and severity as the signs are replaced and upgraded.

G.4.3 Pre-planned Detour Routes

One effective tool for incident response is to have a set of pre-planned detour routes on hand. These routes would be developed "off-line" by ODOT staff or consultants, and would identify alternative routes in the event that an incident is blocking a segment of a freeway. According to ODOT's statewide ITS strategic plan, several hundred pre-planned detour routes will be developed as shown in Table G-17.

	Region					State
	1	2	3	4	5	Total
Existing	0	0	0	0	0	0
STIP	0	0	0	0	0	0
Existing + STIP	0	0	0	0	0	0
Strategic Plan	500	100	100	50	0	750
Existing + Strategic Plan	500	100	100	50	0	750

Table G-17: Deployment Schedule for Pre-planned Detour Routes.

A set of pre-planned detour routes may be integrated with other ITS deployments. For example, in Mn/DOT's Integrated Corridor Traffic Management project on the I-494 corridor, VMS were installed at expressway access points. When significant congestion is identified, the VMS direct motorists to pre-determined detour routes, as shown in Figure G-11. A more low-tech approach to this has been deployed in Harrisburg, Pennsylvania, where color-coded detour routes were developed in conjunction with highway construction projects. These routes were indicated in the field by static signs (94). This type of system would not be as flexible to specific traffic conditions.

There are two principal types of maintenance activities that would be associated with pre-planned detour routes.

- Route development. Over time, due to changes in land use or construction projects, there may be a need to change detour routes. This type of maintenance would require a traffic engineering analysis that is beyond the scope of this maintenance plan.

- Route selection. To maximize their effectiveness, detour routes should be able to be automatically deployed based on incident location. There should be regular preventative maintenance to ensure that detour routes are selected appropriately.

To maximize the utility of pre-planned detour routes, it is important to have roadside signage to indicate when detours are in effect, and how motorists should respond. Maintenance of any additional signage required to improve the effectiveness of this device is not included in this analysis.

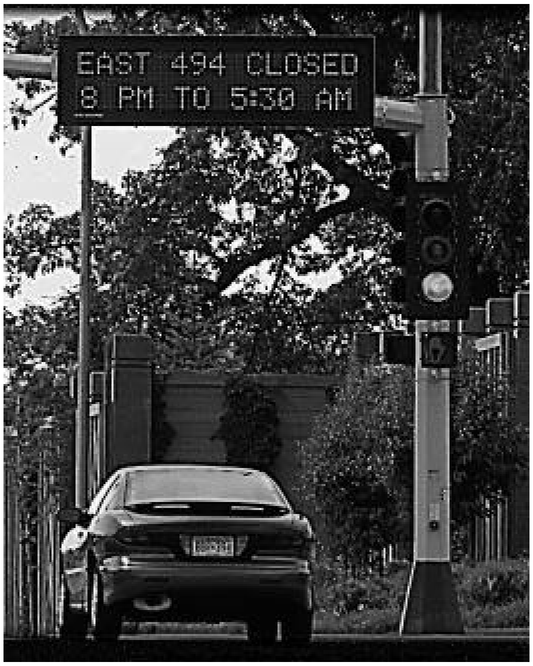

Figure G-11: Detour Signage for ICTM Project.
(Source: 95)

G.4.4 Hazardous Material Response

A special type of incident response is necessary when hazardous materials (HazMat) are involved in order to properly address their consequences and cleanup. This type of incident response involves the electronic tagging of HazMat shipments on commercial vehicles, integrated with a database that would denote vehicle contents. This database would, in turn, be immediately available to emergency response vehicles if necessary. ODOT is planning to implement a statewide system as a part of their Strategic Plan. Examples of tested systems include (96):

- Tranzit Xpress. This system, tested in a field operational test in eastern Pennsylvania, is based on a relational database as well as GPS capabilities. The information dispatching/operations center collects HazMat information from the motor carrier, and communicates with vehicles via cellular modem to transfer shipping orders and to maintain status information. Vehicles were equipped with on-vehicle electronics systems, which include external and internal communications systems, electronic asset tags, a hand-held personal computer device in the cab, and a global positioning system. A mapping product was used to display vehicle locations.

- Operation Respond. This system provided a central point for dissemination of HazMat information. HazMat carriers provide information to a central database. Emergency personnel responding to an incident would read ID numbers off of the vehicle and report them to the information center, where the dispatcher would learn appropriate protocol and response procedures. This system was tested in Atlanta, Buffalo and Houston.

Both systems were effective in accelerating response times to HazMat-related transportation incidents. Tranzit Xpress appeared to have higher initial and operational costs, so a system like Operation Respond may be more reasonable to implement. Currently in Oregon, a special registration is required for motor carriers in Oregon who wish to transport HazMat (97). Installing a system modeled after Operation Respond would require motor carriers to identify all HazMat shipments and provide information about their contents to a central dispatch center.

To maintain the integrity of a HazMat response system, it is recommended that ODOT set up a separate server to manage the HazMat shipments database. Shippers would enter data into this system fairly frequently in order to provide information about shipments currently on Oregon's highways. Maintenance needs would therefore focus on preserving the integrity of the server and the database.

G.5 Pre-trip Traveler Information

ITS devices can be used to provide travelers with information before their travel in order to assist them in making appropriate route and/or mode choice decisions to save time and reduce the risk of accidents. The devices listed in this section represent the primary systems by which ODOT assembles and disseminates information to the traveling public[4].

G.5.1 Alphanumeric Paging

One of the most common means for travelers to find out information about incidents, construction delays and other traffic-related information is through commercial media, including television and radio. To facilitate this, ODOT works with the local media in Region 1 to improve dissemination about incident information through an alphanumeric paging system.

Every operator workstation at the TMOC has access to client-server software that enables pages to be sent to the local media. When a TMOC operator identifies an incident, the operator types in a page message. Upon prompting, the server will send one page message to a paging service that, in turn, pages all of the local media (76). This system is not currently integrated with the Region 1 ATMS, but it may be in the future.

ODOT relies on a commercial paging service that is responsible for ensuring the integrity of the paging units and the supporting communications infrastructure. Consequently, the maintenance needs for this system from ODOT's perspective are negligible.

G.5.2 Highway Travel Conditions Reporting System

The Highway Travel Conditions Reporting System (HTCRS) is a component of Oregon's advanced traveler information system. HTCRS is a database application that allows ODOT personnel across the state to provide information about road conditions and incidents (98). The

---

[4] Travelers may, on their own, use other sources for pre-trip information, including commercial media or motor clubs.

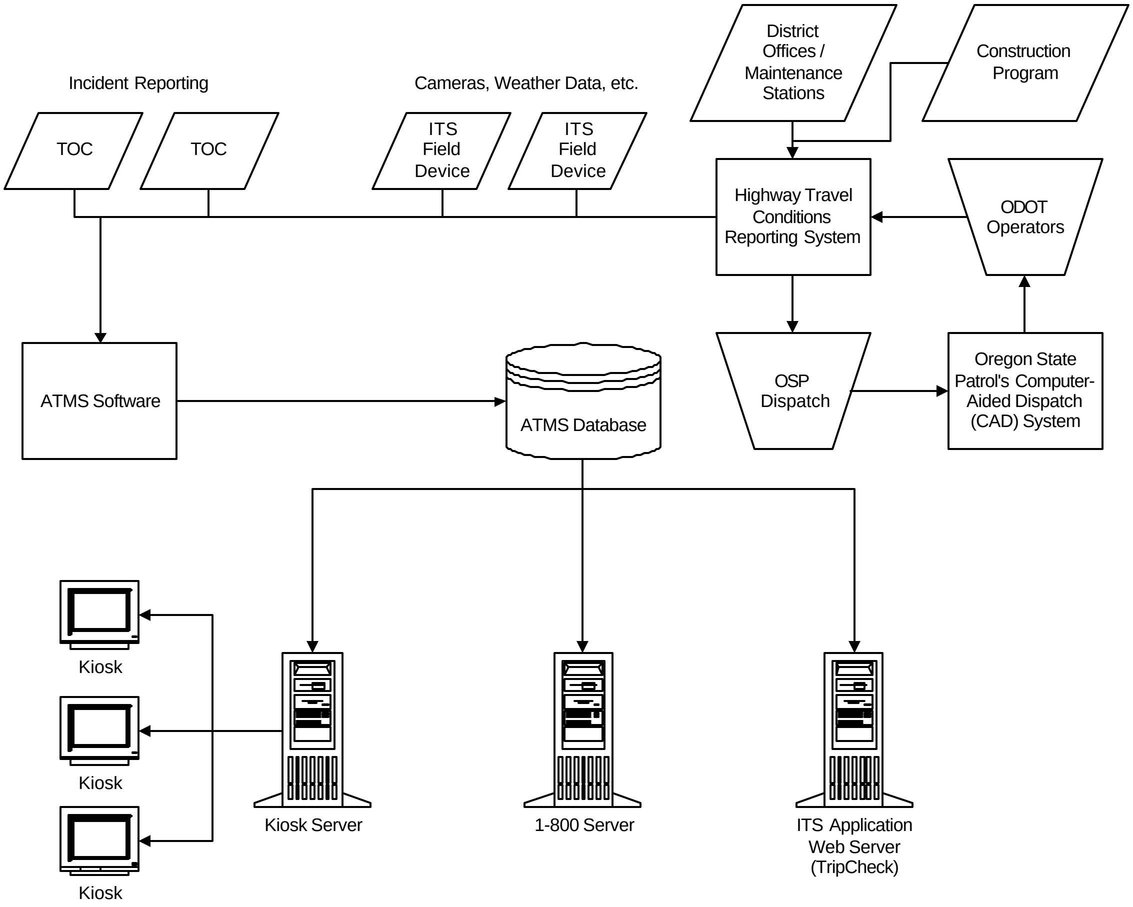

Figure G-12: Relationship Between Traveler Information System Elements.

relation of the HTCRS to other traveler information systems is shown in Figure G-12. It is intended to be a secondary information source beyond information collected from cameras, RWIS and other field devices. The HTCRS database will be structured such that information from this database may be read by the ATMS and thereby disseminated to other information systems, such as kiosks, to allow users to find detailed traveler information for specific parts of the state.

Related to the HTCRS will be an application that will interface with OSP's CAD system. The application will, through both manual and automatic filtering, identify recent entries in the CAD database which require some type of ODOT intervention. The interface will preserve some of the data fields created by the CAD system, such as time and location of the report, and will allow for additional fields of data to be created, such as number of lanes blocked (99). This works toward the long-term goal of having a single entry input system.

Because this application is being developed in-house, application development and debugging time needs to be considered as a part of the maintenance plan. Application development and database maintenance will occur centrally in Salem as a "preventative maintenance" activity.

Once the application is operating satisfactorily, it is likely that upgrades will occur due to the desire for increased functionality.

G.5.3 800-number Information

One way of disseminating information collected by HTCRS is through the use of an 800-number. ODOT provides a toll-free number for in-state residents (1-800-977-6368) as well as a telephone number for out-of-state residents (1-503-588-2941) (100). The 800-number is operated on a statewide basis and is updated to reflect the latest highway and weather conditions. The service is responsive to the traveler's specific needs, allowing motorists to review conditions on specific routes or in specific parts of the state. It is heavily used during the winter months, averaging between 150,000 and 250,000 calls per month (91).

The hardware for the system is located in the Western Regional Dispatch Center in Salem. The system includes five servers and dozens of telephone lines. One server houses current traveler data. This server is responsible for receiving data updates, sending data packet updates onto the other servers, and receiving and directing telephone callers. The system is currently somewhat labor-intensive in that it requires manual administration and recording of new traveler information data. As HTCRS becomes better integrated, a text-to-voice conversion tool will reduce the need for direct human involvement. The system requires maintenance for preserving the integrity of the servers, and upgrading and repairing the software.

G.5.4 Internet Access

Another form of pre-trip traveler information that is becoming increasingly utilized is ODOT's Internet travel advisor, called TripCheck. TripCheck, when fully functional, will include information such as camera images, weather conditions, descriptions of ongoing road construction, and alternative travel modes. It will also geographically indicate incident locations along with estimates for anticipated potential delay at each incident location. As is shown in Figure G-12, TripCheck will get its information directly from the ATMS. It will poll the HTCRS every five to ten minutes to update TripCheck's maps (102).

Similar to HTCRS, the TripCheck application will require continual "maintenance" to incorporate additional deployments, increased functionality, as well as potential re-designs. Because TripCheck has also been developed in-house, ODOT would be responsible for all of this maintenance. Operation of the TripCheck application will also require a dedicated server, which will require regular maintenance activity to preserve its efficiency and integrity.

G.5.5 Kiosks

Kiosks are another form of information dissemination that ODOT is considering implementing in the future. These are stand-alone cabinets with a computer that would be linked to the statewide ATMS database. The kiosks may have the potential to be linked to other information as well, such as lodging and recreation information. Kiosks are typically located at areas where large numbers of people are making travel-related decisions, such as major employers, shopping centers, highway rest areas, truck stops, airports, and transit transfer centers.

	Region 1	Region 2	Region 3	Region 4	Region 5	State Total
Existing	0	0	0	0	0	0
STIP	0	0	0	0	0	0
Existing + STIP	0	0	0	0	0	0
Strategic Plan	117	30	30	30	30	237
Existing + Strategic Plan	117	30	30	30	30	237

Table G-18: Deployment Schedule for Kiosks.

ODOT currently does not have any kiosks deployed, as shown in Table G-18. Some kiosks are included in the current STIP for Region 5, although ODOT staff members have expressed reservations about the maintenance and deployment details of putting kiosks in Region 5. The strategic plan proposes the deployment of 237 kiosks, with 117 kiosks in metropolitan Portland. It is assumed that the other kiosks would be scattered across the state.

Figure G-12 showed one potential system architecture design for kiosk deployment in Oregon, where kiosks receive regular information updates from a central server. This is similar in architecture to that used in several kiosk deployments (104, 106). Kiosks would be connected by dedicated phone lines to the ODOT wide-area network. Information on the kiosks would include all information provided by TripCheck, as well as potentially transit and tourism-related information.

The State of Oregon's Department of Administrative Services (DAS) currently uses a kiosk system for providing information about employment opportunities. In their experience, the most significant maintenance issues with their kiosks have been printer problems, network breakdowns, and software failures. Because kiosks are often located in areas that are not as environmentally controlled, the printers often fail due to "bad air" – i.e. poor temperature or humidity control. In addition, printers need regular maintenance to ensure that the paper supply and print quality are adequate. Network breakdowns often occur because kiosks are moved at their host sites causing physical damage to network connections. Another major source of network failures is the reliance on local networks that are out of the State of Oregon's control, which may have firewalls preventing regular updating of the kiosk information. The software application was developed in-house, so there are occasional issues with resolving code problems. To manage the 157 kiosk sites, DAS relies on a central program that polls each location every two hours. This can identify quickly when network or software problems are present (108). It is assumed that if ODOT were to implement a kiosk system that it may encounter similar problems.

Maintenance needs for a kiosk system would be focused on the computer at the kiosk itself. Typical preventative maintenance activities would include cleaning the computer screen and testing to ensure that the user interfaces (keyboard, touch-screen, etc.) function acceptably. Due to the visibility of kiosks, preventative maintenance should be performed very frequently, perhaps even monthly. Because of the frequency of maintenance and the limited technical expertise it requires, people at the site hosting the kiosk may be the best qualified to perform this type of maintenance. Repairs maintenance may be required not only due to component failures as identified earlier, but also due to vandalism.

The challenge of providing maintenance support to high-visibility and geographically scattered kiosks may be eased through the use of public-private partnerships. Locations like truck stops, shopping malls and major tourist destinations may be willing to pay for the capital, operations and maintenance costs of kiosks to serve as a host site. In addition, ODOT could consider allowing advertising on kiosk cabinets in exchange for companies paying for on-site maintenance through a contractor.

G.6 En-route Traveler Information

In addition to pre-trip information, ITS devices can be used to provide travelers with information during their travel. This information serves several functions, including warning motorists of safety hazards, and advising motorists of traffic or weather conditions that may affect their travel decisions. The devices included in this section are those over which ODOT has significant operational and maintenance responsibility, in contrast to reports carried by commercial radio.

G.6.1 Changeable Message Signs

Changeable message signs (CMS) are roadside devices that have the capability of displaying one of a limited number of fixed messages. The technology employed in CMS may vary considerably, from a radio-activated, fold-out sign that opens on a hinge, to a warning sign that is only illuminated during windy conditions. For this ITS maintenance plan, CMS are defined to include only those signs that must be manually activated by ODOT personnel[5].

Some of the current deployments in Oregon include the following.

- Icy bridge warning systems. There are two deployments on the Interstate 5 viaduct (one per direction) in Medford. This deployment consists of signs that are manually activated by remote switches whenever maintenance officials identify that icy conditions are present (109).

- Tunnel lane closure advisory. At the entrance to the Vista Ridge tunnel on the Sunset Highway (US 26) in Region 1, there are manually activated neon signs used to indicate lane closures within the tunnel (110).

- Snow zone advisory. For some of the more heavily traveled mountain passes, CMS may be used to indicate when snow tires and/or chains are required. In the past, these signs used either manually rotated drums or fold-out signs. ODOT has replaced this technology at some locations, including Cabbage Hill and Ladd Canyon in Region 5, with telephone-activated, rotating drum signs (111).

- Oversize vehicle closure. Sometimes roads will be closed to mobile homes or other large vehicles when there are significant crosswinds. In these areas, oversize vehicle closure CMS advise large vehicles to leave the roadway until conditions improve. Several systems are located in Region 4 (112).

---

[5] Technologies that integrate detectors with warning signs, such as the downhill speed advisory system, will be discussed in a later section.

- Bridge CMS. Each highway bridge that opens to allow maritime traffic to pass through has CMS to warn highway traffic of the bridge activity. A bridge operator manually activates these CMS whenever a maritime vessel requiring greater vertical clearance is awaiting passage under a bridge.

CMS are considered to be an ITS device, but because of the signs' lack of flexibility and their reliance on human interpretation of conditions, it is understood that ODOT is not planning any additional CMS installations beyond what is in place. ODOT would instead opt for automatically-activated warning signs, or variable message signs (VMS) that have a higher degree of message flexibility.

Maintenance for CMS focuses on two elements: the communication of the signal to the sign, and the operation of the sign itself. For communications to the sign, it seems a combination of hard wiring and radio or cellular communications are used, with minimal preventative maintenance needs. The sign displays' maintenance needs may vary considerably, based on the age of the equipment and environmental protection. Because CMS are legacy devices pre-dating most of ODOT's ITS infrastructure, it is unclear what other CMS ODOT has deployed, how many there are, and in what locations.

G.6.2 Variable Message Signs

Unlike CMS, variable message signs (VMS) are not constrained to a fixed number of messages. Messages may be programmed to describe information specific to existing conditions, including incident location, detour information, weather-related closures, and other types of information.

A typical system architecture schematic for VMS is shown in Figure G-13. Messages for the VMS are created at the TOC, and are relayed by dedicated phone line to a modem in the VMS. A processor located in the VMS interprets the message and sends signals to the sign pixels to change to reflect the new message.

There are three basic VMS technologies that may be used individually, or in combination

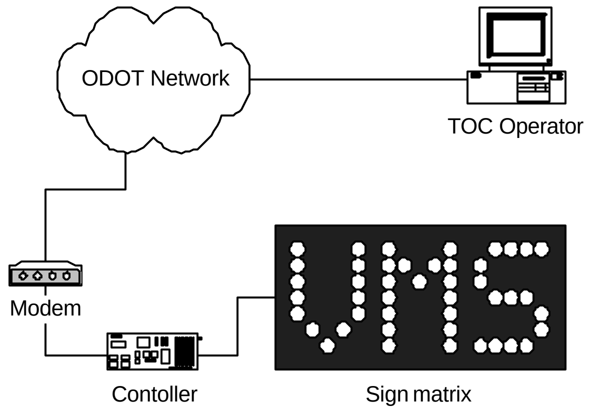

Figure G-13: Architecture for Variable Message Signs.

to achieve more optimal displays (113, 114). These base technologies include the following.

- Flip disk. This technology uses a matrix of disks with one side black and one side covered with bright, reflective material. Each disk is electromechanically flipped based on input from the controller.
- Light-emitting diode (LED). Typically, four bright LEDs are joined to create one cluster that represents a pixel on the sign matrix. The controller provides power to different pixels based on input from the controller.
- Fiber optic. This technology has two light sources and bundles of glass fibers that serve as the pixels in the matrix. Shutters in front of each pixel open and close in order to display messages.

VMS maintenance will depend heavily on the type of technology that is used. Flip disk systems require regular disk cleaning twice a year, and the electromechanical components may be susceptible to failure due to environmental conditions. LEDs are rated for 100,000 hours of continuous operation at the rated voltage (113, 115), and therefore require little maintenance. The lamps used in fiber optic systems have about 6,000 hours of rated life, which requires occasional lamp replacement (116, 117). Regardless of the matrix display used, maintenance may also be necessary on the sign housing, controller, power supply, and communications equipment. It is recommended that filters be cleaned between two and four times per year (115, 117, 118), and that components be inspected annually.

In addition to different types of sign displays, there are two types of VMS deployments: permanent and portable.

Permanent VMS. Permanent VMS are normally mounted on bridges and overpasses or on overhead trusses. Smaller permanent VMS may also be installed on the roadside, although ODOT is not currently using permanent VMS in this way.

Table G-19 shows where permanent VMS are deployed in Oregon. Many of the deployments in Oregon are concentrated in Region 1. Additional signs are included in the STIP for Regions 1, 2 and 5. According to the Strategic Plan, future deployments of permanent VMS will be restricted to Region 1. There are several signs included in the Strategic Plan inventory for Region 5 as well. These are signs

	Region					State Total
	1	2	3	4	5	
Existing	12	5	2	1	5	25
STIP	4	4	0	0	5	13
Existing + STIP	16	9	2	1	10	38
Strategic Plan	16	0	0	0	8	24
Existing + Strategic Plan	32	9	2	1	18	62

Note: ODOT is assumed to have no maintenance responsibility over CSEPP signs (Region 5 only) until after STIP expires, although they can currently be used for operations. It is assumed, as a worst case scenario, that ODOT would take over maintenance for all eight CSEPP-related VMS.

Table G-19: Deployment Schedule for Permanent Variable Message Signs.

provided in conjunction with Umatilla and Morrow Counties' Chemical Stockpile Emergency Preparedness Program (CSEPP) (119). Eight signs associated with CSEPP are already in place on roadways leading to and from the Umatilla Army Depot near the Interstate 84/Interstate 82 junction in Region 5. Under normal conditions, ODOT may use these signs to provide information about weather conditions and road closures. In the event of a chemical accident at the army depot, CSEPP would overtake the operation of these signs, providing messages indicating road closures, detours and other critical information. Maintenance of these signs is currently provided through CSEPP. Once the hazardous chemicals stored at Umatilla have been properly disposed of, ODOT will inherit full operational and maintenance responsibilities for these signs. It is assumed this will occur some time after the current STIP ends.

There are several technologies of permanent VMS currently in use in Oregon, including LED, fiber optic, and LED-flip disk hybrid signs. The variety of VMS types increases the amount of training and spare parts required for maintenance, and likely increases the time required to maintain each sign. Moreover, there has been significant variation in maintenance needs between signs due to quality of manufacturing, vandalism and other factors. Since VMS are typically replaced every ten to fifteen years, it is assumed that ODOT will have lower maintenance, standardized permanent VMS in the future.

Portable VMS. Portable VMS are normally mounted on trailers or trucks, and are transported to locations on demand. Portable VMS may be deployed due to temporary detours, incidents, construction information, or similar situations. Because of their mobility, portable VMS typically need to supply their own power. Solar-powered signs using a battery back-up are a common power mechanism, although diesel power is also used.

Table G-20 shows current and future deployment of portable VMS in Oregon. Currently, many portable VMS are deployed in Region 2, although they are scattered in different locations to maximize responsiveness. The Strategic Plan forecasts an aggressive schedule for increased VMS deployment, assuming an average of two portable VMS per city statewide.

	Region					State Total
	1	2	3	4	5	
Existing	1	19	0	3	0	23
STIP	0	0	0	2	0	2
Existing + STIP	1	19	0	5	0	25
Strategic Plan	60	80	100	97	100	437
Existing + Strategic Plan	61	99	100	102	100	462

Table G-20: Deployment Schedule for Portable Variable Message Signs.

The underlying technology used in portable VMS is similar to that used in permanent VMS. Maintenance needs for the display component are slightly less than for permanent VMS because portable VMS are typically smaller with easier maintenance access, and the sign may be transported to the technician as necessary. Field experience has found that there are significant, frequent problems with communications to portable VMS (91). Many portable VMS use cellular modems, which tend to get damaged or dislodged during transport. It is assumed that more stable systems will be found in the future which will help to reduce maintenance needs.

G.6.3 Highway Advisory Radio

	Region					State Total
	1	2	3	4	5	
Existing	0	0	1	0	0	1
STIP	0	0	0	0	0	0
Existing + STIP	0	0	1	0	0	1
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	0	0	1	0	0	1

Table G-21: Deployment Schedule for Highway Advisory Radio.

Highway Advisory Radio (HAR) is a localized radio broadcast system designed to provide motorists with location-specific information, such as current traffic conditions, construction information, weather advisories, or directions to major tourist destinations. The basic system architecture for HAR is shown in Figure G-14. A low-powered AM transmitter is connected to a voice storage unit via leased telephone lines. The voice storage unit may be updated via telephone in order to reflect changes in conditions. Because HAR systems are typically localized to a 3- to 6-mile radius, roadside signage and/or beacons are used to indicate where HAR systems are present and when they are in operation.

ODOT currently has one HAR installation, southbound on Interstate 5 in Ashland near Siskiyou Summit, which operates only during the winter months. It is a vertical monopole antenna system. Signs indicating the HAR system have flashing beacons that may be turned on by radio. As shown in Table G-21, no other installations are included in either the STIP or the statewide implementation plan.

Maintenance of HAR systems has become less time-consuming over time. The use of solid-state electronics has reduced periodic maintenance needs such as replacing magnetic tape. Annual periodic maintenance activities include periodically checking the HAR sign for interference from vegetation, new construction, signs or other antennae, and regularly checking the range of the signal and the power supply (120).

G.6.4 Weather and Visibility Warning Systems

Several systems, which are either currently under research or have been developed and deployed, combine aspects of CMS with RWIS technology. Figure G-15 indicates how these

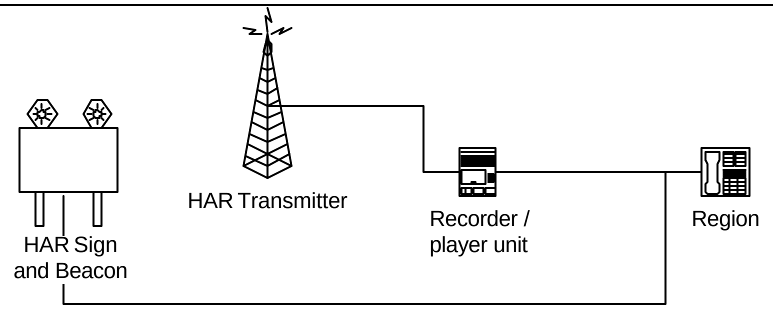

Figure G-14: Architecture for Highway Advisory Radio.

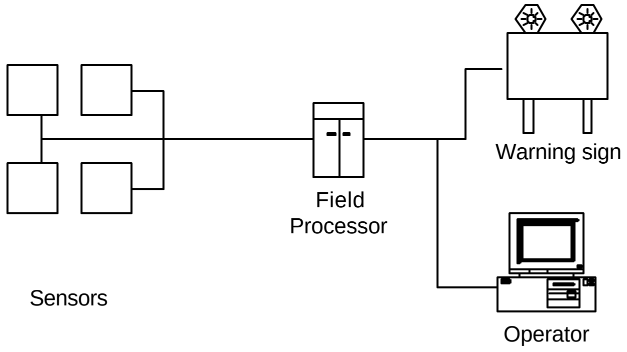

Figure G-15: Proposed Architecture for Weather and Visibility Warning Systems.

systems might function. Field sensors are used to measure weather and visibility conditions. A field processor analyzes the sensor-provided data, and will activate flashing beacons on an adjacent sign to inform motorists of a particular condition. The field processor would also have a communication link, likely by dial-up modem, to the TOC. The communications link would permit the processor to inform the operator when warnings are active as well as when self-diagnostic processes indicate there is a repair need.

Example applications of these systems include:

- <u>Icy bridge detection systems</u>. There is currently an icy bridge detection system located on the Quartz Creek Bridge in Region 1. As shown in Table G-22, twenty deployments were included in ODOT's Strategic Plan. Pavement sensors are used to measure temperature and moisture, as well as the presence of ice.

	Region					State Total
	1	2	3	4	5	
Existing	1	0	0	0	0	1
STIP	0	0	0	0	0	0
Existing + STIP	1	0	0	0	0	1
Strategic Plan	4	4	4	4	4	20
Existing + Strategic Plan	5	4	4	4	4	21

Table G-22: Deployment Schedule for Icy Bridge Detector Systems.

- <u>Oversize load detector systems</u>. These systems gather information about pavement temperature, wind speed and similar conditions, in order to identify conditions when oversize vehicles would have difficulty negotiating the road. The warning sign would be used to indicate when routes are closed to larger vehicles. As shown in Table G-23, ODOT has programmed several installations of this technology in Region 4 as a part of the STIP.

These systems have function like a CMS in that they give messages only when certain weather and visibility conditions are present. These systems also have the function of an RWIS in their reliance on in-field sensors, in-field intelligence and server support. Maintenance of weather and visibility warning systems will therefore include a combination of the maintenance aspects of CMS and RWIS. Maintenance for the CMS components will usually be fairly negligible, involving annual testing to ensure that the sign is activated when appropriate conditions are present and deactivated when these conditions are absent. The sensors and field processing unit need to be regularly inspected and reset to insure proper operations. To simplify maintenance, these systems may incorporate the same sensor package and processing unit software as other RWIS systems, and may therefore rely on the same server infrastructure used by RWIS.

	Region					State
	1	2	3	4	5	Total
Existing	0	0	0	0	0	0
STIP	0	0	0	5	0	5
Existing + STIP	0	0	0	5	0	5
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	0	0	0	5	0	5

Table G-23: Deployment Schedule for Oversize Load Detector Systems.

G.6.5 Variable Speed Limit Systems

Variable speed limit systems (VSLS) combine VMS and RWIS technology in order to improve safety through reducing speed-related incidents. Atmospheric and surface weather sensors provide information by which posted speed limits may be adjusted on a real-time basis.

As shown in Table G-24, ODOT is planning to deploy 20 VSLS as part of the Strategic Plan. Specific locations have not been determined, but it is assumed that most locations will be in the more mountainous regions of the state where weather can create the most hazardous conditions.

	Region					State
	1	2	3	4	5	Total
Existing	0	0	0	0	0	0
STIP	0	0	0	0	0	0
Existing + STIP	0	0	0	0	0	0
Strategic Plan	2	3	5	5	5	20
Existing + Strategic Plan	2	3	5	5	5	20

Table G-24: Deployment Schedule for Variable Speed Limit Systems.

Figure G-16 shows an example of how a VSLS may be set up. Various roadway surface sensors provide information about the presence of snow, ice or moisture. Other sensors may detect local visibility, such as fog, dust and other matter. Pairs of loop detectors are embedded in the roadway surface to determine vehicle speed. The information collected from these sensors is input into a field processor. The field processor may contain algorithms for estimating appropriate speed limits based on the results of sensor data (121). An alternative to using an automated algorithm is to provide sensor information to the TOC via a radio link. The TOC could then set speed limits based on experience and professional judgment. Once a reduced speed limit has been decided upon, the field processor activates a flashing beacon warning sign along with a VMS, which indicates the revised speed limit (122).

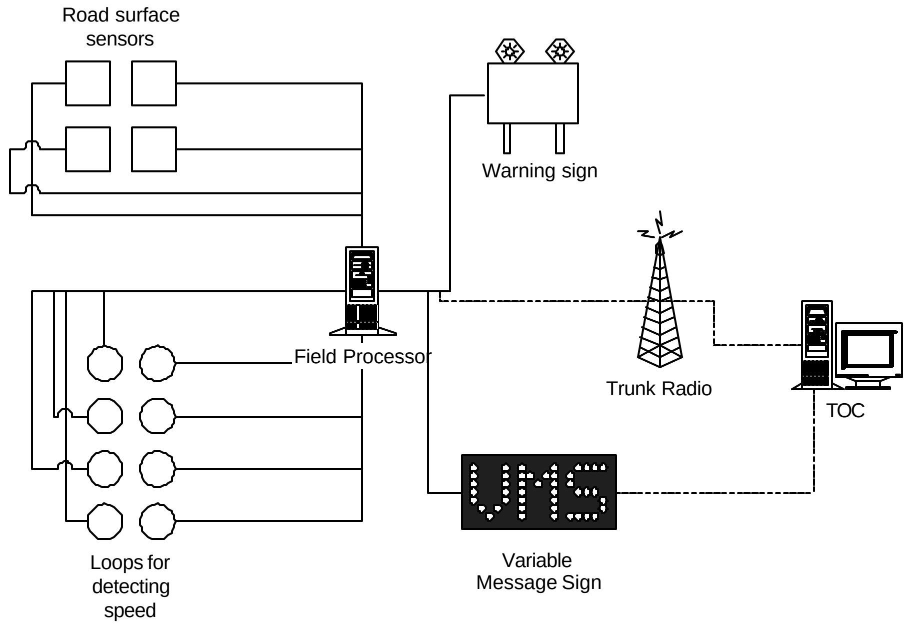

Figure G-16: Proposed Architecture for Variable Speed Limit System.

Maintenance of these systems would be similar to that required for RWIS. Because communications between the VMS and the field processing unit would be entirely in the field, VMS maintenance needs would be somewhat reduced over stand-alone VMS deployments. Because of the liability exposure that may be associated with this system (123), timely preventative and repair maintenance activities are critical. Preventative maintenance activities, including routine testing of sensors and detectors, would be vital to minimizing liability exposure.

G.6.6 Queue Detection System

The purpose of a queue detection system is to alert motorists in poor-visibility areas of upcoming queues in order to avoid rear-end collisions. As shown in Table G-25, ODOT currently has one experimental queue detection system, located in Region 2. The system works as depicted in Figure G-17. Inductive loops are installed in the road pavement based on studies of rear-end incidents at that location. The loops are connected to a timer, in order to check every four seconds whether vehicles are still present on the loop. If a vehicle continues to be present, this will activate a flashing beacon sign well upstream of the loops (124). The sign is

	Region					State Total
	1	2	3	4	5	
Existing	0	1	0	0	0	1
STIP	0	0	0	0	0	0
Existing + STIP	0	1	0	0	0	1
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	0	1	0	0	0	1

Table G-25: Deployment Schedule for Queue Detection Systems.

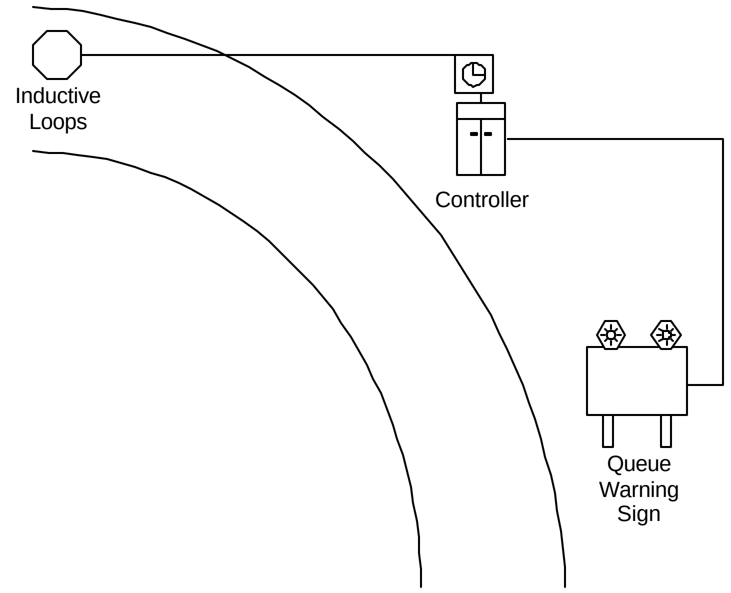

Figure G-17: Architecture for Queue Detection System.

placed such that it provides a reasonable distance for the motorist to safely slow down and avoid getting into a rear-end collision. There are currently no plans to implement this system in other parts of the state.

Maintenance of the system has been designed to be fairly simple. An LED at the timer cabinet indicates when the loop detector is occupied, providing quick diagnostics for the loop and local wiring. Annual testing should focus on ensuring that all connections from the loops to the flashing beacon are functioning acceptably, and that the timer is set at a reasonable delay.

G.7 Commercial Vehicle Operations

An important sub-system of ITS is commercial vehicle operations (CVO). While motor carriers interact with the rest of the traffic system and may be similarly aided by traffic management and traveler information systems, they also have special needs that should be considered separately.

In Oregon, ITS applications for commercial vehicles have been provided exclusively through a sole-source vendor agreement. The vendor has been responsible for the design, installation and maintenance of various motor carrier-related ITS installations throughout the state. After the initial warranty period on new installations expired, ODOT entered into an extended warranty agreement with the vendor to provide maintenance on these installations as well. The primary terms of the agreement are as follows (125).

- The vendor is responsible for maintaining the system in good working condition.
- The vendor will repair malfunctioning equipment within 48 hours of notification, and will provide documentation of corrective actions taken within 30 days of the repair.

- The vendor will perform preventative maintenance on all major systems at six-month intervals.
- The vendor will provide free software upgrades with free manuals, as well as refresher training.
- The vendor will calibrate the systems once per year.
- The vendor will provide labor, tooling, test equipment, and facilities required to perform the maintenance, and will keep adequate spare parts in a central ODOT facility to ensure prompt response times.
- Both ODOT and the vendor will keep records of maintenance activities.
- ODOT will pay the vendor $1.2 million per year.

In stakeholder meetings in May, the Motor Carrier Transportation Division expressed general satisfaction with the vendor agreement to date, and they planned to continue agreements like this for the foreseeable future. Unforeseeable developments in the future, such as unacceptable cost escalation in renewals of the extended warranty agreement or vendor refusal or inability to continue to agreements, make it necessary to consider what the maintenance needs of these devices would be if ODOT were to handle all maintenance with existing resources. This section will examine the maintenance needs for existing and future CVO systems.

G.7.1 Weigh-in-Motion Systems

The purpose of a weigh-in-motion (WIM) system is to allow vehicles to be weighed while in motion. WIM systems in the United States are designed primarily to weigh commercial vehicles at freeway speeds for the purposes of enforcing weight limits on the highways. These systems generally supplement or replace existing conventional weigh stations.

	Region					State Total
	1	2	3	4	5	
Existing	0	2	4	0	5	11
STIP	5	1	0	4	0	10
Existing + STIP	5	3	4	4	5	21
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	5	3	4	4	5	21

Table G-26: Deployment Schedule for Weigh-in-Motion Stations.

Table G-26 shows ODOT's planned deployment of WIM systems is primarily confined to existing weigh station locations. As of June 1999, ODOT had ten operational WIM sites, located primarily on the Interstate system. By the end of 2000, ODOT will have modernized all 21 of its weigh stations statewide to have WIM and automatic vehicle identification (AVI).

Oregon has two types of WIM installations: pre-clearance and data collection. At the pre-clearance stations, commercial vehicles with transponders are allowed to stay on the mainline,

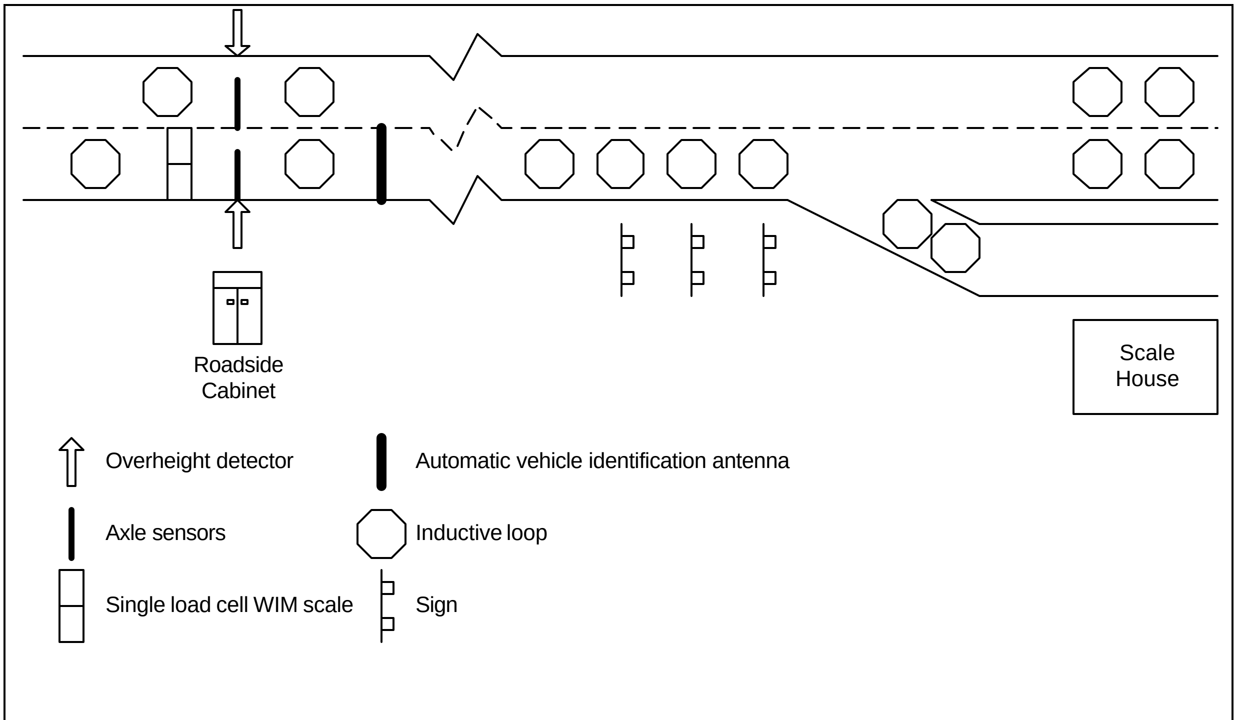

Figure G-18: Architecture for Weigh-in-Motion Site.

(Source: 126)

bypassing the conventional weigh station, and obtain clearance to continue with their trip. The data collection stations simply obtain data on the distribution of vehicles by weight.

Figure G-18 shows how ODOT typically installs its WIM sites. A cluster of equipment is installed about a mile upstream of the conventional weigh station. The equipment includes inductive loops for determining vehicle speed, axle sensors to count vehicle axles, overheight detectors, AVI sensors to read transponders, and automatic vehicle classification (AVC) equipment. This equipment is connected to a roadside cabinet, which relays information to the scale house. At the scale house, the number read from the in-vehicle transponder is checked against a central database on the state supervisory computer. The computer reviews vehicle records against data collected from the in-field equipment. If all information is acceptable, this is communicated from the scale house back to the in-vehicle transponder through a green light. If not, flashing beacons on roadside signage located closer to the scale house directs the vehicle to exit for conventional weighing and inspections.

ODOT has four different types of WIM installations, depending upon the tracking and sorting mechanisms used. These types of WIM are shown in Table G-27. The additional lane of mainline sorting for Type 1 sites creates an increase of in-road hardware and some of the equipment necessary to communicate between the scale house and the vehicle. Type 4 sites have the least equipment, because of the use of visual tracking at the gore and on the ramp instead of inductive loops.

Since ODOT's current established maintenance procedure is specified through a vendor agreement (125), it is assumed that it provides for adequate maintenance of the WIM system.

Type	Description	Locations
1	Two lanes of mainline sorting, connected to previously installed ramp sorting systems	• I-5 at Woodburn (NB & SB)
2	One lane of mainline sorting and piezoelectric lane control sorting systems on ramp	• I-5 at Booth Ranch (NB) • I-5 at Wilbur (SB)
3	One lane of mainline sorting and tracking systems at gore and on ramp	• I-5 at Ashland (NB & SB) • I-82 at Umatilla (SB) • I-84 at Cascade Locks (EB) * • I-84 at Emigrant Hill (WB) ** • I-84 at Farewell Bend (WB) • I-84 at LaGrande (EB) • I-84 at Olds Ferry (EB) • I-84 at Wyeth (WB) • US 97 at Klamath Falls (NB)
4	One lane of mainline sorting and visual tracking at gore and on ramp	• US 26 at Brightwood (WB & EB) • US 30 at Rocky Point (WB) • US 97 at Juniper Butte (NB & SB) • US 97 at Klamath Falls (SB) • OR 58 at Lowell (WB & EB) ***

* - Includes radio frequency communication system
** - Includes downhill speed advisory system
*** - Incorporates one lane of data collection

Table G-27: Types of Weigh-in-Motion Installations in Oregon.

(Source: 125)

According to the vendor, repair maintenance tasks may include servicing sensors on failure (65). Because of the vendor contract, ODOT maintenance staff would likely need to receive additional training in WIM diagnostics and repair prior to attempting to maintain the systems.

G.7.2 Downhill Speed Advisory System

The purpose of the downhill speed advisory system (DSAS) is to warn commercial vehicles of excessive traveling speeds, based on weather conditions and vehicle characteristics including weight and dimensions, through the use of VMS. It is intended to complement runaway truck ramps and potentially reduce the number of times they would be needed (123).

Table G-28 shows the current deployment schedule for DSAS in Oregon. ODOT has established one DSAS at Emigrant Hill on westbound Interstate 84, through the use of an existing WIM and VMS. A second system will be operational by the fall of 2000 on northbound Interstate 5 on the Siskiyou Pass near Ashland. This second system would require a new WIM and VMS.

	Region					State Total
	1	2	3	4	5	
Existing	0	0	0	0	1	1
STIP	0	0	1	0	0	1
Existing + STIP	0	0	1	0	1	2
Strategic Plan	0	4	7	7	6	24
Existing + Strategic Plan	0	4	8	7	7	26

Table G-28: Deployment Schedule for Downhill Speed Advisory Systems.

A typical DSAS configuration is shown in Figure G-19. The system includes WIM equipment that measures individual vehicle weights and dimensions. A field processor determines the maximum safe speed for each vehicle based on the operating characteristics of truck braking systems. When the truck passes over an activation loop, a downstream VMS is triggered to display the calculated safe speed (123). Since the WIM and VMS will likely be separated by a relatively short distance, communications between the WIM and VMS might be provided through coaxial cable.

In terms of maintenance needs, DSAS maintenance needs should reflect a combination of the maintenance needs of its WIM and VMS components. Regular calibration of the WIM scales and cleaning and testing of the VMS would be necessary.

G.8 Communications Systems

In addition to the many field deployments of ITS discussed in this chapter, there are communications networks which must be maintained to ensure the integrity of the ITS infrastructure. This section will briefly discuss the maintenance needs associated with these infrastructure items.

G.8.1 Fiber Optic Networks

ODOT is installing fiber optic cable along expressways in the Portland area to satisfy the

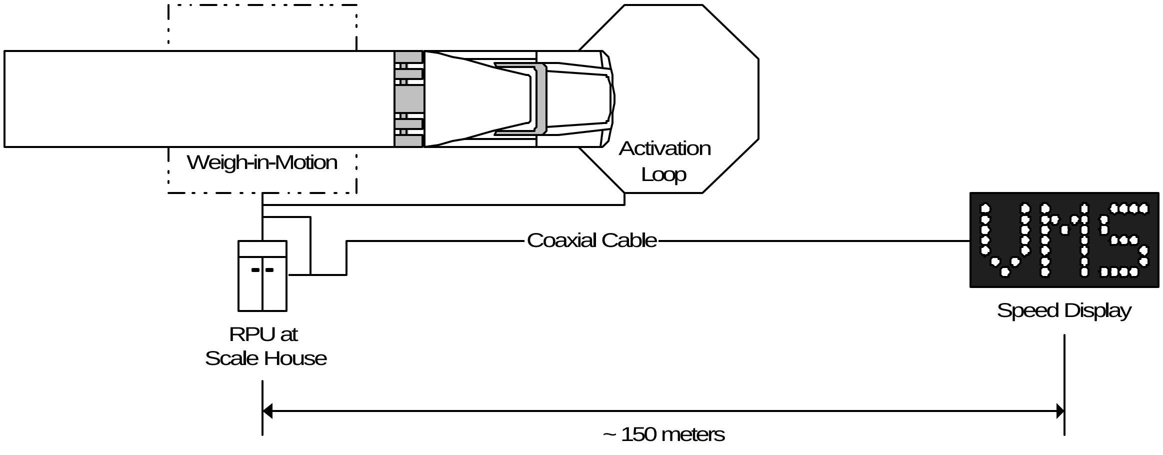

Figure G-19: Architecture for Downhill Speed Advisory System.

need for real-time communications between various ITS deployments in Region 1. Fiber optic cable has adequate bandwidth to allow for many devices, including CCTV, ramp meters, travel time estimation and video detection, to rely on the same communications links. As Table G-29 indicates, it is estimated that regionwide deployment of fiber optic along all of the Portland area's expressways would require approximately 80 miles of fiber optic cable.

	Region					State
	1	2	3	4	5	Total
Existing	0	0	0	0	0	0
STIP	80	0	0	0	0	80
Existing + STIP	80	0	0	0	0	80
Strategic Plan	0	0	0	0	0	0
Existing + Strategic Plan	80	0	0	0	0	80

Table G-29: Deployment Schedule for Fiber Optic Cable (Miles).

Maintenance requirements of fiber optic systems are fairly minimal, with major problems primarily arising from damage due to digging and construction. Minor preventative maintenance must be performed on fiber optic cables in performing optical time domain reflectometer tests to test power loss once every two years for every 15 miles of cable (6).

G.8.2 Radio Communications

Another critical communications component of ODOT's ITS infrastructure is radio communications. Radio is involved primarily in locations needing limited data transmission frequency or packet size which are not accessible by cellular or land-line telephone. This includes several RWIS locations, radio consoles used by TOCs for incident management and response, and radio units located in incident response vehicles.

All of ODOT's radio systems are supported by a system of towers, buildings and antennas scattered throughout the state. Because this infrastructure was in place before ITS, it is assumed that ITS-related communications would result in negligible additional maintenance. There will be maintenance needs associated with devices that transmit or receive signals from the radio system, however. For many consoles and hand-held units, however, the cost of repair maintenance and the rate of technological advancement are quickly making replacement a more attractive option than repair. Consequently, negligible preventative maintenance is recommended for the hand-held units, and repair maintenance will seldom be inexpensive enough that it would make more sense to repair than to replace. For consoles located at the TOCs, the cost benefits of timely maintenance would be more apparent. Table G-30 shows the estimated deployment schedule for radio consoles in the TOCs around the state. Each of the consoles would require some annual preventative maintenance as well as occasional repair maintenance.

	Region					State
	1	2	3	4	5	Total
Existing	4	5	2	2	0	13
STIP	0	0	0	0	0	0
Existing + STIP	4	5	2	2	0	13
Strategic Plan	0	0	0	0	2	2
Existing + Strategic Plan	4	5	2	2	2	15

Table G-30: Deployment Schedule for Radio Consoles.

G.9 Maintenance Coordination

The final element in estimating the resources required to maintain the ITS infrastructure is to examine the costs associated with coordination, tracking and logging of maintenance activities. As was discussed in Chapter 2, stakeholders agreed that there should be improvements in how maintenance is handled and coordinated through ODOT so that repairs are done in a more timely and systematic fashion. Therefore, resources need to be allocated to maintenance coordination activities, which include delegating repairs as appropriate, ensuring that all preventative maintenance tasks are performed and documented as scheduled, that all repair activities are logged, and that maintenance is tracked from the initial report until the repair is tested and found satisfactory.

The preferred maintenance model alternative recommends that the support coordinator position be used to fill this role. However, regardless of how the role is filled, there are two principal resource needs associated with maintenance coordination.

- Computer support. Based on the preferences for a statewide, common database for tracking maintenance activities, it is assumed that maintenance coordination in each region would ultimately be computer-based. There may be a need for a dual-entry system in the short run – i.e. a field electrician using a paper form to track device maintenance, which then is entered by a technician into a centralized database. In the long-run, it is assumed that the maintenance coordination and tracking process would be computerized from start to finish, relying on wireless communications, laptop computers, personal digital assistants (PDAs) and similar systems.

- Staffing support. There will also be a coordination role in terms of logging and tracking hand-offs between different maintenance groups (such as Information Services and regional electricians). For this, it is assumed that the time spent in coordinating, logging or tracking maintenance would be a small percentage of the time spent in the field on device repair.