4 REPAIR PRIORITIZATION

One critical part of the daily maintenance operations of an organization is the determination of how repairs should be prioritized. This chapter will examine existing procedures for prioritizing repairs within the Oregon Department of Transportation (ODOT) and in other transportation agencies, as well as stakeholder perspectives on the key factors that should influence repair prioritization for Intelligent Transportation Systems (ITS) devices. This chapter will culminate in recommendations for a set of guidelines for prioritization of repairs of ITS devices.

4.1 Review of Existing Prioritization

In order to develop reasonable guidelines for prioritizing maintenance, research was done into procedures in place at ODOT and other transportation agencies. This section highlights the findings from these efforts.

4.1.1 Oregon Department of Transportation

In the ODOT Maintenance Guide (12) a prioritization order has been developed for the repair of electrical work, as shown in Table 4-1. In reviewing these guidelines, several features in the current prioritization scheme should be emphasized:

- The existing guidelines place top priority on safety and legislative mandates. Of particular interest is the priority placed on draw bridges and bridge navigation lights. According to ODOT staff, the maritime system has a higher maintenance priority than the highway system because it was established earlier so marine vessels have

Type of Electrical Repair (in order of decreasing priority)	**Priority**
Emergency services (includes improper signal operation, signal red-out, electrical knockdowns, and any other instance where electrical safety is of concern)	24 hr / 7 day service
Draw bridges and bridge navigation lights	24 hr / 7 day service
Traffic signal repair	24 hr / 7 day service
ODOT radio communications sites	24 hr / 7 day service
Rest areas, ports of entry, scale sites	24 hr / 7 day service
Traffic signal construction and change-out projects	no priority given
Scheduled traffic signal maintenance	no priority given
Scheduled street lighting maintenance	no priority given
Scheduled maintenance for tunnels, rest areas, ports of entry, and scale sites	no priority given
ODOT buildings (construction or maintenance)	no priority given
Outside agency electrical work (non-signal)	no priority given

Table 4-1: Existing Prioritization of Electrical Repair Work.

(Source: 12)

ultimate right-of-way.

- The top electrical maintenance priorities are expected to have 24 hour / 7 day support. For the top five types of electrical repair, it is anticipated that support will be available around-the-clock. The Maintenance Guide adds that emergency electrical services require personnel to be "on call and prepared to respond" for these requests. In other words, when an electrician, with proper licenses and certification, is contacted, they have the responsibility to respond and correct the problem.

- Repair maintenance takes precedence over preventative (scheduled) maintenance activities.

- The existing guidelines do not include most Intelligent Transportation Systems (ITS) devices. Traffic signals, radio communications sites, ports of entry and scale sites are probably the types of repair most similar to ITS repair.

Not indicated on the chart is an additional level of prioritization for traffic signal repair. ODOT employs a three-tier system for assigning repairs to traffic signals (12).

- Category 1 – Intersections operating at level of service (LOS) F when in flash condition during the 8th highest traffic volume hour of the day.

- Category 2 – Intersections operating at LOS F when in flash condition during the peak traffic hour, but not during the 8th highest hour of the day.

- Category 3 – Intersections operating at LOS E or better in flash condition during the peak traffic hour of the day.

According to ODOT's guidelines, all Category 1 signals must be repaired before Category 2 signals are repaired, and all Category 2 signals must be repaired prior to repairs on Category 3 signals.

4.1.2 Other Transportation Agencies

Some of the maintenance plans discussed in Chapter 2, along with other documents identified by WTI staff, include guidance for prioritizing ITS maintenance. These prioritization guidelines are summarized in tables in Appendix D. The following two observations may be made about prioritization guidelines presented in these documents.

- Devices are typically prioritized according to their relative necessity to the daily operation or integrity of the system.

- Safety-related or traffic control devices tend to have a higher priority than traveler information devices.

4.2 Review of Stakeholder Input

As was shown in reviewing ODOT's existing prioritization guidelines, most ITS devices are currently not considered as a part of repair prioritization decisions. Consequently, surveys were distributed in June 1999 to the ITS Executive Steering Committee, the TOC Managers and the District Managers in order to determine how ODOT stakeholders perceive the repair priority of different ITS deployments (13). The survey forms are included as Appendix E, and the results of these surveys are detailed in Appendix F.

In summary, stakeholders indicated that prioritizing ITS device repair is going to be highly dependent on several factors, including:

- device type,
- device location within region,
- device function,
- region, and
- time of year.

There were different responses between district managers and TOC managers in different geographical areas, which highlights the need for some flexibility in prioritization, in order to allow local decision-makers to develop guidelines which best meet their needs.

4.3 Guidelines for Prioritizing Repair

Based on ODOT's existing prioritization schedule, stakeholder input, and a review of repair prioritization guidelines developed by other agencies, this section will give broad guidelines for how ITS maintenance can be prioritized across the state. These guidelines are intended to be flexible according to local needs. Because of the differences in priorities that exist across regions, this section will also examine how the priority scheme may be implemented on a regional basis to reflect local conditions.

4.3.1 General Guidelines

Figure 4-1 presents a suggested model for deciding how ITS maintenance should be prioritized across the state. The model is a broad flow chart, describing maintenance problems not by device specifically but by device function and problem type. Response times are listed as recommendations only; specific response times may be shorter for critical deployment locations. The ability to meet response times depends primarily on the availability and flexibility of staff and other resources. Actual response times should be used primarily as performance criteria for evaluation of the adequacy of maintenance resources to meet regional needs.

Each portion of the model in Figure 4-1 will be discussed in greater detail in this section.

4.3.1.1 Fulfill Legal Mandates

The first priority for ODOT in ITS maintenance should be to satisfy legislative mandates or legal requirements. Currently, few of ODOT's ITS devices could be classified as necessary to

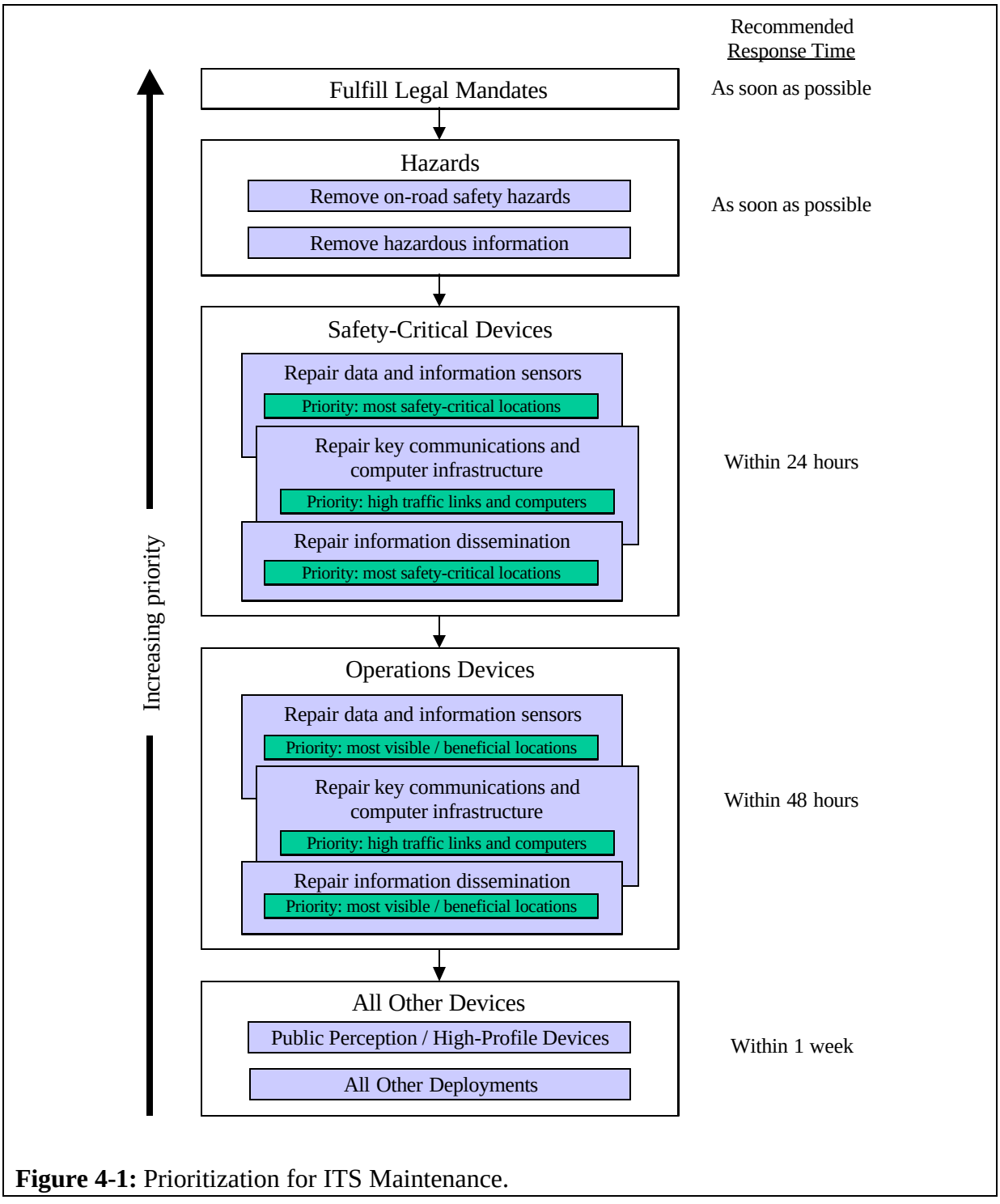

Figure 4-1: Prioritization for ITS Maintenance.

fulfill specific legislative mandates. One exception is ATRs which, according to ODOT staff, are required by federal mandates. Some other devices, such as traffic signals, may have liability implications if they are non-operational, but there is not necessarily a liability concern if they are not operational.

4.3.1.2 Hazards

The second priority level for ITS maintenance is to address safety hazards caused by ITS devices. Safety is considered to be critical to ODOT, as illustrated not only by the survey responses of various ODOT stakeholders but also in the agency's mission statement: "to provide *safe* and effective transportation systems that support economic opportunity and livable communities for Oregonians." (emphasis added) (1) When they are maintained well, ITS devices may provide significant safety benefits.

Poorly maintained or non-operational ITS devices can have one of two adverse safety consequences. First, at a minimum, non-operational devices will have no net safety benefit and will have essentially diverted capital dollars from programs where they may have been a better safety benefit, such as improving guardrails or roadway reflectors. At worst, a non-operational device could create a greater hazard by its presence than if it were not there at all. Examples of this could include ITS devices that fall off of their support structures and into the roadway, or exposed electrical wiring which could result in electrical shock. In addition, as the public places greater trust in en-route information systems, non-operational devices could result in significant additional safety problems. For example, truck drivers may get used to relying on signs associated with a downhill speed advisory system rather than their own judgment for determining their vehicle speed. As a result, if the system is not functioning properly, drivers may exceed safe speeds, resulting in potential injuries or fatalities.

Consequently, after fulfilling any legislative mandates, ODOT should address present electrical and physical safety hazards introduced by malfunctioning devices. As soon as ODOT is made aware of these kinds of problems, ODOT should dispatch repair services to provide emergency clearance of the problem, not necessarily to restore the device to normal operation. For example, if a variable message sign was disconnected from its canopy and fell to the roadway, maintenance personnel should remove the sign from the roadway first as an emergency precaution. Restoring the sign to useful operation would fall further down the prioritization list, based on other factors.

After this, the next priority is to make sure that there are no information dissemination devices that are giving bad and potentially harmful information to users. Incorrect information may increase risks for drivers depending upon the information provided. For example, an outdated VMS message encouraging drivers to take a detour route to avoid an incident on the freeway may direct them into worse conditions as conditions have changed, with potential safety problems. ODOT should focus on information dissemination devices, such as VMS, the 800-telephone numbers, and information kiosks, which are reported to be providing potentially hazardous information. The goal of repairing these devices is not necessarily to restore the device to operations, but to stop the flow of erroneous information.

4.3.1.3 Safety-Critical Devices

Because of the high priority placed on safety not only throughout ODOT but also in other transportation agencies, devices that have a high impact on motorist safety should have a high repair priority. Therefore, after addressing safety hazards, the next level of priority shown in

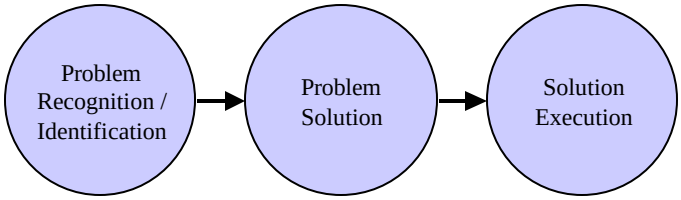

Figure 4-2: Information Flow for ITS Devices.

Figure 4-1 are safety-critical devices. "Safety-critical" is a broad term that may include various types of ITS devices, depending upon the region, the time of year, and other factors.

For every ITS device that provides a safety benefit to the motoring public, there are three stages involved in the device's operation, as shown in Figure 4-2.

1. Problem recognition or identification. The device must first recognize there is some sort of existing or potential problem. This may be accomplished through human recognition of a problem (through surveillance cameras or other observations) or through automated recognition of a problem (through inductive loops, for example).

2. Problem solution. After recognizing the problem, an appropriate solution must be developed. This may be done through human intervention or an automated procedure.

3. Solution execution. Once the solution to the problem is developed, the solution is executed and users/operators are appropriately informed.

The integrity of the entire process, therefore, hinges on accurate information. Without accurate information, problems cannot be properly recognized, or the solutions to problems cannot be properly executed and acted upon by users and operators. Since the first step in the process is the recognition of problems, maintenance efforts should focus first on those devices that, when operational, could identify when problems have occurred. Emphasis should be particularly placed on locations where the greatest number of safety problems may occur.

Once it is assured that accurate information is available, the next priority is to assure that this information can get to the TOC operators. This includes the entire communications and computer network that goes between field devices and the TOC. The level of priority for this indicates that maintenance support for communications and computer equipment needs to parallel the operations of the transportation operation centers. If a TOC is operating on a 24-hour-a-day, 7-day-a-week basis, maintenance support for communications and computer equipment needs to be available at the same level. The greatest emphasis should be placed on the portions of the information network receiving the most traffic, including critical servers.

Once communications links have been addressed, the next step is to have decisions made at the TOC level communicated to users. This will involve not only the communications network between the TOC and any field devices providing information, such as VMS, but also operations of field devices which provide information.

As Figure 4-1 shows, there may be some overlap between these priorities. Decisions to prioritize should have some flexibility within this framework to address unusual repair circumstances. In cases of catastrophic failure with the communications or computer systems, for example, these problems would likely take precedence since other maintenance concerns would be unable to be identified or addressed.

It should be the responsibility of TOC managers and district managers to identify the most critical, safety-oriented aspects of their respective jurisdictions, and place appropriate emphasis on their maintenance.

4.3.1.4 Operations-Critical Devices

After safety-critical maintenance has been taken care of, the next step would be to perform maintenance on ITS devices that enhance and improve the operational efficiency of the transportation system. This would include a variety of systems, such as ramp meters, some VMS deployments, and weigh-in-motion systems.

At this point, prioritization may reflect more economic issues: the number of users who would benefit, the amount of time which could be saved, or the amount of inconvenience that could be avoided. Repair should be prioritized to maximize the amount of benefit that can be yielded. As was done with the safety-related devices, precedence should be placed first on ensuring that information provided from the field is correct, then on repairing the communications network, and finally on the information dissemination component to the public.

4.3.1.5 All Other Devices

There are many devices that may have no direct safety benefits and very limited operational benefit but are perceived as very valuable by the traveling public for the information they provide. These devices would be considered next in the priority list. Examples of these might include kiosks, as well as Internet pictures from ODOT's field cameras during non-winter travel. These devices will be often be used for pre-trip planning, and may improve the travel experience for travelers in the state, especially recreational travelers and tourists.

4.3.1.6 Comparison to Existing Guidelines

Figure 4-3 presents a comparison between these guidelines and ODOT's existing prioritization scheme. There are several pertinent observations that can be made from this comparison.

- Both prioritization schemes emphasize liability, safety and high profile maintenance. In this way, the proposed prioritization scheme does not represent a radical restructuring of existing ODOT procedures.

- The existing prioritization scheme assumes a degree of separation between electrical components which does not exist under ITS. For example, the current prioritization scheme delineates traffic control and communication components as separate priorities. Consequently, the proposed prioritization scheme indicates some overlap between traffic control and communications elements, based on device function.

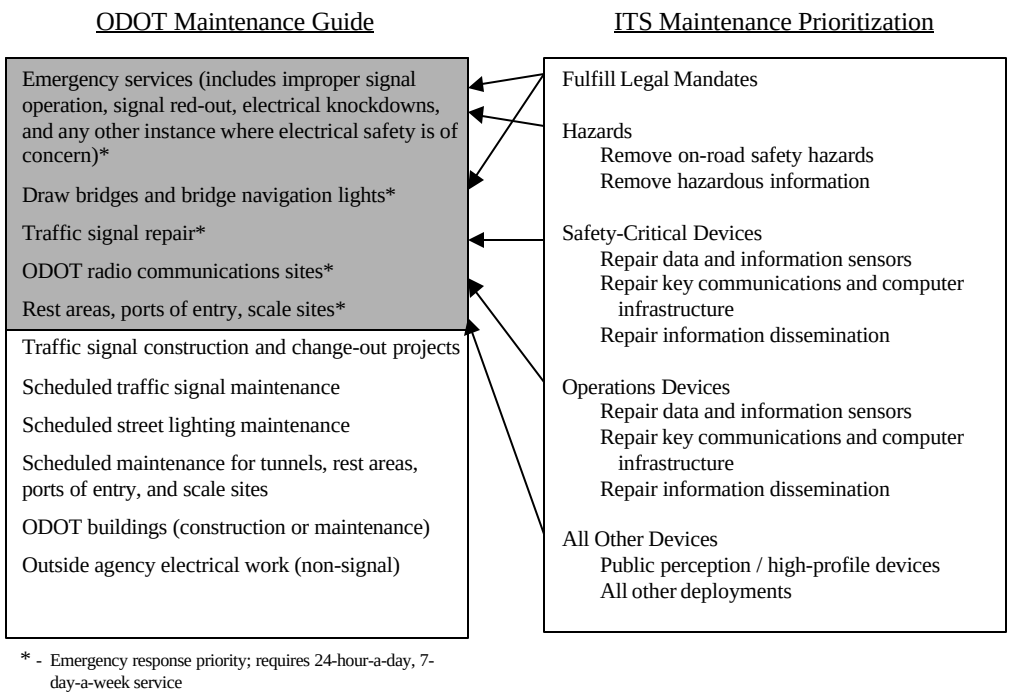

Figure 4-3: Comparison Between Proposed ITS and Existing Prioritization Schemes.

- ITS maintenance logically falls toward the upper end of maintenance priorities according to ODOT standards. According to the existing ODOT maintenance procedures, all of these types of devices are classified as emergency response priorities, with on-call service available on a 24-hour, 7-day-a-week basis. This is consistent with the trend toward continuous operations at the TOCs.

- The proposed guidelines have greater flexibility than the existing guidelines. This flexibility is largely due to the nature of ITS devices, and is necessary for managers and operators to identify priorities based on regional needs. It should be noted that, without proper documentation of priorities by TOC staff, this has the potential to increase the single-point-failure concept that was a concern of stakeholders. Regions would be encouraged to document lists of device priorities, by time of year as appropriate, to not increase the likelihood of single-point-failure.

4.3.2 Regional-Specific Guidelines

It has been emphasized throughout this chapter that prioritizing repairs is a decision that is best left to individuals who are closest to each of the regions and their unique travel needs. However, since this chapter has been primarily abstract and theoretical, it may be helpful to show how priorities might work out in different environments. Table 4-2 provides a broad categorization of how priorities may work out in different environments. Four different combinations of geography and weather are considered, based on an urban or a rural TOC, under

Device		Category											
		Safety-Critical				Operations-Critical				Other			
Response Time		24 hours				48 hours				1 week			
		Location		Weather		Location		Weather		Location		Weather	
Data Collection	Automatic Traffic Recorders												
	Speed Zone Monitoring Stations												
	Closed-Circuit Television (CCTV)												
	Video Detection Systems												
	Road and Weather Information System (RWIS)												
	Travel Time Estimation												
	Automatic Vehicle Location (AVL)												
Traffic Management	Traffic Signals												
	Ramp Metering Systems												
	Emergency Signal Preemption												
	Transit Signal Prioritization												
	Advanced Traffic Management System												
Incident Detection	Mayday Callboxes	not applicable											
	Cellular Call-In	not applicable											
	Urban Automatic Incident Detection System												
	Intersection-Based Incident Detection System												
Incident Management and Response	Computer-Aided Dispatch												
	Incident Response Vehicles												
	Pre-Planned Detour Routes	not applicable											
	Hazardous Materials Response												
Pre-Trip Traveler Information	Alpha-Numeric Paging	not applicable											
	Highway Travel Conditions Reporting System												
	800-number information												
	Internet access												
	Kiosks												
En-Route Traveler Information	Icy Bridge Warning System (Low-Tech)												
	Tunnel lane closure advisory												
	Snow Zone Advisory												
	Snow Zone Changeable Message Sign												
	Oversize Vehicle Closure CMS												
	Bridge CMS												
	Permanent Variable Message Signs (VMS)												
	Portable Variable Message Signs (VMS)												
	Highway Advisory Radio (HAR)												
	Icy Bridge Detectors												
	Oversize load detectors												
	Variable speed limit signs												
	Queue Detection System												
Commercial Vehicle Operations	Weigh-in-Motion (WIM) Stations												
	Downhill Speed Advisory Systems												
Communication Systems	Fiber optic networks												
	Radio Communications												
Maintenance Coordination													

LEGEND				
Some	All		All	
		Urban Deployment		Hazardous Weather
		Rural Deployment		Good Weather

Table 4-2: Regional Repair Prioritization Guidelines.

good or bad weather conditions. The gray boxes indicate devices in which some but not all locations would be classified at the indicated priority level.

These guidelines place high statewide priority on devices that have clear safety implications, such as traffic signals and variable speed limit signs. Emphasis is also given to devices or systems that help to reduce the time between incident occurrence and the deployment of an appropriate response. This includes the advanced traffic management system, the hazardous materials response system, fiber optic communication systems and incident response vehicles.

Many ODOT's ITS field devices in Table 4-2 are depicted with gray boxes, indicating the need for regional input in identifying the most critical device locations. Because incidents are more likely to occur under inclement weather, the repair priority of most ITS devices is elevated when the weather turns bad.

4.4 Recommendations

In order to implement the repair prioritization guidelines depicted in Figure 4-1, there are at least three actions which need to be undertaken in order to ensure these guidelines will be both usable and useful.

- Communicate throughout ODOT the importance of ITS to fulfilling ODOT's mission. Figure 4-3 showed clearly how ITS maintenance should rank as a high-priority maintenance item under ODOT's prioritization schedule for electrical maintenance. This fact should be communicated through the agency.

- Each region should develop and publish guidelines for identifying specific high-priority maintenance items. These guidelines should be coordinated at a statewide level, to improve identifying when staffing resources should be shared across regions.

- ODOT should identify and locate resources to meet response time goals. This is especially critical because some ITS devices that have high public visibility, such as kiosks, are ranked as lower in priority than other devices. ODOT may require a combination of in-house staff and contract maintenance to meet its response time goals. This topic will be discussed further in Chapter 6.