6 RESOURCE ANALYSIS

The previous three chapters addressed some theoretical or idealized perspectives on how ITS maintenance should be performed within ODOT. They described how maintenance requests should be processed through ODOT, what activities should have the highest priority, and what preventative maintenance activities would be desirable for each part of ODOT's ITS infrastructure. To keep this maintenance plan practical, however, it is important to be able to address the following questions.

- What resources are needed to make this happen?
- What resources does ODOT currently have?
- Where are there shortfalls or surpluses in resources?
- How should these gaps be addressed?

This chapter seeks to answer each of these questions, and is organized in four sections accordingly. The first three sections of this chapter relate as shown in Figure 6-1: resource needs, available resources and resource gaps. Resource needs refer to the number of full-time employees (FTEs) required for a given skill set in each region of the state in order to perform appropriate and adequate preventative and repair maintenance on all of the existing and proposed ITS infrastructure. The available resources refer to the number of FTE equivalents ODOT is currently devoting to ITS maintenance activities. The difference between these two matrices indicates where resource gaps or surpluses may exist. The fourth section of this chapter examines alternatives that may be used to resolve any gaps that may exist.

6.1 Resource Needs

There is a relationship between the number and type of ITS devices that ODOT deploys and the amount of resources that must be devoted to ITS maintenance. As was discussed in Chapter 2, however, few maintenance plans have attempted to quantify this relationship. This section seeks to develop estimates, on a per-device basis, of the staffing resources required to maintain ODOT's existing and planned infrastructure.

6.1.1 Key Assumptions

Several simplifying assumptions were applied in order to estimate the resources needed for

$$\underbrace{\begin{pmatrix}\text{resource}\\ \text{needs}\end{pmatrix}_{ijk}}_{\text{Section 6.1}} - \underbrace{\begin{pmatrix}\text{available}\\ \text{resources}\end{pmatrix}_{ijk}}_{\text{Section 6.2}} = \underbrace{\begin{pmatrix}\text{resource}\\ \text{gap}\end{pmatrix}_{ijk}}_{\text{Section 6.3}}$$

where i = region (1, 2, 3, 4 or 5)
j = job classification
k = analysis year (existing, existing + STIP or strategic plan build-out)

Figure 6-1: Resource Model Formula.

ITS maintenance. These assumptions are as follows.

1. Multiple sources of information were required to reliably quantify resource needs. The best source of information on identifying the resources needed to maintain the ITS infrastructure would be historical cost data either from internal experience or from other agencies. Conversations with ODOT stakeholders indicate, however, that there is inadequate data within ODOT by which resource needs could be estimated. Consequently, the following sources of information were used.

   - Vendors. With the exception of a few devices, ODOT has purchased or will purchase its ITS devices from vendors who have sold similar products to other departments of transportation or non-transportation entities. Because of their role in component design and their extensive experience, vendors may provide helpful insight on the typical maintenance needs associated with a given device.

   - Arizona Department of Transportation (ADOT). ADOT developed an in-house inventory and accounting system to track maintenance on its ITS infrastructure, and this has been used by ADOT to estimate future resource needs for ITS maintenance (9). This system has produced estimates for maintenance needs per device, divided into preventative and repair maintenance tasks.

   - Caltrans. Caltrans developed estimates for resource needs for preventative and repair maintenance for its ITS infrastructure in the greater Los Angeles area (6). Estimates are included for only a few of the devices which ODOT is deploying, but are very specific in terms of describing the maintenance tasks which are included.

   - Other agencies. In some cases, ODOT has identified individuals at other transportation agencies who have substantial experience with a given ITS device. These agencies may therefore be able to provide good information as to the maintenance needs of a device once all of the initial “bugs” have been resolved.

   - ODOT. ODOT’s ITS Unit identified individuals throughout ODOT who have significant experience with specific devices. These individuals were contacted in order to describe the actual field maintenance experience.

   There are occasions when maintenance estimates provided by different sources were in conflict with each other. In these cases, best professional judgment was applied to determine the most appropriate estimate to be used. Resource needs estimates are intended to provide a “worst case” scenario, so that resource needs are not underestimated.

2. Resource needs must be estimated from a component level. To better clarify the maintenance needs of each ITS device, each device is characterized by up to six different types of components.

    - Sensors. This broadly refers to components that gather data about traffic or environmental conditions. These may include video sensors, audio sensors, pressure sensors, or environmental sensors.

    - Communications. This broad category includes communications from the device in the field to the operator. It could include wireline communications such as coaxial, telephone or fiber optic networks, as well as wireless communications like cellular telephone and radio communications. It also may include hardwire connections in the field between various device components.

    - Field Processors/Controllers. Many ITS devices will have a processor located in the field that analyzes sensor data and performs an appropriate response, or translates the sensor data in a more usable form to the operator. The processor may be a solid-state device with pre-programmed firmware, or it may be a full-fledged microcomputer.

    - Software. There may be specialized software for a given device that is installed onto the field processor, as well as software used by the operator to access or manage various field devices.

    - Center Subsystems. These are components in which data from various field controllers is pooled together and processed in order to make effective decisions or provide information regarding the transportation system. An example of this would be the Transportation Operation Centers (TOCs), which act as information clearinghouses for data collected through a variety of ITS devices and other data sources.

    - Information Delivery. This is the component of the ITS device that gives the right information to the right people at the right time. It includes information delivered to drivers in the field, such as through variable message signs or highway advisory radio, as well as information delivered to operators, through radio systems and computer screens.

    Appendix G describes each of the devices included in this analysis and the maintenance needs associated with each.

3. Staffing needs must be estimated by employee classification. Table 6-1 lists the ODOT staff classifications that were used in developing estimates of resource needs. Multiple classifications were used for the support coordinator position in order to reflect more accurately the desired skill set of individuals who would fill that role. Multiple classifications are also used within each Information Services classification

Title	Abbrev	Description / Explanation	DAS #
Support Coordinator / IS-Diagnostics	SC-I-D	Support Coordinator position is divided into seven categories to better understand the skill set required for the position in each region. IS - Information Services Elec - Electrician-type work Program Technician - work that doesn't require any special technical skill set	TBD
Support Coordinator / IS-Repair	SC-I-R		TBD
Support Coordinator / IS-Preventative Maintenance	SC-I-PM		TBD
Support Coordinator / Elec-Diagnostics	SC-E-D		TBD
Support Coordinator / Elec-Repair	SC-E-R		TBD
Support Coordinator / Elec-Preventative Maintenance	SC-E-PM		TBD
Support Coordinator / Program Technician	SC-P		TBD
Info Services - Kiosk Specialist	IS-K	There is currently no ODOT kiosk specialist; this is assumed to be an IS-4 level position.	1484
Info Services 5 - Radio Technician	IS-5R	Higher IS classifications are used to refer to specialized skill sets which may be needed for some device maintenance.	1485
Info Services 5 - Networks / Servers	IS-5N		1485
Info Services 5 - Software	IS-5S		1485
Info Services 6 - Radio Technician	IS-6R		1486
Info Services 6 - Networks / Servers	IS-6N		1486
Info Services 6 - Software	IS-6S		1486
Info Services 7 - Networks / Servers	IS-7N		1487
Info Services 7 - Software	IS-7S		1487
Fiber Optic Technician	IS-F	ODOT currently does not have any fiber optics technicians, so no DAS classification exists.	TBD
Electrician	ELEC		4213
Traffic Signal Technician 3	TS-3	For some devices, a Traffic Signal Technician 2 (DAS# 3410) may be dispatched. TS-3 is used in order to provide "worst-case" estimates.	3411

TBD - To be determined
DAS - Department of Administrative Services

Table 6-1: ODOT Staff Classifications.

to reflect specialization of skills into networks and servers, software, or radio communications.

Estimates for resource needs are based on the preferred maintenance model discussed in Chapter 3. Based on this model, the following assumptions were used.

- Support coordinators will perform all preventative maintenance, except for activities requiring specialized licensing, training or equipment (i.e. fiber optics training, bucket truck, etc.).
- The support coordinator will perform initial device diagnostics and will make initial attempts at device repair.

- Higher-level support (IS-6, IS-7 or TSSU) would be brought in only when initial attempts at diagnostics and repair are unsuccessful.

- The support coordinator is responsible for all logging and tracking activity.

These assumptions are clarified in greater detail in Appendix H.

4. Future resource needs estimates must reflect technological change. Intelligent transportation systems continue to be an evolving technology. This trend is expected to continue for the foreseeable future, and the rate and nature of technological change could be expected to have a significant impact on ODOT's ITS maintenance needs. Appendix I describes some assumptions about the anticipated direction and effects of technological change that were used in this analysis.

5. The extent of vendor support will affect resource needs. In order to provide a worst case scenario – i.e. maximizing the FTEs ODOT must provide to perform ITS maintenance – it is assumed that ODOT staff will be able to perform device maintenance effectively and efficiently wherever allowed to. In at least two cases vendor support would be utilized.

   - Specialized components. Some components, especially for newer technologies, will be so sophisticated that it may be impossible to diagnose or repair them without specialized equipment. In these cases, it is assumed that ODOT would have no maintenance responsibility. When repairs are needed, the malfunctioning components would be returned to the vendor or supplier for appropriate maintenance.

   - Warranty coverage. Some existing and planned devices will have vendor-provided warranty coverage which would relieve ODOT of significant maintenance responsibility for a period. However, to maintain consistency with a worst case scenario, it is assumed that no warranty coverage will be in effect.

6. FTE equivalents must include appropriate employee benefits and training. It is unreasonable to assume that each ODOT employee can devote 40 hours per week for 52 weeks per year to ITS maintenance. Figure 6-2 shows a series of equations that were used to develop an estimate of 1,627 hours as comprising a FTE equivalent year. This reflects reasonable assumptions in terms of vacation leave and time for training to enhance existing skills and learn new skills.

7. Travel time must be included to accurately reflect true resource needs. Because of uncertainty regarding locations of planned device deployments and the ability to schedule multiple repair activities on one trip, several simplifying assumptions about travel time were necessary. These assumptions are described in greater detail in Appendix J. Travel times that were assumed for this analysis are shown in Table 6-2.

		Region				
Location	**Type of Support**	**1**	**2**	**3**	**4**	**5**
Field Device	Regional	1	1 3/4	2	3 1/4	2 3/4
	Centralized in Salem	1	1 1/4	3 1/4	3 1/2	5 1/4
TOC	Regional	0	0	0	0	0
	Centralized in Salem	1 1/2	0	2	3	6

Table 6-2: Travel Time Assumptions.

Based on these assumptions, Appendix K provides tables for each device which indicate the maintenance needs of each ITS device under each of these six components. For each device, the following information is provided:

- a table indicating the device's existing and planned inventory, by region;
- brief descriptions of maintenance needs for each of the device's six components (where applicable), with tables identifying the anticipated frequency of preventative and repair maintenance, the average length of time required for maintenance, and the staff classifications involved in maintenance activity;
- a summary of the per-unit maintenance needs, summarized over the device's six components, by classification level; and
- a summary of the total maintenance obligation by classification by region in FTEs.

6.1.2 Electricians

Table 6-3 shows the number of electrician FTE equivalents that are required for ITS maintenance. As can be seen, it is estimated that ITS maintenance activities would require less than 1 FTE per region through the end of the STIP. As was stated earlier, it is assumed that electricians would perform few preventative maintenance activities. If they were to perform additional preventative maintenance activities, this would significantly increase the number of

$$52\frac{weeks}{year} - \underset{\text{vacation}}{3\frac{weeks}{year}} - \underset{\text{training}}{2\frac{weeks}{year}} - \underset{\text{sick leave}}{1\frac{week}{year}} = 46\frac{weeks}{year}$$

$$46\frac{weeks}{year} \times 5\frac{days}{week} - \underset{\text{holidays}}{13\frac{days}{year}} = 217\frac{days}{year}$$

$$217\frac{days}{year} \times \left(8\frac{hours}{day} - 2\frac{breaks}{day} \times 0.25\frac{hours}{break}\right) \approx 1{,}627\frac{hours}{year}$$

Figure 6-2: Number of Hours in an FTE Year.

(Source: 14)

FTE equivalents required. By the conclusion of the Strategic Plan, it is estimated that more than 1 FTE each would be required in Regions 1, 4 and 5, and that nearly 1 FTE would be required in Regions 2 and 3.

	Region					State
	1	2	3	4	5	Total
Existing	0.46	0.29	0.12	0.21	0.26	1.35
Existing + STIP	0.63	0.44	0.16	0.51	0.64	2.38
Existing + Strategic Plan	1.47	0.93	0.95	1.34	1.38	6.07

Table 6-3: Staffing Requirements for Electricians.

6.1.3 TSSU

According to the preferred maintenance model, TSSU is dispatched to perform maintenance activities when support coordinators and/or electricians are unable to successfully resolve a problem. In order to be consistent with other classifications, Table 6-4 divides maintenance activities for TSSU by region, although it is assumed that all TSSU staff would continue to be headquartered in Salem.

	Region					State
	1	2	3	4	5	Total
Existing	0.03	0.03	0.02	0.02	0.05	0.14
Existing + STIP	0.04	0.04	0.02	0.05	0.09	0.23
Existing + Strategic Plan	0.06	0.04	0.09	0.09	0.16	0.44

Table 6-4: Staffing Requirements for TSSU.

Table 6-4 indicates that limited involvement is anticipated from TSSU in ITS maintenance. This is based on assumptions regarding the percentage of repairs that support coordinators and/or electricians are able to successfully address. It is anticipated that, even with build-out of the Strategic Plan, only 0.44 FTEs would be required. However, if the first-line of diagnostic and repair capability is less effective in their work, much greater involvement from TSSU would be anticipated.

6.1.4 Information Services

For the purposes of estimating resource needs, Information Services has been sub-divided into three broad classifications based on type of skill set:

- networks and servers, which includes maintenance of desktop computers and workstations;
- software, which includes software installation and programming; and
- radio communications, which is focused on consoles and hand-held units, but not on towers and other supporting infrastructure.

Table 6-5 shows the network and server support that must be provided by Information Services, according to the resource needs estimates. It is estimated that there is need for some support at the IS-5 level, increasing as more devices are deployed. By the time the Strategic Plan is completely implemented, regional needs will vary between approximately 0.4 and 0.6 FTE equivalents at the IS-5 level. The need for IS-6 support for networks and servers is anticipated to be fairly minimal, based on assumptions regarding the percentage of problems which can be adequately addressed by IS-5 technicians.

Info Services 5 - Networks / Servers (IS-5N) - DAS #1485

	Region					State
	1	2	3	4	5	Total
Existing	0.08	0.14	0.01	0.08	0.03	0.34
Existing + STIP	0.10	0.17	0.03	0.16	0.13	0.58
Existing + Strategic Plan	0.39	0.35	0.38	0.61	0.51	2.24

Info Services 6 - Networks / Servers (IS-6N) - DAS #1486

	Region					State
	1	2	3	4	5	Total
Existing	0.02	0.03	0.00	0.02	0.01	0.07
Existing + STIP	0.02	0.03	0.01	0.03	0.03	0.11
Existing + Strategic Plan	0.06	0.05	0.06	0.09	0.08	0.33

Table 6-5: Staffing Requirements for Information Services Network and Server Specialists.

The resource needs for IS software support are shown in Table 6-6. It is assumed that support coordinators will be able to install off-the-shelf software upgrades with little difficulty, and that the software vendor would address any technical support issues. The primary software maintenance issues will be in the development and revision of ODOT-developed packages, such as the TripCheck Web site, as well as in the development of enhancements to packages developed by others, such as database queries developed on a vendor-provided RWIS database.

Info Services 6 - Software (IS-6S) - DAS #1486

	Region					State
	1	2	3	4	5	Total
Existing	0.00	1.06	0.00	0.00	0.00	1.06
Existing + STIP	0.00	1.40	0.00	0.00	0.00	1.40
Existing + Strategic Plan	0.00	1.40	0.00	0.00	0.00	1.40

Info Services 7 - Software (IS-7S) - DAS #1487

	Region					State
	1	2	3	4	5	Total
Existing	0.00	0.01	0.00	0.00	0.00	0.01
Existing + STIP	0.00	0.01	0.00	0.00	0.00	0.01
Existing + Strategic Plan	0.00	0.01	0.00	0.00	0.00	0.01

Table 6-6: Staffing Requirements for Information Services Software Specialists.

According to Table 6-6, more than 1 FTE at the IS-6 level will be required in Salem through the duration of the Strategic Plan. Resource needs are increased slightly when the STIP is in effect due to relative infancy of these computer applications. Limited IS-7 support would be necessary only to assist the IS-6 programmers in more challenging programming efforts.

Table 6-7 shows the estimated resource needs for Information Services' radio technicians. Because ITS maintenance excludes any maintenance performed on ODOT's radio infrastructure, maintenance needs will be fairly minimal. It is estimated that ITS maintenance will demand an average of 0.1 FTE equivalents at the IS-5 level in each of ODOT's regions by the end of the Strategic Plan. There is anticipated to be limited need for IS-6 radio technicians for ITS maintenance, to reflect special maintenance needs.

Info Services 5 - Radio Technician (IS-5R) - DAS #1485

	Region					State
	1	2	3	4	5	Total
Existing	0.02	0.02	0.01	0.02	0.00	0.07
Existing + STIP	0.02	0.02	0.01	0.08	0.00	0.13
Existing + Strategic Plan	0.08	0.10	0.09	0.11	0.10	0.48

Info Services 6 - Radio Technician (IS-6R) - DAS #1486

	Region					State
	1	2	3	4	5	Total
Existing	0.00	0.00	0.00	0.00	0.00	0.01
Existing + STIP	0.00	0.00	0.00	0.01	0.00	0.02
Existing + Strategic Plan	0.01	0.01	0.01	0.01	0.01	0.04

Table 6-7: Staffing Requirements for Information Services Radio Technicians.

There are two other types of maintenance that would likely fall under Information Services' responsibility: kiosk maintenance and fiber optics.

Kiosk maintenance would require regular, preventative inspections of kiosk cabinets and connections, paper levels and print quality. Because of the frequency of maintenance required for this task and the less advanced skill set, kiosk maintenance was treated as a separate IS classification. Table 6-8 shows the estimated resource needs for kiosk maintenance. As can be seen, nearly 4 FTE equivalents would be required for kiosk maintenance. This estimate assumes that ODOT would handle all preventative maintenance activities in-house. ODOT may be able to secure relationships with kiosk hosts such that they would be responsible for some or all preventative maintenance tasks, which may help to reduce this staffing burden.

	Region					State
	1	2	3	4	5	Total
Existing	0.00	0.00	0.00	0.00	0.00	0.00
Existing + STIP	0.00	0.00	0.00	0.00	0.00	0.00
Existing + Strategic Plan	1.42	0.49	0.53	0.74	0.65	3.83

Table 6-8: Staffing Requirements for Information Services Kiosk Specialists.

Fiber optics maintenance is another position that is currently not provided for in ODOT's classification system. Table 6-9 estimates the resources that would be required for

	Region					State
	1	2	3	4	5	Total
Existing	0.00	0.00	0.00	0.00	0.00	0.00
Existing + STIP	0.19	0.00	0.00	0.00	0.00	0.19
Existing + Strategic Plan	0.19	0.00	0.00	0.00	0.00	0.19

Table 6-9: Staffing Requirements for Information Services Fiber Optic Technicians.

maintenance of ODOT's Region 1 fiber optics system are less than 0.2 FTE equivalents, assuming that there is no more than 80 miles of fiber optic cable under ODOT's responsibility. As fiber optics is increasingly used for field communications between device components, this staffing burden will increase.

6.1.5 Support Coordinator

Table 6-10 summarizes the estimated FTE equivalent needs for the support coordinator position. As can be seen, there are extensive FTE needs associated with the support coordinator position both currently and into the future. Under the existing inventory deployment, it is estimated that there is enough maintenance activity to occupy more than 1 FTE in both Regions 1 and 2. After the STIP is complete, the FTE requirement in four of ODOT's regions would be for approximately 2 FTEs. By the time the Strategic Plan is fully implemented, the maintenance needs are estimated to increase to a total of over 35 FTEs statewide. Slightly more FTEs are allocated to Regions 4 and 5 under the Strategic Plan, which reflects in part the effect of increased travel times in those regions.

	Region					State
	1	2	3	4	5	Total
Existing	1.29	1.53	0.34	0.89	0.66	4.71
Existing + STIP	1.67	2.03	0.53	2.02	1.85	8.10
Existing + Strategic Plan	5.80	6.03	6.25	9.02	7.99	35.09

Table 6-10: Resource Needs for Support Coordinators.

Because of the significant number of FTEs devoted to the support coordinator position, it would be helpful to see how these FTEs are divided into different activities. Table 6-11 shows, for the existing inventory, the percentage of work for each of seven sub-classifications for support coordinators. As can be seen, the largest potion of time overall – 24 percent statewide, with 37 percent in Region 1 – is devoted to preventative maintenance tasks on computer and communications systems. Overall, support coordinators in Regions 1, 2 and 4 would devote more of their efforts to Information Systems maintenance activity than electrician-related activity, whereas the reverse is true in Regions 3 and 5.

	Region					
	1	2	3	4	5	Total
Coordination	8%	22%	12%	10%	7%	13%
Elec - Diag	14%	17%	21%	16%	29%	18%
Elec - Repair	14%	13%	21%	12%	26%	16%
Elec - PM	6%	6%	7%	8%	7%	7%
IS - Diag	15%	19%	9%	19%	8%	16%
IS - Repair	6%	9%	5%	11%	4%	8%
IS - PM	37%	14%	26%	25%	18%	24%
Total	100%	100%	100%	100%	100%	

Table 6-11: Percent Breakdown of Support Coordinator Time – Existing.

Across the five regions, support coordinators would spend an average of 13 percent of their time on coordination, logging and tracking of maintenance. Region 2 has a larger percentage of time devoted to coordination than other regions because of the statewide systems that are based in Region 2.

Table 6-12 shows that there is little change in the percentage allocation of support coordinator time once the STIP has been implemented. One significant change is that a smaller percentage of time is spent on coordination of maintenance activities.

	Region					
	1	2	3	4	5	Total
Coordination	8%	19%	10%	9%	7%	11%
Elec - Diag	15%	16%	18%	16%	21%	17%
Elec - Repair	16%	14%	18%	13%	19%	16%
Elec - PM	6%	6%	8%	7%	7%	7%
IS - Diag	14%	17%	11%	18%	13%	15%
IS - Repair	6%	9%	6%	11%	7%	8%
IS - PM	35%	19%	29%	26%	26%	26%
Total	100%	100%	100%	100%	100%	

Table 6-12: Percent Breakdown of Support Coordinator Time – STIP.

Once the Strategic Plan has been implemented, it is anticipated there would be significant changes in the support coordinator's role, as shown in Table 6-13. In all regions, the percent of time spent on maintenance coordination has increased, to an average of 19 percent of time statewide. For each of the regions, an increasing portion of time would be devoted to IS-related diagnostics and repair, indicating an increasing need for that skill set over time.

	Region					
	1	2	3	4	5	Total
Coordination	18%	23%	22%	17%	18%	19%
Elec - Diag	11%	11%	13%	14%	14%	13%
Elec - Repair	15%	13%	14%	14%	17%	15%
Elec - PM	9%	9%	9%	8%	8%	8%
IS - Diag	14%	16%	16%	17%	16%	16%
IS - Repair	9%	11%	12%	13%	12%	12%
IS - PM	24%	16%	15%	17%	14%	17%
Total	100%	100%	100%	100%	100%	

Table 6-13: Percent Breakdown of Support Coordinator Time – Strategic Plan.

Because of the significant increase in FTEs required from the existing deployment to the deployment under the Strategic Plan, it is important to note how many FTEs would be required for each of these roles in the future. Table 6-14 reflects the product of the percentages shown in Table 6-13 and the

	Region					
	1	2	3	4	5	Total
Coordination	1.04	1.40	1.37	1.55	1.48	6.83
Elec - Diag	0.62	0.68	0.79	1.27	1.13	4.49
Elec - Repair	0.88	0.81	0.86	1.30	1.37	5.23
Elec - PM	0.52	0.52	0.57	0.71	0.62	2.95
IS - Diag	0.81	0.95	0.99	1.50	1.27	5.53
IS - Repair	0.52	0.68	0.73	1.17	0.97	4.07
IS - PM	1.41	0.99	0.93	1.51	1.16	5.99
Total	5.80	6.03	6.25	9.02	7.99	35.09

Table 6-14: Number of Support Coordinator FTEs by Type of Work – Strategic Plan.

FTE requirements estimated under the Strategic Plan. It is estimated that each region would need at least one FTE devoted to maintenance coordination. At least 0.5 FTE would be required for each of the indicated skill sets in each region. Most activities in Region 4 and 5 would require at least 1.0 FTE each, indicating the effects of increased travel time on resource needs.

6.2 Available Resources

In addition to identifying what staffing resources are necessary for ODOT's ITS maintenance, it is important to identify what staffing resources ODOT currently has for performing ITS maintenance. Initially, telephone contacts were made with ODOT staff in the regional maintenance offices, Information Services and TSSU to discern how much time is currently being spent on ITS maintenance. In reviewing this data, it was determined that a lack of consistent record keeping across the organization made this data suspect. Therefore, job descriptions were reviewed for various ODOT positions to determine the percentage of time it was anticipated that each staff position should be spending on ITS maintenance.

6.2.1 Electricians

Based on telephone contacts with several ODOT electricians, it was determined that electricians are spending a small portion of their time on ITS maintenance (15, 16, 17). Based on review of job descriptions, however, it was determined that the time electricians currently spend on ITS maintenance is not a part of their job descriptions (18, 19, 20). Therefore, in terms of resource availability, it is assumed that there are zero electricians in any region available for ITS maintenance.

6.2.2 TSSU

There are three broad classifications of staff at TSSU: lead technician, journey level ITS technician, and journey level traffic signal technician (21). Job descriptions for each of these positions were reviewed to identify those duties that are most similar to the resource needs evaluated in Section 6.1. For this reason, the following types of duties identified in job descriptions were not included:

- any activities with traffic signals;
- providing training, since time was already allocated for training under the FTE formula developed in Section 6.1;
- construction turn-on inspection; and

Classification	No. of Staff	% of Time on ITS Maintenance	No. of FTEs
Lead Technician	1	65%	0.65
Journey Level ITS Technician	3	63%	1.89
Journey Level Traffic Signal Technician	4	4%	0.16
Total			**2.70**

Table 6-15: Available FTEs for TSSU Technicians.

- special projects.

On this basis, Table 6-15 provides estimates for the number of FTEs estimated to be available for ITS maintenance from TSSU. All TSSU staff are based in Salem, although they will be required to travel to service field devices.

6.2.3 Information Services

In ODOT, computer support for workstations, networks and servers is handled by Information Services both in Salem and through the Field Services unit. Table 6-16 shows the estimated FTE availability of network and server support from Information Services. It was determined that several field services technicians are currently providing ITS maintenance, although it is only explicitly in the job descriptions of technicians working in Regions 1 and 2 and not in those of technicians in other regions (27, 28, 29).

	Region					State
	1	2	3	4	5	Total
IS Field Services FTEs	0.70	1.30	0.00	0.00	0.00	2.00

Table 6-16: Available FTEs for Information Services Network and Server Support.

(Sources: 22, 23, 24, 25, 26)

There are currently three FTEs in Information Services devoted to ITS software applications, including development as well as maintenance (30); of these 3.0 FTEs, it is estimated that 0.2 FTEs are devoted to maintenance (20). Because of the difficulty in separating out software maintenance activity from other duties in application development, the number of actual FTEs may be somewhere in between these two values. For a worst-case scenario, it is assumed that only 0.2 FTEs are available.

Since the job descriptions for Information Services' radio technicians do not include ITS maintenance (31), it will be assumed that there are zero available FTEs for radio-related ITS maintenance. Technicians currently spend minimal time on applications directly related to ITS (32).

As was alluded to in the previous section, ODOT currently does not have any dedicated fiber optics technicians. Some TSSU technicians have obtained some training in fiber optics and the unit also possesses some testing equipment (21). The availability of these technicians was considered in Table 6-15. ODOT currently does not have any staff positions devoted to kiosk maintenance, either.

6.2.4 Support Coordinators

Currently, there are no support coordinator positions within ODOT. As a part of a program options package approved in 1999, however, three FTE positions were obtained for the support coordinator role. Based on subsequent discussions, it was agreed that one of these positions would be given to TSSU for support of ITS field devices in Region 1[5] (33). Based on position

[5] Because the TSSU position has not been filled as of yet, it is still included with the support coordinator positions.

descriptions prepared by ODOT's ITS Unit, it is estimated that these individuals would spend between 50 and 70 percent of their time in support or coordination of preventative and repair maintenance activities on ITS devices. Based on these assumptions, Table 6-17 provides estimates for resource availability of support coordinators in each ODOT region.

	Region					State
	1	2	3	4	5	Total
Support Coordinator FTEs	0.60	0.60	0.00	0.60	0.00	1.80

Table 6-17: Available FTEs for Support Coordinators.

6.3 Resource Gaps

This section will analyze the gaps in resources between what is needed to properly maintain ODOT's ITS infrastructure and what ODOT currently has devoted to ITS maintenance.

6.3.1 Staffing Gaps

The first type of gap to be analyzed is the gap in staffing as expressed in FTEs. Table 6-18 shows an initial assessment of staffing gaps. Estimates of available FTEs are provided in the leftmost column. Because it is unclear how staffing decisions will evolve in the future, it was assumed that no additional FTEs would be acquired by ODOT for ITS maintenance through the completion of the Strategic Plan. Estimates of FTE needs are presented under the existing, STIP and Strategic Plan build-out deployment levels, along with estimates of the staffing gaps or surpluses. Positive values for staffing resource differences represent gaps, whereas negative values represent apparent resource surpluses.

The most notable finding in Table 6-18 is that there is currently an overall shortage of staffing resources for performing ITS maintenance at acceptable levels. It is estimated that ODOT currently needs 7.74 FTEs for ITS maintenance, with only 4.9 FTEs available, for a gap of 2.84 FTEs. The addition of the support coordinator positions for the STIP increases resource availability to 6.7 FTEs; however, the resource gap increases to 6.45 FTEs because of the increase in the number of ITS devices deployed. This gap widens to 43.41 FTEs by the time the Strategic Plan is completed because it is assumed ODOT will not be able to add additional maintenance staff to keep pace with increasing levels of deployment. To put it differently, it is estimated that ODOT would need to be able to add about 2 FTEs per year for the next twenty years to have adequate staffing to perform all ITS maintenance in-house.

Gaps are not consistent across all staffing classifications, primarily because the staffing positions where resources are available are not necessarily the positions which will be performing ITS maintenance under the preferred maintenance model alternative. For example, TSSU has an apparent surplus of staffing through the end of the Strategic Plan. However, they are likely currently doing some of the diagnostic and repair work of both regional electricians and support coordinators. The same is likely true of Information Services' network and server support.

For this reason, resource gaps were also analyzed by skill set or maintenance activity. Maintenance activities were divided into seven categories: three for electrical maintenance

				FTEs					
Classification		Region	Avail.	Existing		STIP		Strategic Plan	
				Need	Gap*	Need	Gap**	Need	Gap**
Electricians		1	-	0.46	0.46	0.63	0.63	1.47	1.47
		2	-	0.29	0.29	0.44	0.44	0.93	0.93
		3	-	0.12	0.12	0.16	0.16	0.95	0.95
		4	-	0.21	0.21	0.51	0.51	1.34	1.34
		5	-	0.26	0.26	0.64	0.64	1.38	1.38
		Statewide	-	1.35	1.35	2.38	2.38	6.07	6.07
TSSU		Statewide	2.70	0.14	(2.57)	0.23	(2.47)	0.44	(2.26)
IS	Networks / Servers (incl. Field Services)	1	0.70	0.10	(0.60)	0.12	(0.58)	0.44	(0.26)
		2	1.30	0.17	(1.14)	0.20	(1.10)	0.40	(0.90)
		3	-	0.02	0.02	0.03	0.03	0.44	0.44
		4	-	0.10	0.10	0.19	0.19	0.70	0.70
		5	-	0.03	0.03	0.15	0.15	0.59	0.59
		Statewide	2.00	0.41	(1.59)	0.70	(1.31)	2.57	0.57
	Radio Communications	1	-	0.02	0.02	0.02	0.02	0.09	0.09
		2	-	0.02	0.02	0.03	0.03	0.10	0.10
		3	-	0.01	0.01	0.01	0.01	0.10	0.10
		4	-	0.03	0.03	0.09	0.09	0.12	0.12
		5	-	-	-	-	-	0.10	0.10
		Statewide	-	0.08	0.08	0.15	0.15	0.52	0.52
	Software	Statewide	0.20	1.07	0.87	1.41	1.21	1.41	1.21
	Fiber Optics	Statewide	-	-	-	0.19	0.19	0.19	0.19
	Kiosks	Statewide	-	-	-	-	-	3.83	3.83
Support Coordinators		1	0.60	1.29	1.29	1.67	1.07	5.80	5.20
		2	0.60	1.53	1.53	2.03	1.43	6.03	5.43
		3	-	0.34	0.34	0.53	0.53	6.25	6.25
		4	0.60	0.89	0.89	2.02	1.42	9.02	8.42
		5	-	0.66	0.66	1.85	1.85	7.99	7.99
		Statewide	1.80	4.71	4.71	8.10	6.30	35.09	33.29
Total		Statewide	6.70	7.74	2.84	13.15	6.45	50.11	43.41

* - Does not include support coordinators.
** - Assumes that no additional FTEs are obtained.

Table 6-18: Staffing Gaps by Classification and Region.

(diagnostics, repair and preventative maintenance), three for Information Services-related maintenance (diagnostics, repair and preventative maintenance), and one for maintenance coordination. In order to establish a relationship between resource availability by staff classification and resource availability by maintenance activity, the following assumptions were made.

- For Information Services maintenance activities, 75 percent of time is spent on diagnostics, 20 percent on repair and 5 percent on preventative maintenance.

- For electrical maintenance activities, 50 percent of time is spent on diagnostics and 50 percent on repair. No time is allocated for preventative maintenance in order to reflect the perception that preventative maintenance is not being done.
- Support coordinators are assumed to spend 0.1 FTE of their time on maintenance coordination activities. The remainder of their time is split equally between Information Services and electrical maintenance activities.

Using these assumptions, Table 6-19 shows estimated staffing gaps for maintenance activities in each region. Based on this analysis, it is clear that there are staffing gaps in electrical maintenance, IS-related maintenance and maintenance coordination. The analysis shows that staffing gaps are currently greatest for preventative maintenance activities. On a regional basis, each of the regions shows staffing gaps for both electrical and IS-related maintenance, with the exception of electrical maintenance in Region 2 where resource availability is skewed by the allocation of all available TSSU staff time to that region.

6.3.2 Skills Gaps

While ODOT may have "warm bodies" to fill roles in maintenance, it is important to assess, on a broad level, the level of skills of these individuals with respect to their designated responsibility. For simplicity, skills gaps have been estimated in a broad sense for each of the major classification groups. Responses received from many ODOT stakeholders in June 1999 (13), as well as telephone conversations, were used to provide an assessment of existing skill levels.

Based on these forms of input, it seems as though the most significant skills gaps in ODOT are related to maintenance of field or electrical components. It does not appear as though skill gaps are caused by a lack of experience in the organization overall, as there seems to be some in-house expertise for each existing field device in ODOT's ITS infrastructure. Rather, skill gaps appear to exist at a regional level, based either on a lack of familiarity with a particular device or a lack of adequate support or training from the device vendor. Skill gaps exist on a variety of ITS devices throughout the state. Skills gaps do not seem to be as substantial in Region 1, where there is generally a greater deployment of ITS devices. This data suggests that ODOT may be able to resolve its own skills gaps through internal training efforts. For repair activities for which IS would be typically called, Field Services technicians report that they seldom if ever need to call on more specialized support from Salem to help resolve a problem.

6.4 Training and Contracting Alternatives

To resolve these resource gaps in staffing and training levels, ODOT has two broad options: enhance and develop resources within the organization in order to provide for adequate staffing and training, or rely on contract support. This chapter reviews potential alternatives for each option and then proposes recommendations for how gaps may best be resolved.

Type of Work		Region	FTEs: Available		Existing		STIP		Strategic Plan	
			Now	Future	Need	Gap	Need	Gap	Need	Gap
Coordination		1	-	0.10	0.10	0.10	0.14	0.04	1.04	0.94
		2	-	0.10	0.33	0.33	0.38	0.28	1.40	1.30
		3	-	-	0.04	0.04	0.05	0.05	1.37	1.37
		4	-	0.10	0.09	0.09	0.18	0.08	1.55	1.45
		5	-	-	0.05	0.05	0.13	0.13	1.48	1.48
		Total	-	0.30	0.61	0.61	0.88	0.58	6.83	6.53
Electrical / Electronic	Diagnostic	1	-	0.11	0.26	0.26	0.36	0.25	0.73	0.62
		2	1.35	1.46	0.31	(1.04)	0.41	(1.05)	0.76	(0.71)
		3	-	-	0.10	0.10	0.12	0.12	0.87	0.87
		4	-	0.11	0.18	0.18	0.41	0.30	1.38	1.27
		5	-	-	0.25	0.25	0.51	0.51	1.26	1.26
		Total	1.35	1.69	1.09	(0.26)	1.82	0.13	4.99	3.31
	Repair	1	-	0.11	0.38	0.38	0.52	0.41	1.48	1.37
		2	1.35	1.46	0.33	(1.02)	0.47	(1.00)	1.19	(0.27)
		3	-	-	0.13	0.13	0.17	0.17	1.29	1.29
		4	-	0.11	0.20	0.20	0.49	0.37	1.88	1.77
		5	-	-	0.31	0.31	0.64	0.64	2.02	2.02
		Total	1.35	1.69	1.34	(0.01)	2.28	0.59	7.86	6.17
	Preventative Maintenance	1	-	0.03	0.30	0.30	0.42	0.39	1.34	1.32
		2	-	0.03	0.23	0.23	0.33	0.31	1.04	1.01
		3	-	-	0.08	0.08	0.12	0.12	1.10	1.10
		4	-	0.03	0.17	0.17	0.39	0.36	1.46	1.44
		5	-	-	0.17	0.17	0.45	0.45	1.39	1.39
		Total	-	0.08	0.94	0.94	1.71	1.64	6.33	6.25
	Total	1	-	0.25	0.93	0.93	1.30	1.05	3.55	3.30
		2	2.70	2.95	0.86	(1.84)	1.21	(1.74)	2.99	0.04
		3	-	-	0.31	0.31	0.41	0.41	3.26	3.26
		4	-	0.25	0.55	0.55	1.29	1.04	4.72	4.47
		5	-	-	0.73	0.73	1.60	1.60	4.66	4.66
		Total	2.70	3.45	3.37	0.67	5.81	2.36	19.18	15.73
Information Services	Diagnostic	1	0.53	0.71	0.24	(0.29)	0.34	(0.37)	1.40	0.68
		2	1.13	1.31	0.38	(0.74)	0.48	(0.84)	1.23	(0.08)
		3	-	-	0.04	0.04	0.07	0.07	1.26	1.26
		4	-	0.19	0.21	0.21	0.45	0.26	1.89	1.71
		5	-	-	0.07	0.07	0.30	0.30	1.60	1.60
		Total	1.65	2.21	0.93	(0.72)	1.64	(0.57)	7.38	5.17
	Repair	1	0.14	0.19	0.14	0.00	0.26	0.07	1.27	1.08
		2	0.30	0.35	0.26	(0.04)	0.33	(0.02)	1.15	0.80
		3	-	-	0.03	0.03	0.05	0.05	1.22	1.22
		4	-	0.05	0.16	0.16	0.39	0.34	1.93	1.88
		5	-	-	0.05	0.05	0.22	0.22	1.60	1.60
		Total	0.44	0.59	0.64	0.20	1.25	0.66	7.18	6.59
	Preventative Maintenance	1	0.04	0.05	0.48	0.44	0.64	0.59	2.21	2.17
		2	0.08	0.09	1.26	1.19	1.75	1.66	2.63	2.55
		3	-	-	0.09	0.09	0.16	0.16	1.23	1.23
		4	-	0.01	0.24	0.24	0.55	0.54	1.93	1.92
		5	-	-	0.12	0.12	0.47	0.47	1.53	1.53
		Total	0.11	0.15	2.19	2.08	3.57	3.42	9.54	9.39
	Total	1	0.70	0.95	0.86	0.16	1.24	0.29	4.88	3.93
		2	1.50	1.75	1.91	0.41	2.55	0.80	5.02	3.27
		3	-	-	0.16	0.16	0.29	0.29	3.71	3.71
		4	-	0.25	0.61	0.61	1.39	1.14	5.75	5.50
		5	-	-	0.23	0.23	1.00	1.00	4.73	4.73
		Total	2.20	2.95	3.76	1.56	6.46	3.51	24.10	21.15
Total		1	0.70	1.30	1.89	1.19	2.68	1.38	9.46	8.16
		2	4.20	4.80	3.10	(1.10)	4.14	(0.66)	9.40	4.60
		3	-	-	0.51	0.51	0.75	0.75	8.34	8.34
		4	-	0.60	1.24	1.24	2.86	2.26	12.02	11.42
		5	-	-	1.01	1.01	2.73	2.73	10.87	10.87
		Total	4.90	6.70	7.74	2.84	13.15	6.45	50.11	43.41

Table 6-19: Staffing Gaps by Maintenance Activity by Region.

6.4.1 Staffing Development Alternatives

There are two broad classes of staffing development alternatives: increasing maintenance staff size, and increasing skills levels.

6.4.1.1 Staffing

To enhance resources within ODOT for staffing levels would require the addition of new FTE positions or the reassignment of existing FTE positions. As was demonstrated by the program options package this summer, it is feasible for ODOT to add new FTE positions. Under continued pressure from the state legislature to restrain hiring levels, however, it may be difficult for ODOT to continue this course in the future, especially at a rate to meet planned deployment levels.

Alternatively, ODOT may choose to reassign existing FTEs from other divisions into ITS maintenance, and then use contract support to address maintenance needs elsewhere. The advantage of juggling staff like this is that it may be easier to contract some ODOT functions than it would be to contract ITS maintenance. It is beyond the scope of this plan to identify other activities within ODOT that would be better candidates for contracting than ITS maintenance.

6.4.1.2 Training

Five different training concepts were identified as possibilities for addressing training gaps:

- contractual training, where training is included as a part of device procurement;
- remedial training, which is provided by the vendor under a separate contract after the device has been deployed;
- development training, which is provided by colleges or technical schools and may provide theoretical understanding that may be applicable to multiple devices;
- training from other agencies, which involves taking advantage of contractual training received at other transportation agencies when they receive a new device deployment; and
- internal training, where senior ODOT maintenance technicians train junior technicians on maintenance activities.

The main characteristics of each of these training methods are outlined in Table 6-20 and are described in detail in Appendix L.

6.4.1.3 Staff Enhancement Guidelines

Based on this evaluation, the following guidelines are recommended for staffing and training enhancement.

- ODOT should require a training component in all new device procurements. Contractual training should not only include operations training, but also maintenance. It is critical that multiple technicians who would be involved in

	Type of Training				
	Contractual	**Remedial**	**Development**	**Other Agencies**	**Internal**
Description	Obtain training through initial procurement contract	Obtain training from vendor after deployment	Take professional development or continuing education classes	Obtain training in conjunction with other agencies' deployments	ODOT trains itself
Areas of Training					
Field components	All	All (provided vendor is still in business)	Theoretical training	Some (based on deployment)	Some (based on experience)
IS components	Custom applications	Custom applications	All	Custom applications	All
Characteristics					
Schedule availability	Only on deployment	On demand	Subject to course providers	Subject to their deployment	Subject to staff availability
Duration of training	Short course	Short course	Short or long course	Short course	Short course
Cost per staff	Negligible	Negligible	Full	Some	Negligible
Vendor cost	Time	Time, travel, lodging	Included in tuition	Time, partially borne by other agency	None
Advantages	• Reduces vendor cost • Minimizes down time after installation	• If training is not included in procurement it may reduce deployment cost • Fills existing training gaps	• Theoretical training may apply to many devices • May assist in recruiting and retention	• Reduces ODOT cost	• No additional vendor or class cost • Builds upon unique local experience • Builds camaraderie • Ensures all staff are expanding skills
Disadvantages	• Training gap until legacy devices are replaced • Training gap if people leave ODOT	• Vendor cost is high • Device-specific training: little "bang for the buck"	• Time to acquire theoretical training may be significant • May hurt in retention	• Subject to schedules and manufacturers selected by other agencies	• Useless without existing skills base • Requires ODOT staff to be available to teach

Table 6-20: Training Alternatives.

maintenance attend, so that there is no single point-of-failure. The maintenance training should include demonstrations of recommended preventative maintenance activities, and instructions on basic diagnostics and repairs.

- ODOT should strive to have basic troubleshooting skills on all ITS devices in-house. As ODOT's diagnostic capability increases, this will reduce the amount of time and expense that must be committed to device repair.

- ODOT should have extensive repair capabilities in-house on high-priority devices. To maintain leverage with contractors as well as to minimize response time, ODOT should preserve the ability to perform all diagnostic and most repair functions on its high-priority devices.

- ODOT should minimize the use of remedial training. Remedial training will be more expensive and less convenient than cross-training and will typically be applicable to only a specific manufacturer of a specific device. Based on the analysis of skills gaps, Table 6-21 shows that for only two devices – weigh-in-motion systems and fiber optics communication systems – would it be advisable for ODOT consider relying on remedial training.

- ODOT should pursue greater cross-training to improve overall staff skill levels. Surveys conducted throughout ODOT reveal that there is, in-house, basic knowledge adequate for troubleshooting on nearly every ITS device ODOT has deployed. However, there has not been adequate knowledge dissemination across regions to improve the overall skills base. Improving the overall level of training will, at a minimum, give ODOT leverage in negotiating contracts with vendors. It would also help to improve the efficiency at which ODOT performs maintenance activities.

- ODOT should allocate time for staff to participate in training activities. The benefits of training staff on ITS maintenance (e.g. reducing device down-time, improving staff morale, increasing device longevity, decreasing maintenance cost) are significant, and should not be ignored in maintenance planning. These training activities must be planned to maximize the benefit of cross-training workshops and to ensure that they may occur when ITS maintenance needs are less time-sensitive.

- Staff should have the opportunity to use training. Staff will perceive training programs to be a waste of time unless they have the opportunity to apply their training to real-world maintenance needs.

6.4.2 Contracting Alternatives

As an alternative or supplement to enhancing and developing ODOT's staffing resources, ODOT may decide to utilize contracts to fulfill ITS maintenance needs. The trend for using contractors to perform highway maintenance activities is on the increase. Table 6-22 lists those factors most frequently cited in a survey of transportation agencies as reasons which contracting is used. Based on anecdotal evidence, ITS maintenance is also following this trend. Table 6-23

	No Training Necessary	Cross-Training	Training by Procurement	Remedial Training
Automatic Traffic Recorders	✓			
Speed Zone Monitoring Stations	✓			
Closed-Circuit Television (CCTV) Surveillance		✓		
Video Detectors			✓	
Road and Weather Information System (RWIS)		✓		
Travel Time Estimation			✓	
Automatic Vehicle Location (AVL)			✓	
Traffic Signals	✓			
Ramp Metering	✓			
Emergency Signal Preemption	✓			
Transit Signal Prioritization	✓			
Advanced Traffic Management System		✓		
Callboxes	✓			
Cellular Call-In	✓			
Regional Incident Detection System	✓			
Intersection-Based Incident Detection System	✓			
Computer-Aided Dispatch		✓		
Incident Response Vehicles		✓		
Pre-planned Detour Routes	✓			
Hazardous Material Response	✓			
Alphanumeric Paging	✓			
Highway Travel Conditions Reporting System	✓			
800-number Information	✓			
Internet Access	✓			
Kiosks			✓	
Icy Bridge Warning CMS	✓			
Tunnel Lane Closure CMS	✓			
Radio-Controlled Snow Zone CMS	✓			
Telephone-Activated Snow Zone CMS	✓			
Oversize Vehicle Restriction CMS	✓			
Permanent Variable Message Signs		✓		
Portable Variable Message Signs		✓		
Highway Advisory Radio (HAR)	✓			
Icy Bridge Detectors		✓		
Oversize Load Detectors		✓		
Variable Speed Limit Systems		✓		
Queue Detection System	✓			
Weigh-in-Motion (WIM) Systems		✓		✓
Downhill Speed Advisory Systems		✓		
Fiber Optic Networks				✓
Radio Communications	✓			
Maintenance Coordination	✓			

Table 6-21: Training Recommendations for Closing Skills Gaps.

lists some agencies that are relying almost exclusively on contracting for maintenance of ITS deployments.

Reason	Respondents	
	No.	%
Limitations on in-house staff	51	96%
The need for specialized equipment	50	94%
The need for specialized personnel	44	83%
To cover peak work loads	42	79%
To obtain services at lower cost	38	72%
Executive policy	37	70%
Emergency work	35	66%
To improve responsiveness	31	58%
Legal restrictions on the amount of work performed by agency forces	16	30%
Legal restrictions on contracting	16	30%
Employee contract restrictions	11	21%

Table 6-22: Top Reasons for Contracting Highway Maintenance.
(Source: 34)

Agency / Facility	Location	Types of Devices
Florida DOT (35, 36)	Orlando Tampa (Sunshine Skyway Bridge)	CCTV, VMS, loop detectors CCTV, wind sensors, callboxes
Indiana DOT (37)	Indianapolis	*CCTV, VMS, detectors
Kentucky Transportation Cabinet (38, 39, 40)	Statewide Cincinnati Cumberland Gap Tunnel	RWIS CCTV, VMS, detectors CCTV, VMS, CMS
Michigan DOT (41)	Detroit	CCTV, VMS, detectors
Missouri DOT (42)	St. Louis	*CCTV, VMS, microwave detectors
New York State DOT (43, 44)	Buffalo Long Island	CCTV, VMS, HAR CCTV, VMS, ramp meters, traffic signals, loop detectors
North Carolina DOT (45)	Greensboro	CCTV, VMS
Pennsylvania DOT (46, 47)	Philadelphia Scranton/Wilkes-Barre	CCTV, VMS, ramp meters, loop detectors CCTV, VMS
Pennsylvania Turnpike (48)	Systemwide	CCTV, VMS, HAR, queue detection stations, electronic toll collection
Wisconsin DOT (49)	Milwaukee	CCTV, VMS, ramp meters, loop detectors, microwave detectors

* - Planned deployment

Table 6-23: Selected Agencies Relying on Contracting for ITS Maintenance.

	Enhance Existing Staff	Contracting
Advantages	• Promotes ownership of system, which may improve maintenance quality and responsiveness • Potentially less expensive for frequent maintenance activities • Promotes organizational autonomy	• Politically simpler than trying to get additional FTEs • Potentially less expensive to contract infrequent or high-skill maintenance activities than to develop in-house expertise • Reduces need to continually train staff as new devices are implemented • Expedites acquisition of spare parts
Disadvantages	• Staff expansion may be constrained by legislation • Staff expansion requires additional support infrastructure (i.e. building space, etc.) • Difficult to cost-effectively acquire additional staff • Staff turnover can mean loss of skills base • Need to continually train staff as new devices or technologies are implemented • Inefficient to have many staff trained on infrequent maintenance problems	• Hard to develop sense of ownership for new contractor relationship • Difficult to obtain for some regions and devices • 24-hour, 7-day-a-week support may be prohibitively expensive • Quality and responsiveness of contractor maintenance is somewhat out of ODOT control • Hard to control costs

Table 6-24: Advantages and Disadvantages of Contracting for Maintenance

Table 6-24 summarizes some of the advantages and disadvantages of contracting for maintenance relative to enhancing and developing in-house capabilities. The trend of agencies toward using contracting is motivated primarily by the difficulty of hiring additional FTEs or giving staff adequate training. Many agencies have used contracts only out of necessity, however, and would rather use in-house support because of the perceived value of staff having a sense of ownership.

6.4.2.1 Contracting Methods

If ODOT elects to use contracting for some or all ITS maintenance activities, it is important to decide which contracting methods would best meet their needs. ODOT may elect to use traditional contracting methods or more innovative contracting practices.

Traditional Contracting. According to the 1997 Oregon Revised Statutes (ORS) 279.029, after a decision has been made that a contract is to be awarded, the contract is awarded to the lowest responsible bidder. The lowest responsible bidder is further defined as the lowest price, responsive bidder who has complied with all prescribed public bidding procedures and requirements, and who is not disqualified for any of the following reasons specified in ORS 279.037[6]:

- it does not have sufficient financial ability to perform the contract,
- it does not have equipment available to perform the contract,
- it does not have key personnel available of sufficient experience to perform the contract, or
- it has repeatedly breached contractual obligations to public and private contracting agencies (50).

The purpose of using a low-bid method for procuring maintenance has the benefit of encouraging competition. ORS 279.005 states, however, that price does not have to be the only grounds of comparison for ensuring competition in a bidding process, but that performance evaluations and evaluations of capabilities may be taken into consideration as well (50).

Assuming that price is the only criteria that ODOT uses for selecting a contractor, there are many potential types of low-bid contracts that may be pursued (51):

- fixed-price contracts, which establish a ceiling price for all prescribed maintenance activities;
- cost-reimbursement contracts, which pay for allowable incurred costs up to an estimated cap, which may be exceeded on the authority of the contracting agency;
- incentive contracts, which use various types of incentives or disincentives to motivate the contractor to perform in a way that may not be likely or possible under a fixed-price contract;
- indefinite-delivery contracts, which limit the agency's obligation to a minimum amount of maintenance as specified in the contract but use work orders to obtain services on an "as-needed" basis; and
- time-and-materials (T&M) contracts, which provide for acquiring service on the basis of direct labor hours at specific hourly rates (including overhead costs) and materials at cost.

Table 6-25 compares how these contracts may be structured for various types of ITS maintenance activities and highlights some of their relative strengths and weaknesses.

[6] ORS 279.015 allows several exemptions from the competitive bidding process (described in ORS 279.005 and ORS 279.007), including but not limited to:

- the contract value is less than $5,000;
- such an exemption is unlikely to encourage favoritism in the awarding of contracts or substantially diminish competition for contracts;
- using the exemption for a contract award will result in substantial cost savings to the public agency; or
- emergency conditions require prompt execution of the contract, and the contract value is less than $50,000.

ORS 366.445 specifies an additional exemption for ODOT to repair "at once any state highway which has been damaged by slides, flood or other catastrophe" such that it must be closed to traffic. This could include, for example, an overhead VMS structure falling onto a roadway.

	Fixed-price	Cost-reimbursement	Incentive	Indefinite-delivery	Time-and-materials
Description	Establish a ceiling price for all prescribed maintenance activities	Pay for costs up to an estimated cap, which may be exceeded on the authority of the contracting agency	Use incentives or disincentives to motivate the contractor	Obtain services on an "as-needed" basis	Acquire services based on specific hourly labor rates (with overhead) and materials at cost.
Example 1: VMS maintenance	Perform preventative and repair maintenance on VMS statewide for $900,000 per year	Pay contractor based on incurred costs to repair VMS (spare parts, labor)	Contractor pays $5,000 / day penalty for an urban VMS being down	Pay contractor only when VMS breaks $1,000 per visit (pre-determined in contract)	VMS technician bills at $50 / hour (including overhead) for repair activities
Example 2: RWIS server maintenance	Perform preventative and repair maintenance on RWIS regional servers for $10,000 per year	Pay contractor for each visit that is required and any hardware replacement costs	Contractor gets $500 / day for number of days where server operates acceptably	Call technician whenever server isn't functioning properly	Information technology specialist bills at $100 / hour (including overhead) for repair visits
Advantages	• Agency has fixed budget commitment • Good for preventative maintenance	• Works well when uncertainties in cost estimates do not allow for a fixed-price contract	• Rewards contractor for exceptional service	• Good when frequency of repair activity is unknown	• Good when it is difficult to accurately estimate the extent or duration of the work
Disadvantages	• Not good for repair maintenance unless frequency and severity of repairs can be reasonably predicted	• Requires contractor to have adequate accounting system • Requires appropriate monitoring to provide reasonable assurance that there are efficient cost controls	• Difficult to quantify incentives appropriate for ITS maintenance	• Different service calls may require different amounts of repair effort • Not appropriate for preventative maintenance	• Requires appropriate monitoring, because there is no incentive for labor efficiency

Table 6-25: Comparison of Traditional Contracting Methods.

In contracts specifically focused on maintenance activities, ORS 646.265 and ORS 646.267 define three broad classes of contracts that the State of Oregon will allow:

- maintenance agreements, which are contracts of limited duration that provide for scheduled (i.e. preventative) maintenance only;
- service contracts, which are contracts to perform "the repair, replacement or maintenance of property for operational or structural failure due to a defect in materials, workmanship or normal wear and tear" or due to damage "resulting from lightning, power surges or accidental damage from handling"; and
- warranties, which are given solely by the manufacturer as a part of a purchase agreement, without being negotiated as a part of the sale of the product, to cover defective parts and mechanical or electrical breakdowns (50).

These contracts would be able to, if desired by ODOT, cover ITS maintenance from the time a device is put into the field until it is replaced. On a preliminary analysis, there does not appear to be restrictions that these maintenance agreements and service contracts must be developed independently of each other.

Innovative Contracting. ORS 279.015 subsection (6)(a) calls for the agency director to, where appropriate, "direct the use of alternative contracting and purchasing practices that take account of market realities and modern or innovative contracting and purchasing methods." (50) Many innovative contracting methods have been developed in associated with highway construction projects as well as some ITS deployments. Some of the more commonly used innovative contracting methods for highway construction projects include the following.

- A+B Bidding (also known as cost plus time). A low-bidder is selected based on a combination of the contract bid items (A) and the time (B) needed to complete the project (52). Because the time frame involved in ITS maintenance activities is short, this method appears to have little applicability.

- Design-Build. According to the Utah Technology Transfer Center, design-build (DB) is a process "by which a single entity provides both the design and construction through the use of a single contract between the agency and the contractor" (53). By itself, DB has little applicability to ITS maintenance. Variations of DB, such as design-build-maintain (DBM) or design-build-warrant (DBW), may have some applicability for ITS maintenance after vendor warranties on field components have expired. Design-build contracts would have no applicability for existing ITS devices.

- Lane Rental. This type of contract assesses the contractor daily or hourly "rental fees" for each lane, shoulder or combination of lanes and shoulders that are taken out of service to perform contracted activities (54). This provides the contractor with an incentive to minimize the disruption that maintenance activities may cause on traffic flow. ODOT has used this method for two reconstruction projects on U.S. 26 in Portland (55). This type of contract may have applicability for maintenance activities which require lane closures, such as some overhead VMS maintenance, some CCTV maintenance activities, and replacement of loop detectors. It is important to note, however, that the time involved in lane closures for ITS maintenance will be minimal compared to that for traditional highway construction projects.

- Warranty. For highway projects, these are generally provided for a two- to five-year period after construction and are limited to items over which the contractor has full control (56). The purpose of this contract is to force the contractor to stand behind its work. A warranty may have applicability for repair of ITS field devices to a certain extent. For ITS devices, however, a warranty of this duration on device maintenance would not be practical; a shorter warranty, such as six months to one year, may be more appropriate.

- Job Order Contracting. Contractors will bid by submitting on a proposed contract with a factor that includes overhead, profit, and similar costs. The factor is multiplied by unit prices developed by the agency in order to determine the total contract amount (57). This is readily applicable to highway construction projects where many unit prices have been clearly established. Because reliable unit prices have not been developed for ITS maintenance, this would not appear to be viable at this time.

- Life Cycle Cost Procurement. The state of Missouri has used this approach for selecting bridge seismic retrofit systems, so that initial fabrication costs are included along with installation, inspection and maintenance costs (58). This type of procurement has potential application for new deployments in ODOT's ITS infrastructure, and would require the vendor to stand behind its product. This would not be applicable for legacy ITS devices.

6.4.2.2 Contracting Activities

ODOT must also decide which, if any, portions of its ITS maintenance activities should be contracted. There are several different classes of maintenance activities that may be contracted either independently of one another or in combination. These alternatives include the following:

- preventative maintenance, which may also be called a maintenance agreement;
- repair maintenance, which may also be called a service contract;
- low-level maintenance, which refers to lower skill level maintenance activities;
- high-level maintenance, where more sophisticated or specialized maintenance activities are contracted; and
- select devices, where certain devices are contracted for end-to-end maintenance.

These alternatives are summarized in Table 6-26, and are discussed in greater detail in Appendix M.

6.4.2.3 Contract Guidelines

When contract maintenance is used, the following guidelines should be kept in mind.

	Staffing Alternatives			Training Alternatives	
Name	**Preventative**	**Repair**	**Low-Level**	**High-Level**	**Select Devices**
Description	Use contractors to perform preventative maintenance	Use contractors for addressing repair or response maintenance	Use contractors for low skill-level maintenance activities	Use contractors for high skill-level maintenance activities	Use contractors for all maintenance (preventative and repair) on select devices
Advantages	• Ensures preventative maintenance will not be neglected • Potential for greater competition in more regions and on more devices	• Provides guarantee for response time • Eliminates need for ODOT to acquire expensive equipment for infrequent repairs	• Potential for greater competition in more regions and on more devices • Maintenance staff may continue to gain expertise	• Potential for savings in training and salary costs for staff • Consistent with organizational philosophy	• Allows ODOT to focus its maintenance activities on areas where its skills are strongest • Can contract for devices only where it may be cost-effective • Compatible with procurement schedules
Disadvantages	• Quality control is hard to enforce • Contractor will have no incentive to make repairs not in contract • Requires larger deployment to be cost-effective for vendors	• 24-hour, 7-day support is expensive • Lack of perceived ownership may limit willingness to make off-hour repairs	• Response time suffers, because these tasks may be handled more quickly by ODOT • May require multiple repair visits to restore operations	• Few contractors would be able to provide high-level maintenance in rural regions • Limits career path for field technicians	• Ties ODOT to vendor • Does not develop in-house expertise on these devices • Requires larger deployment to be cost-effective for vendors

Table 6-26: Contracting Alternatives.

- Maintenance contracts should provide performance specifications for maintenance. The contract should provide guidelines for emergency versus non-emergency repairs, with appropriate response times for each type. The contract should be very clear on how the contractor is notified of problems, how response time is defined, and how repairs are tested to ensure that they are adequate. In addition, the stringency of performance specifications should affect the decision about whether or not to contract. A Transportation Research Board report on maintenance contracting recommends that activities requiring fairly short response times and less than full-time contractor commitments should normally not be contracted (34).

- Contract maintenance has a mixed track record for responsiveness to repair needs. Simply specifying a response time in the contract does not guarantee contractor responsiveness. Moreover, depending upon how contracts are administered, response time may not be enforceable. At one agency contacted in this study, the maintenance contract serves the needs of the traffic division, but the contract was administered through the construction division because they have more experience with contract administration. The construction division has not been willing to enforce response time provisions to the level that the traffic division would like (46). Other agencies have had more favorable contractor experiences.

- The vendor may not always be the best party to perform contract maintenance. There are several advantages to retaining the original vendor for contract maintenance, such as expedience in acquiring spare parts, greater device-specific knowledge and good familiarity with local applications. If a vendor uses some non-standardized components in its devices, however, such an arrangement may leave ODOT vulnerable to contract price escalation.

- Multiple, concurrent contracts may lead to “finger pointing”. In some agencies where multiple concurrent contracts have been issued for a specific region, contractors may tend to blame each other for device malfunctions (49). This may increase response time and decrease system performance.

- Maintenance contracts should be fairly short in duration, with renewal options. In order to avoid getting saddled with an ineffective contractor for an extended period of time, ODOT should not allow maintenance contracts to be too lengthy in duration. This is especially appropriate in ITS maintenance, where technology upgrades may significantly affect maintenance needs. In conversations with other agencies, most maintenance contracts seem to run between one and two years. In order to reward contractor performance, however, ODOT should seek to include contract renewal options. This will encourage contractors to develop a long-term relationship with the agency, and will increase the contractor’s sense of ownership.

- Cost of specialized equipment should be considered in contracting. If there are significant equipment costs involved in a maintenance contract, such as fiber optic test equipment or bucket trucks, a short-term contract may end up discouraging bid competition (34). One alternative that ODOT may consider, when equipment costs are significant, is to provide the specialized equipment to whichever contractor has been selected. Alternatively, ODOT may elect to develop a longer term contract, which would allow the contractor to fully depreciate the cost of the specialized equipment.

- Price contracts may hinder developing long-term maintenance relationships. In some instances where the agency is required to select the lowest price bid on a contract, there have been some bad experiences with underqualified entities winning maintenance contracts and satisfactory entities losing contracts.

- Contracts should be administered in a way that does not restrain competition. Options include cost competition between ODOT and a contractor on given maintenance activities, or subdividing a maintenance activity (such as preventative maintenance on VMS) between multiple contractors (34).

- A new maintenance contractor may require some in-house expertise. New contractors, especially if they did not perform the initial system installation, may be unfamiliar with many specific aspects about the ITS infrastructure, such as communications interfaces. Some in-house expertise may be necessary to provide a new contractor with enough initial knowledge to be able to effectively maintain the system.

6.4.3 Recommendations

In order to successfully meet its ITS maintenance needs, ODOT must select some combination of training and contracting alternatives. Table 6-27 provides some recommendations for where ODOT should use in-house expertise versus using contract support for maintenance. There were three primary determinants for whether or not maintenance activities should be contracted out.

- Is a particular device especially critical to how ODOT plans to fulfill its mission to the traveling public? The more critical a device is to ODOT's daily operations, then the better it is to have resources in-house available to minimize response time.

- Does a particular device have a broad enough deployment around the state to make a contract economically viable? As was shown in Table 6-23, it is not uncommon for a metropolitan area within a state Department of Transportation to decide to contract for ITS maintenance independent of other regions in the state. While ODOT may try that with deployments in Region 1, this would likely hinder the ability of ODOT to contract much other maintenance around the state. Therefore, ODOT should seek to – where possible – use statewide maintenance contracts for activities that are deemed appropriate for contracting.

- Could clear lines of responsibility between ODOT and the contractor be readily established? The absence of a clear demarcation between where the contractor's responsibility ends and ODOT's responsibility begins creates the potential for conflict and finger-pointing during times when critical repairs are needed.

		Existing		STIP		Strategic	
Device	**Activity**	**PM**	**Rep**	**PM**	**Rep**	**PM**	**Rep**
Automatic Traffic Recorders	All						
Speed Zone Monitoring Stations	All						
Closed-Circuit Television (CCTV)	Prev. Maint.					C	C
	Repair Maint.						
Video Detectors	All	W	W	W	W		
Road and Weather Information System (RWIS)	Field Units					C	C
	Servers						
Travel Time Estimation	All	W	W	W	W	C	C
Automatic Vehicle Location (AVL)	Repair of Sensors					C	C
	All other maint.						
Traffic Signals	All						
Ramp Metering	All						
Emergency Signal Preemption	All						
Transit Signal Prioritization	All						
Advanced Traffic Management System	All						
Callboxes	All						
Cellular Call-In	All	no maintenance necessary					
Regional Incident Detection System	All						
Intersection-Based Incident Detection System	All						
Computer-Aided Dispatch	All						
Incident Response Vehicles	All						
Pre-planned Detour Routes	All						
Hazardous Material Response	All						
Alphanumeric Paging	All						
Highway Travel Conditions Reporting System	All						
800-number Information	All						
Internet Access	All						
Kiosks	All	W	W	W	W	C	C
Icy Bridge Warning CMS	All						
Tunnel Lane Closure CMS	All						
Radio-Controlled Snow Zone CMS	All						
Telephone-Activated Snow Zone CMS	All						
Oversize Vehicle Restriction CMS	All						
Permanent Variable Message Signs (VMS)	Prev. Maint.					C	C
	Repair						
Portable Variable Message Signs (VMS)	All					C	C
Highway Advisory Radio (HAR)	All						
Icy Bridge Detectors	Field Units					C	C
Oversize Load Detectors	Field Units					C	C
Variable Speed Limit Systems	Field Units					C	C
Queue Detection System	All						
Weigh-in-Motion (WIM) Stations	All	C	C	C	C	C	C
Downhill Speed Advisory Systems	WIM components	C	C	C	C	C	C
	PM - VMS					C	C
	Repair - VMS						
Fiber Optic Networks	All	C	C	C	C	C	C
Radio Communications	All						
Maintenance Coordination	All						

(1) Responsibility may change hands in the future.

LEGEND
- (blank) - In-house (default)
- (grey) - In-house, currently outside of ITS maintenance
- W - Warranty coverage
- C - Contract coverage

Table 6-27: Contracting Recommendations by Device.

On that basis, the following devices were determined as most appropriate to contract.

- Weigh-in-motion (WIM) systems. These devices are ranked as the lowest repair priority among ITS devices. Moreover, contract maintenance has already been used successfully for these devices. The WIM component of the downhill speed advisory systems would also lend itself to contract maintenance.

- Kiosks. Contracting for kiosks would be favorable for many reasons, including the need for frequent preventative maintenance, the lower technical skill involved in maintenance, and the number of kiosks deployed statewide. While kiosks would be a high visibility item, they would not be the only way in which travelers in Oregon may receive pre-trip information, and would likely serve smaller volumes of user traffic than either the Internet or the 800-number.

- Preventative maintenance on CCTV and permanent VMS. The wide deployment of these devices favors contract maintenance. Due to the mission-critical nature of these systems, however, it is recommended that ODOT continue to do repair maintenance in-house.

- RWIS field units. Broader statewide distribution of RWIS systems should allow a contractor to economically perform preventative and repair maintenance on these devices. It is recommended that ODOT continue to maintain RWIS regional and statewide servers because of their integration in ODOT's wide-area network. On the same basis, the weather sensors and field units for icy bridge detectors, oversize load detectors and variable speed limit systems would be recommended for contracting as well. The field devices for these latter systems would have a higher priority than simple RWIS stations, however, because of the potential for liability exposure when they are non-operational in critical situations.

- Travel time estimation. This system does not seem to be as critical to traffic management in Region 1 as other ITS devices at this time; this may change once an operational system is deployed. Nevertheless, because this system has not been deployed, it may be an excellent candidate for a design-build-maintain procurement contract.

- Automatic vehicle location in-vehicle sensors. Because of the wide number of maintenance vehicles that will eventually have AVL equipment, this could be a cost-effective contracting arrangement.

- All maintenance activities on portable VMS. Contracting is only recommended under the Strategic Plan, when deployment of portable VMS statewide is planned to reach over 400. The number of portable VMS would likely allow individual units to be out of service for a couple of days in order to have maintenance performed, so response time may not be as critical.

- Fiber optics. Fiber optic communications is clearly an ITS support element that is critical to ITS operational success, especially in Region 1. However, the cost of test equipment for performing repair fiber optic maintenance may exceed $50,000 (6), and the frequency of maintenance tasks is limited. Unless ODOT significantly increases its fiber optics infrastructure, ODOT would likely have difficulty in recovering the cost of the test equipment. It should be emphasized, however, that ODOT does have adequate training and test equipment to be able to perform some localized fiber optics maintenance tasks.

Maintenance on all other ITS devices is recommended to be performed by ODOT staff. In order for ODOT to successfully maintain these items, it is critical that the training gaps mentioned previously in this chapter be addressed through cross-training.