7 MAINTENANCE BUDGET

A final critical element in the maintenance plan is the development of a comprehensive maintenance budget. The purpose of this budget is to quantify how much money should be devoted to ITS maintenance activities, not necessarily how much money is currently being spent on these activities throughout ODOT. The budget is developed at both regional and device levels by considering individually the following cost components:

- staffing,
- vendor/contractor costs,
- training,
- device replacement,
- spare parts, and
- test/specialized equipment.

After stating some general assumptions applied to developing the maintenance budget, this chapter will describe assumptions specific to each of these cost components. The chapter will conclude with some summary tables of a comprehensive maintenance budget for three forecast years – existing, STIP and Strategic Plan build-out – and recommendations for further courses of action.

7.1 General Assumptions

Given the lack of available data on actual, historical maintenance costs, developing a comprehensive statewide ITS maintenance budget requires several simplifying assumptions. These assumptions are described as follows.

- Indirect costs are excluded. There are many indirect costs associated with ITS maintenance activities, such as utilities to TOCs and vehicle costs for servicing field components. It is assumed that these costs would be included elsewhere in ODOT's budget.

- Operations costs are excluded. The cost of operating ITS devices, including the cost of supplying power and telephone service, is excluded from the budget. Salary costs for operators at the TOCs are also excluded. These costs would be encumbered elsewhere in ODOT's budget.

- All budgets are developed in current-year dollars. In order to simplify the analysis, no consideration will be made for the effect of salary inflation, change in costs for spare parts and device replacement, or other instances where the price of a resource may change over time.

- Each group of devices is considered homogeneous from a cost perspective. Conversations with ODOT stakeholders have revealed that there are variations in maintenance needs between manufacturers as well as deployment locations. It is

assumed that improvements in manufacturing technology and maintenance practices will tend to dampen these variations over time.

- Costs reflect contracting recommendations described in Section 6.4. Different decisions on whether or not to contract specific maintenance activities may have significant effects on the maintenance budget.

7.2 Staffing

The most significant component of ODOT's maintenance budget will be the cost of personnel. In addition to the assumptions presented in Chapter 6 when estimates of staffing resource needs were developed, the following assumptions have been applied.

- Labor rates. Monthly salary estimates for ODOT staff classifications were estimated from tables published by the State of Oregon's Department of Administrative Services (DAS). These tables offer several cost levels for each classification (59, 60, 61, 62, 63). In order to provide a worst case scenario, it was assumed that all work done at each classification level would be charged at the highest labor cost for that classification. Table 7-1 shows the resulting estimates for ODOT employee salaries.

Position	Abbrev	FTE	Monthly
Support Coordinator / IS-Diag	SC-I-D	42,000	3,500
Support Coordinator / IS-Repair	SC-I-R	42,000	3,500
Support Coordinator / IS-Preventative Maintenance	SC-I-PM	42,000	3,500
Support Coordinator / Elec-Diag	SC-E-D	42,000	3,500
Support Coordinator / Elec-Repair	SC-E-R	42,000	3,500
Support Coordinator / Elec-Preventative Maintenance	SC-E-PM	42,000	3,500
Support Coordinator / Program Technician	SC-P	42,000	3,500
Info Services - Kiosk Specialist	IS-K	30,000	2,500
Info Services 5 - Radio Technician	IS-5R	51,180	4,265
Info Services 5 - Networks / Servers	IS-5N	51,180	4,265
Info Services 5 - Software	IS-5S	51,180	4,265
Info Services 6 - Radio Technician	IS-6R	54,780	4,565
Info Services 6 - Networks / Servers	IS-6N	54,780	4,565
Info Services 6 - Software	IS-6S	54,780	4,565
Info Services 7 - Networks / Servers	IS-7N	60,708	5,059
Info Services 7 - Software	IS-7S	60,708	5,059
Fiber Optic Technician	IS-F	60,000	5,000
Electrician	ELEC	46,392	3,866
Traffic Signal Technician 3	TS-3	45,024	3,752

Table 7-1: Assumed Monthly Salary Rates for ODOT Staff.

(Sources: 59, 60, 61, 62, 63)

- Fringe benefits. Based on discussions with ODOT staff, it was assumed that 70 percent of salary would represent an appropriate estimate of employee fringe benefits and support costs.

- Overtime compensation. ORS 279.340 provides for state employees to be paid at a premium for work in excess of 40 hours in a given week (50). For simplicity, it is assumed that no work would be performed which would require overtime compensation rates.

Table 7-2 provides estimates of annual maintenance costs for ODOT personnel by region. Costs for centralized maintenance support employees based in Salem, such as TSSU and centralized IS support, are included in the region their maintenance activities occur.

7.3 Vendor/Contractor Costs

For the purposes of estimating vendor and contractor costs, a distinction is made between maintenance provided by vendors and maintenance provided by contractors. Vendor maintenance refers to maintenance activities which, due to the specialized nature of a component, are performed exclusively by the vendor or supplier. Examples of this include repairs to automatic vehicle location (AVL) in-vehicle units, emergency call boxes, and similar "black-box" components. Estimating vendor maintenance costs is complicated by the following factors.

- The cost of repairs for a given black box component may vary considerably from one repair to another. In some cases, the cost of repair may be deemed to be more expensive than replacement, so the vendor may elect simply to replace the defective component.

- Vendors may change over time. Vendors may offer differing degrees of warranty coverage, affecting the vendor maintenance costs that need to be borne by ODOT. Some vendors may offer lifetime warranties for certain components, which would reduce ODOT's maintenance costs. In some cases, warranty coverage may also change when one vendor is bought out by another.

- According to anecdotal evidence, vendor maintenance is required infrequently for successful device operations, such as in the cases of the AVL in-vehicle units and emergency call boxes described above.

	Region					State
	1	2	3	4	5	Total
Existing	$ 140,355	$ 243,117	$ 23,282	$ 92,196	$ 47,694	$ 546,644
Existing + STIP	$ 171,439	$ 323,427	$ 37,120	$ 193,526	$ 175,709	$ 901,221
Existing + Strategic Plan	$ 203,650	$ 273,676	$ 112,878	$ 145,538	$ 170,312	$ 906,054

Table 7-2: Estimated Personnel Costs by Region.

Contractor Support	ODOT Salary	Labor Premium	Overhead	Monthly Cost
Support Coordinator	3,500	10%	1.50	5,775
Information Services - Kiosks	2,500	10%	1.50	4,125
Information Services Level 5	4,265	10%	1.50	7,037
Information Services Level 6	4,565	10%	1.50	7,532
Information Services Level 7	5,059	10%	1.50	8,347
Information Services - Fiber Optics	5,000	10%	1.50	8,250
Electrician	3,866	10%	1.50	6,379
Traffic Signal Technician 3	3,752	10%	1.50	6,191

Table 7-3: Assumed Monthly Salary Rates for Contractors.

For these reasons, explicit vendor maintenance costs are excluded from the maintenance budget.

Contract maintenance includes maintenance activities that do not have to be exclusively performed by the vendor, although the vendor may perform them if they are selected in a competitive bidding process. As was discussed last chapter, there is considerable variety in the types of contracts that may be used, each with different cost implications. For simplicity, the following assumptions have been imposed over all contractual maintenance included in ODOT's ITS maintenance program.

- Contract structure. It is assumed that contractors would bill on a time-and-materials basis. The cost of materials, such as replacement and spare parts, will be considered in sections 7.5 and 7.6. The overhead rate is assumed to be 150 percent of salary.

- Labor rates. It is assumed, for the purpose of estimating maintenance costs, that the maintenance contractor would have similar staffing classifications as ODOT. Hourly rates for contract maintenance are assumed to be 10 percent higher than comparable ODOT rates. Table 7-3 shows estimates of assumed labor rates for contract maintenance staff.

- Overtime. Similar to ODOT personnel costs, no overtime compensation is assumed for contractors, although contractors may be eligible for it[7].

- Travel time. It is assumed that ODOT would pay for a certain portion of travel time – up to one hour each way – in any maintenance contract. Any travel time in addition to

[7] According to ORS 279.334, contractors are eligible for overtime pay:
- for all overtime in excess of eight hours a day or 40 hours in any one week when the work week is five consecutive days, Monday through Friday; or
- for all overtime in excess of 10 hours a day or 40 hours in any one week when the work week is four consecutive days, Monday through Friday; and
- for all work performed on Saturday and on recognized legal holidays (50).

	Region					State
	1	2	3	4	5	Total
Existing	$ -	$ 6,484	$ 12,967	$ -	$ 20,754	$ 40,205
Existing + STIP	$ 40,528	$ 9,726	$ 17,512	$ 12,967	$ 20,754	$ 101,487
Existing + Strategic Plan	$ 585,181	$ 425,714	$ 437,911	$ 474,445	$ 454,975	$2,378,226

Table 7-4: Estimated Contractor Costs by Region.

this would be incorporated in the contractor's overhead rate. This would provide a contractor with the incentive to put staff in close proximity to field devices, which would improve response time.

- Work efficiency. It is assumed that contractors will not be able to perform work more efficiently than ODOT staff who have been adequately trained in similar maintenance activities.

Table 7-4 presents estimates of vendor costs by region for each of the forecast years.

7.4 Training

The previous chapter discussed training and skills deficiencies within ODOT, identifying areas where training gaps need to be closed. Because ODOT has one or more staff members who are experts in each deployed device, it was determined that a comprehensive and continual cross-training program could resolve most training deficiencies within ODOT. Two areas were identified where ODOT may yield benefit from relying on paid training provided outside of the organization. In both of these areas, ODOT has some maintenance experience – primarily through TSSU – but more training would be desirable.

- Commercial vehicle applications. Because maintenance on ODOT's weigh-in-motion systems is currently performed via a vendor contract, ODOT does not have significant day-to-day experience with the maintenance requirements of these systems. Remedial training may be advisable, even though it has been recommended that ODOT continue to use a contract relationship for this maintenance, in order for ODOT to protect itself against potential complications with the existing contractor.

- Fiber optic maintenance. ODOT currently has some fiber optic maintenance abilities within TSSU. Additional training – along with supporting test equipment – would allow ODOT to be more responsive to instances when critical communications links are damaged. Due to the cost of test equipment, however, maintenance of fiber optics communications networks has been recommended as an activity for contracting.

Cost estimates for these two types of training are shown in Figure 7-1. These are provided for illustrative purposes; it is recommended that ODOT does not enroll technicians in these classes if it plans to use contracting for maintenance of these devices. If ODOT pursues a continual program of cross-training its own staff, these training efforts should be a one-time

Commercial vehicle applications		Fiber optic training	
Number of days	2	Number of students	3
Cost per hour	$125	Cost per class*	$1,195
Lodging (per night)	$75	ETA certification	$150
Travel costs	$1,000	Lodging (per night)	$75
Total Training Cost	$3,150	Total Training Cost	$4,935

Notes:
ETA - Electronics Technicians Association
* - Cost is estimate for one company which conducts courses in Portland. Other companies offer training in other states or video tape training.

Figure 7-1: Remedial Training Costs.

(Source: 64)

expense. All training costs would be allocated to Region 2, since these activities would occur on a statewide basis.

7.5 Device Replacement

Another component of the maintenance budget is the cost of device replacement. In general, the maintenance budget should reflect only emergency replacements, as normal technological upgrades and replacements would be included as either a part of the STIP or other funding programs. Emergency device replacement will result from exceptional circumstances such as lightning damage and cabinet knockdowns. In order to preserve the operational integrity of the ITS infrastructure by minimizing downtime, it is recommended that ODOT budget for the costs of such emergency device replacement.

In order to estimate the cost of emergency device replacement, estimates for the capital cost and life cycle of each piece of equipment were developed from a variety of sources, including Oregon's ITS Strategic Plan (3), other maintenance plans (7, 9), and vendors (65). For each piece of equipment, failure rates – i.e. the probability of component failure within a twelve-month period – were estimated in part from anecdotal evidence provided by some vendors (66). It was assumed that the likelihood of emergency replacement would increase with the degree of environmental exposure. Table 7-5 summarizes these assumptions for each ITS device.

The estimated replacement cost for each device component is derived according to the equation shown in Figure 7-2. This equation reflects normal device upgrades.

$$\left(\underbrace{\text{Inventory} - \frac{\text{Inventory}}{\text{Life Cycle}}}_{\text{Inventory that is not upgraded in a given year}}\right) \times \begin{pmatrix}\text{replacement}\\ \text{cost}\end{pmatrix} \times \begin{pmatrix}\text{failure}\\ \text{rate}\end{pmatrix} = \begin{pmatrix}\text{emergency device}\\ \text{replacement costs}\end{pmatrix}$$

Figure 7-2: Calculating Emergency Device Replacement Costs.

Device	Component	Replacement cost (est.)	Life Cycle (yrs)	Annual failure rate
Closed-Circuit Television (CCTV)	Field camera	35,000	10	10%
	Camera server	5,000	4	2%
	Video switching equipment	100,000	10	2%
Video Detection Systems	Field unit	25,000	10	10%
Road and Weather Information System (RWIS)	Field unit	20,000	10	10%
	Regional server	5,000	4	2%
	Statewide server	5,000	4	2%
Travel Time Estimation	Field unit	15,000	10	5%
	Server	5,000	4	2%
Automatic Vehicle Location (AVL)	In-vehicle equipment	1,000	10	5%
	Server	5,000	4	2%
Advanced Traffic Management System	Server	5,000	4	2%
	Workstation	2,500	4	2%
Mayday Callboxes	Field unit	15,000	10	5%
Urban Automatic Incident Detection System	Server	5,000	4	2%
Intersection-Based Incident Detection System	Server	5,000	4	2%
Computer-Aided Dispatch	Workstation	2,500	4	2%
Incident Response Vehicles	On-board sign	30,000	10	10%
Hazardous Materials Response	Server	5,000	4	2%
800-number information	Server	5,000	4	2%
Internet access	Server	5,000	4	2%
Kiosks	Field unit	15,000	7	10%
	Server	5,000	4	2%
Icy Bridge Warning System (Low-Tech)	Sign	5,000	10	10%
Tunnel lane closure advisory	Sign	5,000	10	10%
Snow Zone Advisory	Sign	5,000	10	10%
Snow Zone Changeable Message Sign	Sign	5,000	10	10%
Oversize Vehicle Closure CMS	Sign	5,000	10	10%
Permanent Variable Message Signs (VMS)	Sign	125,000	10	10%
Portable Variable Message Signs (VMS)	Sign	30,000	10	10%
Highway Advisory Radio (HAR)	Field unit	50,000	20	10%
Icy Bridge Detectors	Field unit	25,000	5	10%
Oversize load detectors	Field unit	25,000	5	10%
Variable speed limit signs	Field unit	25,000	5	10%
Queue Detection System	Field unit	5,000	10	5%
Weigh-in-Motion (WIM) Stations	Field unit	52,200	10	5%
Downhill Speed Advisory Systems	Field unit	82,200	10	5%
Fiber optic networks	Per mile	10,000	20	1%
Radio Communications	Console	15,000	10	5%
	Handheld unit	1,000	10	5%
Maintenance Coordination	Laptop	2,500	4	2%

Table 7-5: Device Life Cycle, Cost and Failure Assumptions.

Because the likelihood of emergency replacement in any region may be small in a given year, it is recommended that this money be allocated to a central fund, controlled by ODOT's ITS unit in Salem, from which regions may draw as emergency repair needs occur.

On this basis, Table 7-6 shows the estimated annual cost of emergency device replacement under each of the three forecast years. It should be noted that these costs are greater than either the personnel or contracting costs.

	State Total
Existing	$ 642,806
Existing + STIP	$1,023,358
Existing + Strategic Plan	$3,993,222

Table 7-6: Estimated Emergency Replacement Costs.

7.6 Spare Parts

Having an inventory of spare parts for its ITS devices will help ODOT in two principal ways. First, some preventative maintenance activities will involve systematic replacement or substitution of easily worn components, such as light bulbs, display boards and similar hardware. An active spare parts inventory would help to ensure that preventative maintenance activities may occur as scheduled. Second, repair maintenance activities may also be expedited by having spare parts on hand. Anecdotal evidence has suggested that the ability to get spare parts quickly is one of the most common reasons to rely on contract maintenance (67, 68, 36).

The cost, type and quantity of spare parts required is highly dependent upon the manufacturer and model of a particular component, its environmental exposure, and its maintenance history. To provide a budgetary estimate for spare parts, the Caltrans District 7 maintenance plan (6) was used to define the average money allocated for spare parts for several ITS devices, including CCTV, VMS and HAR. This average cost was divided into the cost of device replacement identified in Section 7.5 to develop an estimate of the cost of spare parts as a percentage of device cost. Table 7-7 shows these percentages for each of the ITS devices evaluated in this study. Based on these percentages, the estimated cost of spare parts for each of ODOT's regions is shown in Table 7-8.

7.7 Test/Specialized Equipment

The final component of the maintenance budget is the cost of specialized equipment that is required in the maintenance of field devices. The cost of such equipment for maintenance of fiber optics communications network was used as the primary justification for relying on contract maintenance. Based on conversations with ODOT's ITS Unit, the cost of any equipment that is used exclusively for ITS maintenance should be included in the maintenance budget.

Percentage*	Devices
1%	CCTV; video detectors; RWIS; kiosks; changeable message signs; HAR; oversize load detectors; variable speed limit signs; queue detection systems; fiber optic networks
0.5%	Travel time estimation; AVL; incident response vehicles; VMS; WIM; downhill speed advisory systems; radio communications

* - Annual cost of spare parts as a percentage of device cost.

Table 7-7: Spare Parts Cost as Percentage of Device Cost.

	Region					State
	1	2	3	4	5	Total
Existing	$ 25,345	$ 10,622	$ 3,594	$ 6,625	$ 5,841	$ 52,027
Existing + STIP	$ 40,200	$ 15,998	$ 4,605	$ 13,044	$ 18,716	$ 92,563
Existing + Strategic Plan	$ 136,825	$ 53,242	$ 48,257	$ 50,971	$ 55,457	$ 344,752

Table 7-8: Estimated Spare Parts Cost by Region.

Equipment needs are expected to vary by region, based on their current equipment inventory. As a starting point, it is suggested that the following pieces of equipment be acquired for each region for field maintenance.

- Laptop computer. This can be used to help assist in troubleshooting some devices in the field. This would be a second laptop for each region, in addition to the laptop provided for the support coordinator's use.

- Portable video monitor. This can enable a camera technician to test the image being transmitted by a CCTV camera.

- Portable digital multimeter. This may be used in a variety of electrical diagnostic activities. It is assumed that each region already has at least one multimeter. However, multimeters are relatively inexpensive, and having additional ones would ensure that field maintenance activities do not have to wait for the availability of a multimeter.

Additional equipment may be required depending upon regional needs. An examination of other maintenance plans (6, 7, 5, 69) suggests that most other equipment involved in ITS maintenance, with the exception of fiber optic test equipment, is commonly available in most highway maintenance shops.

Table 7-9 provides an estimate for equipment costs for each region. It is assumed that these equipment costs would be incurred during the STIP.

Type of Equipment	Purpose	Estimated Unit Cost	Quantity	Cost Per Region
Laptop Computer	Used for maintenance coordination Used for testing of field devices	$ 3,800	2	$ 7,600
Portable Video Monitor	Use to view images received from a video signal source	$ 1,060	1	$ 1,060
Digital Multimeter	Measures a multitude of signal parameters	$ 400	1	$ 400

Table 7-9: Cost of Test/Specialized Equipment.

(Source: 6)

	Cost Component					
Device	**Staffing**	**Fringe**	**Spares**	**Replace**	**Vendor**	**Total**
Closed-Circuit Television (CCTV)	45,161	31,613	20,700	178,350	-	275,824
Video Detectors	1,595	1,117	1,000	9,000	-	12,712
Road and Weather Information System (RWIS)	47,905	33,534	4,300	36,450	-	122,189
Automatic Vehicle Location (AVL)	2,738	1,917	60	390	-	5,105
Advanced Traffic Management System	32,213	22,549	-	825	-	55,587
Callboxes	759	531	-	2,700	-	3,990
Computer-Aided Dispatch	5,729	4,010	-	338	-	10,077
Incident Response Vehicles	4,916	3,441	1,050	18,900	-	28,307
Alphanumeric Paging	68	48	-	-	-	116
800-number Information	11,278	7,895	-	75	-	19,248
Internet Access	35,669	24,968	-	75	-	60,712
Icy Bridge Warning CMS	548	384	50	450	-	1,432
Tunnel Lane Closure CMS	386	270	50	450	-	1,156
Radio-Controlled Snow Zone CMS	3,376	2,363	200	1,800	-	7,739
Telephone-Activated Snow Zone CMS	5,430	3,801	400	3,600	-	13,231
Oversize Vehicle Restriction CMS	870	609	50	450	-	1,979
Permanent Variable Message Signs	52,168	36,517	15,625	281,250	-	385,560
Portable Variable Message Signs	60,629	42,440	3,450	62,100	-	168,619
Highway Advisory Radio (HAR)	741	519	500	4,750	-	6,510
Icy Bridge Detectors	588	412	250	2,000	-	3,250
Queue Detection System	653	457	50	225	-	1,385
Weigh-in-Motion (WIM) Stations	396	277	2,871	25,839	35,660	65,043
Downhill Speed Advisory Systems	2,781	1,947	411	3,699	4,545	13,383
Radio Communications	4,958	3,470	1,010	9,090	-	18,528
Total	**321,555**	**225,089**	**52,027**	**642,806**	**40,205**	**1,281,682**

Table 7-10: Maintenance Budget by Device – Existing.

	Cost Component						
Device	**Staffing**	**Fringe**	**Spares**	**Replace**	**Test Eq**	**Vendor**	**Total**
Closed-Circuit Television (CCTV)	75,951	53,166	31,550	276,000	5,300	-	441,967
Video Detectors	2,560	1,792	1,500	13,500	-	-	19,352
Road and Weather Information System (RWIS)	123,603	86,523	11,700	103,050	-	-	324,876
Automatic Vehicle Location (AVL)	20,402	14,282	330	2,520	-	-	37,534
Advanced Traffic Management System	32,759	22,931	-	863	-	-	56,553
Callboxes	759	531	-	2,700	-	-	3,990
Regional Incident Detection System	1,965	1,376	-	75	-	-	3,416
Intersection-Based Incident Detection System	2,692	1,885	-	150	-	-	4,727
Computer-Aided Dispatch	5,729	4,010	-	338	-	-	10,077
Incident Response Vehicles	7,725	5,407	1,650	29,700	-	-	44,482
Alphanumeric Paging	68	48	-	-	-	-	116
Highway Travel Conditions Reporting System	21,334	14,934	-	-	-	-	36,268
800-number Information	11,278	7,895	-	75	-	-	19,248
Internet Access	35,669	24,968	-	75	-	-	60,712
Icy Bridge Warning CMS	548	384	50	450	-	-	1,432
Tunnel Lane Closure CMS	386	270	50	450	-	-	1,156
Radio-Controlled Snow Zone CMS	3,376	2,363	200	1,800	-	-	7,739
Telephone-Activated Snow Zone CMS	5,430	3,801	400	3,600	-	-	13,231
Oversize Vehicle Restriction CMS	870	609	50	450	-	-	1,979
Permanent Variable Message Signs	81,206	56,844	23,750	427,500	-	-	589,300
Portable Variable Message Signs	68,106	47,674	3,750	67,500	-	-	187,030
Highway Advisory Radio (HAR)	741	519	500	4,750	-	-	6,510
Icy Bridge Detectors	902	631	250	2,000	-	-	3,783
Oversize Load Detectors	9,156	6,409	1,250	10,000	-	-	26,815
Queue Detection System	653	457	50	225	-	-	1,385
Weigh-in-Motion (WIM) Stations	756	530	5,481	49,329	-	68,078	124,174
Downhill Speed Advisory Systems	4,989	3,493	822	7,398	-	9,090	25,792
Fiber Optic Networks	198	139	8,000	7,600	-	24,319	40,256
Radio Communications	7,317	5,122	1,230	11,070	-	-	24,739
Maintenance Coordination	3,000	2,100	-	190	40,000	-	45,290
Total	**530,128**	**371,093**	**92,563**	**1,023,358**	**45,300**	**101,487**	**2,163,929**

Table 7-11: Maintenance Budget by Device – STIP.

	Cost Component					
Device	**Staffing**	**Fringe**	**Spares**	**Replace**	**Vendor**	**Total**
Closed-Circuit Television (CCTV)	101,661	71,163	97,700	871,350	155,166	1,297,040
Video Detectors	21,663	15,164	26,500	238,500	-	301,827
Road and Weather Information System (RWIS)	24,627	17,240	25,900	230,850	292,725	591,342
Travel Time Estimation	1,462	1,023	6,025	54,075	127,528	190,113
Automatic Vehicle Location (AVL)	54,285	37,999	2,680	23,370	101,985	220,319
Advanced Traffic Management System	65,362	45,753	-	2,063	-	113,178
Callboxes	759	531	-	2,700	-	3,990
Regional Incident Detection System	1,924	1,347	-	75	-	3,346
Intersection-Based Incident Detection System	2,669	1,869	-	150	-	4,688
Computer-Aided Dispatch	5,480	3,837	-	338	-	9,655
Incident Response Vehicles	6,031	4,222	1,650	29,700	-	41,603
Pre-planned Detour Routes	432	304	-	-	-	736
Hazardous Material Response	1,787	1,251	-	75	-	3,113
Alphanumeric Paging	68	48	-	-	-	116
Highway Travel Conditions Reporting System	21,297	14,908	-	-	-	36,205
800-number Information	11,197	7,838	-	75	-	19,110
Internet Access	35,628	24,940	-	75	-	60,643
Kiosks	3,516	2,462	35,600	304,788	236,036	582,402
Icy Bridge Warning CMS	538	377	50	450	-	1,415
Tunnel Lane Closure CMS	381	267	50	450	-	1,148
Radio-Controlled Snow Zone CMS	3,172	2,220	200	1,800	-	7,392
Telephone-Activated Snow Zone CMS	5,275	3,693	400	3,600	-	12,968
Oversize Vehicle Restriction CMS	837	586	50	450	-	1,923
Permanent Variable Message Signs	68,964	48,275	38,750	697,500	53,870	907,359
Portable Variable Message Signs	12,510	8,757	69,300	1,247,400	1,094,789	2,432,756
Highway Advisory Radio (HAR)	710	497	500	4,750	-	6,457
Icy Bridge Detectors	431	300	5,250	42,000	38,130	86,111
Oversize Load Detectors	100	70	1,250	10,000	8,791	20,211
Variable Speed Limit Signs	503	352	5,000	40,000	44,164	90,019
Queue Detection System	645	452	50	225	-	1,372
Weigh-in-Motion (WIM) Stations	751	525	5,481	49,329	67,146	123,232
Downhill Speed Advisory Systems	47,625	33,338	10,686	96,174	133,577	321,400
Fiber Optic Networks	198	139	8,000	7,600	24,319	40,256
Radio Communications	27,605	19,324	3,680	33,120	-	83,729
Maintenance Coordination	2,875	2,015	-	190	-	5,080
Total	**532,968**	**373,086**	**344,752**	**3,993,222**	**2,378,226**	**7,622,254**

Table 7-12: Maintenance Budget by Device – Strategic Plan.

7.8 Maintenance Budget

Appendix N presents a series of tables detailing cost estimates for ODOT's comprehensive ITS maintenance budget. This section will summarize the findings on a device and regional level.

7.8.1 By Device

Tables 7-10, 7-11 and 7-12 summarize the ITS maintenance budget by device under the existing, STIP and Strategic Plan forecast years, respectively. The budget is divided into the components discussed earlier: personnel, training, vendor/contractor costs, device replacement, spare parts, and test/specialized equipment. The maintenance budget under existing deployment levels is estimated at $1,281,682. By the conclusion of the STIP, the annual maintenance budget is estimated to be $2,163,929, which represents a 69 percent increase over the existing deployment level budget. If the Strategic Plan is implemented as presented in this plan, the maintenance budget will increase to an estimated $7,622,254, which represents a 595 percent increase over the existing budget level.

Figure 7-3 shows how the share of the maintenance budget spent on personnel, contractor and other cost components changes over the three budget forecast years. As can be seen, the largest portion of the maintenance budget for each of the three years is devoted to emergency device replacement. In terms of staffing costs, the mix of costs shifts toward using contractor maintenance as the Strategic Plan becomes reality.

Table 7-13 presents the budget data by device in a different format, by identifying the devices that comprise the largest portion of the statewide maintenance budget. Permanent VMS, CCTV, RWIS and portable VMS are the four devices which account for the largest portions of

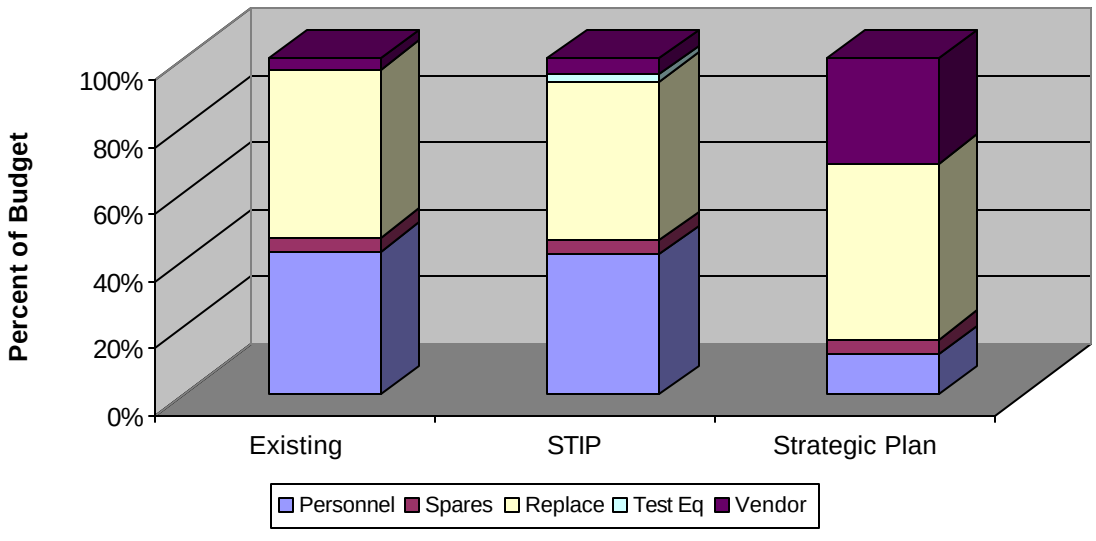

Figure 7-3: Maintenance Spending by Cost Component.

	Existing			STIP			Strategic Plan		
Rank	**Device**	**Budget**	**Pct.**	**Device**	**Budget**	**Pct.**	**Device**	**Budget**	**Pct.**
1	Permanent VMS	385,560	30.1%	Permanent VMS	589,300	27.2%	Portable VMS	2,432,756	31.9%
2	CCTV	275,824	21.5%	CCTV	441,967	20.4%	CCTV	1,297,040	17.0%
3	Portable VMS	168,619	13.2%	RWIS	324,876	15.0%	Permanent VMS	907,359	11.9%
4	RWIS	122,189	9.5%	Portable VMS	187,030	8.6%	RWIS	591,342	7.8%
5	WIM	65,043	5.1%	WIM	124,174	5.7%	Kiosks	582,402	7.6%
6	Web Site	60,712	4.7%	Web Site	60,712	2.8%	Downhill Speed System	321,400	4.2%
7	ATMS	55,587	4.3%	ATMS	56,553	2.6%	Video Detectors	301,827	4.0%
8	Incident Resp. Vehicles	28,307	2.2%	Coordination	45,290	2.1%	AVL	220,319	2.9%
9	800-number	19,248	1.5%	Incident Resp. Vehicles	44,482	2.1%	Travel Time Estimation	190,113	2.5%
10	Radio Systems	18,528	1.4%	Fiber Optics	40,256	1.9%	WIM	123,232	1.6%
All other devices		82,065	6.4%	All other devices	249,289	11.5%	All other devices	654,464	8.6%

Table 7-13: Top Ten Devices by Statewide Maintenance Costs.

the maintenance budget under both the existing and STIP deployment levels. Under the Strategic Plan, kiosks become the fifth most expensive maintenance item, supplanting weigh-in-motion stations.

7.8.2 By Region

Tables 7-14, 7-15 and 7-16 provide a regional breakdown of the maintenance budget for each of the three forecast years. Under the existing and STIP deployments, Regions 1 and 2 have similar amounts of money allocated for ITS maintenance. Since part of the budget in Region 2 reflects centralized server support activities, the maintenance budget levels clearly indicate the concentration of deployment in urban Region 1. By the time the Strategic Plan is completed, the maintenance budget across the regions is expected to be more evenly distributed.

	Cost Component					
Region	Personnel	Replace	Spare Parts	Test Equipment	Vendors	Total
1	140,355	298,880	25,345	-	-	**464,580**
2	243,117	148,736	10,622	-	6,484	**408,959**
3	23,282	46,246	3,594	-	12,967	**86,089**
4	92,196	68,625	6,625	-	-	**167,446**
5	47,694	80,319	5,841	-	20,754	**154,608**
Total	546,644	642,806	52,027	-	40,205	**1,281,682**

Table 7-14: Maintenance Budget by Region – Existing.

	Cost Component					
Region	Personnel	Replace	Spare Parts	Test Equipment	Vendors	Total
1	171,439	390,826	40,200	9,060	40,528	**652,053**
2	323,427	224,983	15,998	9,060	9,726	**583,194**
3	37,120	55,383	4,605	9,060	17,512	**123,680**
4	193,526	127,809	13,044	9,060	12,967	**356,406**
5	175,709	224,357	18,716	9,060	20,754	**448,596**
Total	901,221	1,023,358	92,563	45,300	101,487	**2,163,929**

Table 7-15: Maintenance Budget by Region – STIP.

	Cost Component					
Region	Personnel	Replace	Spare Parts	Test Equipment	Vendors	Total
1	203,650	1,422,280	136,825	-	585,181	**2,347,936**
2	273,676	664,500	53,242	-	425,714	**1,417,132**
3	112,878	579,222	48,257	-	437,911	**1,178,268**
4	145,538	596,223	50,971	-	474,445	**1,267,177**
5	170,312	730,997	55,457	-	454,975	**1,411,741**
Total	906,054	3,993,222	344,752	-	2,378,226	**7,622,254**

Table 7-16: Maintenance Budget by Region – Strategic Plan.

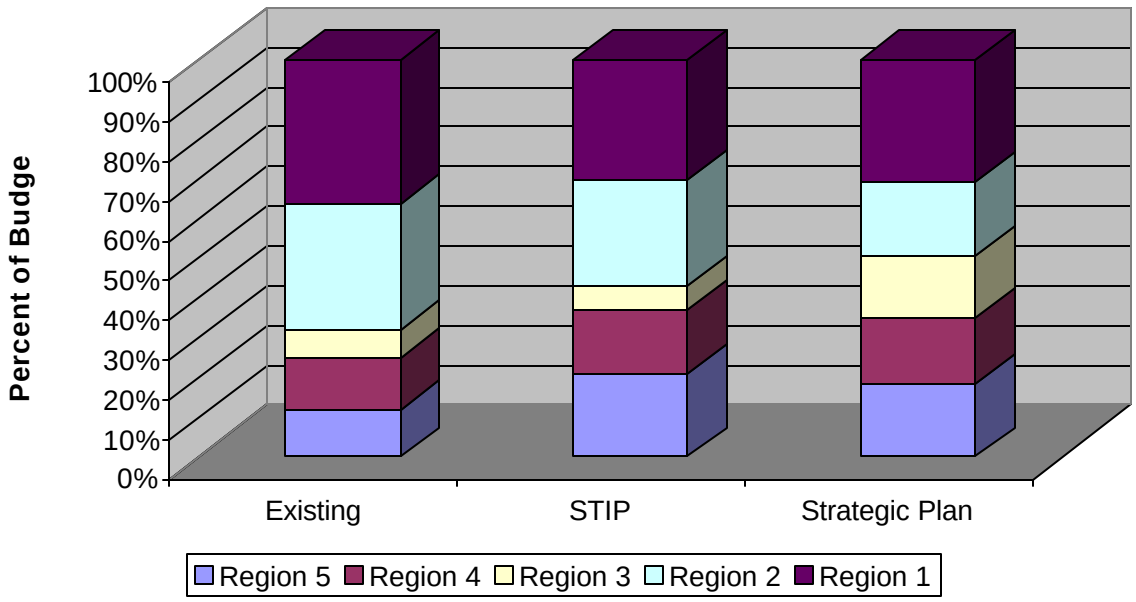

Figure 7-4: Maintenance Budget by Region.

The increased slant of the maintenance budget toward more rural regions is shown in Figure 7-4. This graph demonstrates clearly how the maintenance budget is going to be increasingly directed toward the more rural parts of Oregon.

7.9 Recommendations

This chapter has presented a comprehensive budget for planning purposes. In order to improve the reliability and accuracy of future planning budgets for ITS maintenance activities, it is recommended that the following actions be taken.

- Improve logging and tracking of maintenance activities. Historical cost data, at a device level, is the best predictor of future maintenance costs. This is the method used by the Arizona Department of Transportation in developing future estimates of operations and maintenance costs (9). A new system should allow ODOT to be able to track the amount of time spent on individual devices, as well as the amount of time spent on ITS maintenance by individual staff members.

- Develop an inventory of spare parts. In consultation with vendors and suppliers, ODOT should develop a list of parts which are essential to have on-hand in order to provide for timely repair of ITS devices.

- Identify equipment needed to maintain ITS devices. ODOT should review, at a regional level, the types of testing equipment that may need to be purchased in order to ensure that equipment availability does not impede ITS maintenance.

- Pursue cost competition with contractors on similar maintenance activities. ODOT may wish to contract only a portion of maintenance on a given device and perform the remainder in-house, in order to provide a comparison of the cost and efficiency of contract maintenance. This would help to identify whether using contracting at the levels indicated in this budget is fiscally sound.

- Consider maintenance costs in future deployment planning decisions. For example, the extensive deployment of portable VMS under the Strategic Plan will raise their maintenance costs to represent more than 30 percent of ODOT's statewide total.