INTELLIGENT TRANSPORTATION SYSTEMS MAINTENANCE PLAN

EXECUTIVE SUMMARY:

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GLOSSARY OF ABBREVIATIONS

ADOT	Arizona Department of Transportation
ATMS	Advanced Traffic Management System
ATR	Automatic Traffic Recorder
AVC	Automatic Vehicle Classification
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
CAD	Computer-Aided Dispatch
Caltrans	California Department of Transportation
CCTV	Closed-Circuit Television
CDPD	Cellular Digital Packet Data
CMS	Changeable Message Sign
COATS	California-Oregon Advanced Transportation System
COMET	CorridOr ManagEment Team
CPU	Central Processing Unit
CSEPP	Chemical Stockpile Emergency Preparedness Program
CVO	Commercial Vehicle Operations
DAS	Department of Administrative Services
DB	Design-Build
DBM	Design-Build-Maintain
DBW	Design-Build-Warrant
DOT	Department of Transportation
DSAS	Downhill Speed Advisory System
FMS	Freeway Management System
FTE	Full Time Employee
GPS	Global Positioning System
HAR	Highway Advisory Radio
HazMat	Hazardous Materials
HTCRS	Highway Travel Conditions Reporting System
ICTM	Integrated Corridor Traffic Management
ILD	Inductive Loop Detection
IS	Information Services
ITS	Intelligent Transportation Systems
LED	Light-Emitting Diode
LOS	Level of Service

MCTD	Motor Carrier Transportation Division
MLT	Maintenance Leadership Team
Mn/DOT	Minnesota Department of Transportation
O&M	Operations and Maintenance
ODOT	Oregon Department of Transportation
ORS	Oregon Revised Statutes
OSP	Oregon State Patrol
PAD	Passive Acoustic Detection
PDA	Personal Digital Assistant
PECOS	Performance Controlled System
RPU	Remote Processing Unit
RWIS	Road and Weather Information System
SC&DI	Surveillance, Control & Driver Information
SCATS	Sydney Coordinated Adaptive Traffic System
SSI	Surface Systems Incorporated
STIP	Statewide Transportation Improvement Program
T&M	Time-and-Materials
TDS	Transportation Data Section
TMC	Transportation Management Center (for Caltrans District 7)
TMOC	Traffic Management Operations Center (same as Region 1 TOC)
TOC	Transportation Operation Center
TOS	Traffic Operation System (for Caltrans District 7)
TSMC	Traffic Systems Management Center (for WSDOT)
TSSU	Traffic Signals Services Unit
TWI	Texas Weather Instruments
TxDOT	Texas Department of Transportation
VMS	Variable Message Sign
VSLS	Variable Speed Limit Systems
WIM	Weigh-in-Motion
WSDOT	Washington State Department of Transportation
WTI-MSU	Western Transportation Institute at Montana State University – Bozeman

EXECUTIVE SUMMARY

As part of fulfilling its mission "to provide safe and effective transportation systems that support economic opportunity and livable communities for Oregonians," the Oregon Department of Transportation (ODOT) is increasingly relying on the use of Intelligent Transportation Systems (ITS). ITS devices use advanced technology to improve the safety and efficiency of the transportation system. ODOT's increased emphasis on ITS was demonstrated in the development of a statewide strategic plan governing ITS deployment from 1997 through 2017.

In order to ensure that ITS devices will meet the needs of both ODOT and the traveling public, proper maintenance is essential. For this reason, ODOT partnered with the Western Transportation Institute at Montana State University-Bozeman (WTI-MSU) to develop a long-term maintenance plan to address not only the technical issues associated with ITS maintenance, but the institutional issues as well.

Stakeholder Outreach

To provide an initial context for the development of this plan, staff from WTI-MSU engaged in meetings with many diverse groups of ODOT stakeholders. Stakeholder meetings identified the following as critical issues with ITS maintenance:

- inadequate staffing levels and/or conflicting priorities,
- ambiguous responsibilities,
- inadequate training,
- poor logging and tracking systems, and
- non-standardized devices.

Stakeholders were supportive of the need for a comprehensive ITS maintenance plan that would serve as a foundation for addressing all issues and regions, develop a process for maintaining new technology once it is implemented, raise awareness of staffing, training, maintenance, and standardization needs, and clearly define organizational responsibilities.

Literature Review

WTI-MSU also engaged in a literature review to identify experiences in other transportation agencies and the private-sector. In reviewing the literature, it was determined that ODOT's ITS maintenance planning efforts are unique. No similar statewide effort in the United States has been attempted. Efforts in some cases were identified as having some applicability, especially from a couple of metropolitan areas. These efforts provided some guidance into alternative methods for processing maintenance through an organization, methodologies for developing maintenance budgets, criteria for prioritizing maintenance, and recommendations for preventative maintenance. However, none of these plans reflected the diversity of ODOT's organizational structure, the rural character of some of ODOT's regions, or the variety of devices planned for deployment under ODOT's Strategic Plan. Contacts with the private sector yielded some anecdotal assistance, but no documented plans that would assist in ODOT's efforts.

Maintenance Model

One clear fact that emerges through the literature review is the necessity of having a maintenance model: a method for logging, tracking and processing repairs and requests through the organization so that maintenance is done efficiently and effectively. Several alternative maintenance models were developed and presented in a series of stakeholder meetings. Based on these meetings, a two-tier maintenance model was selected as the consensus preferred model. Some of this alternative's highlights include the following.

- It has different maintenance procedures for newer, emerging technologies and older, mainstream technologies.
- It includes a support coordinator position, whose primary role would be to serve as a single point-of-contact to log and track maintenance activities.
- It relies on district and regional maintenance staff to perform maintenance tasks on field devices, and on Information Services staff to perform maintenance on back-end computer support and communications links from the field device to the Transportation Operation Center (TOC).
- It allows for vendor / contractor support to be used at the discretion of the support coordinator.

The consensus in support of this model served as a starting point for implementation of this model and resolution of some of the concerns cited by stakeholders.

Priority Guidelines

Having a maintenance model provides a framework for performing ITS repairs, but it provides little guidance as to which activities should occur when. While not addressing ITS specifically, electrical repair priority guidelines in ODOT's current highway maintenance manual indicate that ITS devices would likely merit 24-hour/7-day-a-week maintenance support. Based on meetings with stakeholders, it was determined that there were varying perspectives on the relative repair priority of different types of ITS devices based partly on regional needs. In order to harmonize these guidelines across regions, stakeholders were surveyed as to how they normally prioritize repairs within their jurisdiction. Survey results indicated that stakeholders believe that devices should be prioritized for repair not on the basis of a particular technology but on the basis of how critical it is to the mission of ODOT. Identification of mission-critical devices is expected to vary between urban and rural regions, as well as between summer and winter weather conditions. The following guidelines represent the general order of prioritizing repair.

- Fulfill legal mandates.
- Address safety hazards, such as devices physically impeding the safety of the traveling public or devices providing motorists with errant and potentially harmful information.

- Repair safety-critical devices, generally focusing on field devices first, communications links next, and information dissemination third.
- Repair operations-critical devices, generally focusing first on where traveler benefit is maximized.
- Restore all other devices, focusing first on devices that have the most visibility to the traveling public.

Preventative Maintenance

The need to perform repair maintenance may be partially mitigated through the proper prescription of preventative maintenance activities. Through research into practices at other agencies as well as practices recommended by vendors, guidelines were developed describing – in broad terms – the type and frequency of preventative maintenance activities that should be undertaken for each device in ODOT's ITS infrastructure. These guidelines will need to be refined by technicians more familiar with individual devices in order to develop a checklist, which can be used to ensure that all tasks are performed properly. Stakeholders indicated that preventative maintenance is often neglected in favor of performing repair maintenance. Efforts to emphasize preventative maintenance – through integration of preventative maintenance tasks into logging and tracking procedures and through allocation of resources to preventative maintenance – are needed to ensure that these activities will not continue to be neglected.

Resource Analysis

The next part of the maintenance plan is to identify the resources involved in maintaining ODOT's existing and planned ITS infrastructure. In order to properly identify the resources required, a device-by-device investigation was conducted to identify maintenance needs for the six types of components that may comprise a given ITS device, including sensors, communications, field processors, software, center sub-systems and information delivery. For each component, preventative maintenance guidelines may serve as a foundation for estimating the amount of time that needs to be devoted to ITS maintenance activities, but the relative frequency and severity of repair maintenance tasks needs to be considered as well. Estimates for each component were developed from a variety of sources, including ODOT staff, other transportation agencies and vendors. Resource needs per device were multiplied by inventory estimates of each device in each of ODOT's regions, with consideration given to travel time between device locations, in order to develop regional and statewide estimates of the staffing resources required to maintain ODOT's ITS infrastructure. Three forecast years were used in this analysis: the existing deployment, the deployment after completion of ODOT's Statewide Transportation Improvement Program 2000-2003 (STIP), and the deployment after completion of the ITS Strategic Plan mentioned earlier.

These resource needs estimates were compared with the resources ODOT currently has available to identify where staffing gaps may exist. The results, shown in Table A, indicate that ODOT's concerns about staffing gaps are justified. This gap is expected to widen in the future, assuming that ODOT is unable to obtain additional staffing resources.

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 A: Staffing Gaps by Classification and Region.

In addition to this quantitative analysis, surveys were used to qualitatively assess how competent ODOT staff believes it is to maintain existing and planned ITS technologies. This examination showed that organizational expertise exists on essentially every device ODOT currently has; however, regional gaps in knowledge do exist. These training gaps may be readily addressed through the use of cross-training between senior and junior ODOT staff.

One potential alternative for dealing with future staffing gaps is to use contract maintenance. While many agencies are increasingly relying on contracting for ITS maintenance, it should not be viewed as a certain solution for ODOT's ITS maintenance difficulties. Contracting should be targeted toward activities where response time is not as critical, where the device deployment on a statewide basis is fairly extensive, and where clear lines of responsibility between contractors and ODOT may be defined. Activities that were identified as good candidates, either now or in the future, for contracting include:

- weigh-in-motion systems,
- kiosks,
- preventative maintenance on closed-circuit TV cameras and permanent variable message signs (VMS),
- road and weather information system field units,
- travel time estimation,
- automatic vehicle location in-vehicle sensors,
- all maintenance activities on portable VMS, and
- fiber optic communications.

Budget

As a final element in the maintenance plan, a maintenance budget needed to be developed. The budget, shown in Table B, reflects that all maintenance activities are performed as recommended, with contracting applied on a time-and-materials basis where appropriate. The budget includes costs for spare parts and emergency device replacement (such as due to lightning strikes), but excludes costs associated with operations, continued vendor support and routine device replacement. As can be seen, the estimated maintenance budget statewide under the existing deployment level is nearly $1.3 million. As deployment increases, however, the estimated budget increases as well, to a total of over $7.6 million per year by the time devices in the Strategic Plan have been deployed. The largest component of the maintenance budget is emergency device replacement.

	Region					State
Year	**1**	**2**	**3**	**4**	**5**	**Total**
Existing	$ 464,580	$ 408,959	$ 86,089	$ 167,446	$ 154,608	**$ 1,281,682**
STIP	$ 652,053	$ 583,194	$ 123,680	$ 356,406	$ 448,596	**$ 2,163,929**
Strategic Plan	$ 2,347,936	$ 1,417,132	$ 1,178,268	$ 1,267,177	$ 1,411,741	**$ 7,622,254**

Table B: Maintenance Budget by Region.

Strategic Maintenance Plan

This plan is intended as an evolving document that will serve primarily as a starting point for institutionalizing maintenance as a part of ITS devices. On that basis, and on the basis of work done in preparation of this plan, Table C presents recommendations for short-term, medium-term and long-term time frames.

Future Research and Evaluation

There are other activities not related directly to ITS maintenance which are recommended as potential research activities to build on promising areas identified in this research project, including:

- a before-and-after comparison to evaluate the effectiveness of implementing the two-tier maintenance model on ITS maintenance,
- a revision of future maintenance budgets based on cost data provided by the to-be-implemented logging and tracking system, and
- an investigation into contracting opportunities for non-ITS maintenance within ODOT.

Time Frame	Recommendations
Short-Term	1. Continue to develop an organizational consensus as to the importance of ITS in fulfilling ODOT's mission. 2. Continue to pursue implementation of the two-tier maintenance model, including identifying individuals who will fill the support coordinator role for each region. 3. Research and implement a statewide logging and tracking system for ITS maintenance activities. 4. Develop regional guidelines for prioritization of ITS repair maintenance activities. 5. Develop checklists for preventative maintenance tasks on each device. 6. List and quantity an appropriate spare parts inventory for each device. 7. Identify and procure equipment that may be needed in performing diagnostics on ITS field devices. 8. Schedule cross-training activities to improve the overall skill level of ODOT technicians. 9. Investigate contracting alternatives on non-mission-critical devices. 10. Disseminate this plan document to other agencies, to assist them in analyzing ITS maintenance alternatives.
Medium-Term	1. Develop process for on-going cross-training on new devices. 2. Improve the statewide logging and tracking system to minimize time on data entry. 3. Develop statewide, scalable standards for ITS devices, as well as a process for these standards to be developed and implemented in the future. 4. Investigate alternatives for competition between ODOT and contractors on ITS maintenance, in order to evaluate the benefits and consequences of contracting. 5. Research contracting alternatives that may be used in procurement of new devices to reduce maintenance costs.
Long-Term	11. Replace non-standardized devices with devices that are compatible with ODOT's standards. 12. Regularly evaluate ITS maintenance activities on a series of performance measures, including repair response time and the length of time a device is inoperable. 13. Pursue strategic planning efforts that incorporate maintenance planning as a key consideration.

Table C: Strategic Recommendations for ITS Maintenance.