APPENDIX C ALTERNATIVE MAINTENANCE MODELS

This appendix will summarize the four alternative maintenance models that were reviewed by ODOT stakeholders during August 1999, highlighting each alternative's distinctive features. This will be followed by a summary of stakeholder comments regarding these models.

Of the numerous alternatives that were developed, four alternatives were selected for presentation to ODOT staff. These particular models were selected to highlight key strategic decisions that need to be made by ODOT in deciding how ITS maintenance should be done. Three principal assumptions guided the development of maintenance model alternatives.

1. Each alternative should build upon the existing ODOT organizational structure.

2. Each alternative should include systematic logging and tracking of maintenance.

3. Additional staff will be available for ITS maintenance, although the maintenance model will be used to help identify how these staff should fit into ODOT's organizational structure.

For each of the four alternatives, a flow chart showing the repair procedure is included, along with a table highlighting roles and responsibilities.

C.1 District/Regional Maintenance

The district/regional maintenance model may be considered the base case model as it most closely reflects ODOT's current organizational structure. The model is intended to preserve maintenance functions in their existing structure within the ODOT organization; therefore, it leaves the responsibility for performing maintenance at the district and/or regional level.

Figure C-1 shows how the reporting process under this model works. Descriptively, the model works as follows:

- Problem diagnosis. Once a problem is reported, the TOC dispatches a regional electrician to diagnose the problem. It is assumed that the electrician will have adequate training to be able to successfully diagnose, if not repair, most ITS problems. If the electrician is unable to diagnose the problem, the electrician will report it to a TSSU technician. If the TSSU technician is unable to diagnose the problem, the TOC is notified and dispatches vendor service to perform a diagnosis.

- Problem repair. Whoever is able to diagnose the problem has significant responsibility in determining how the problem will get resolved. If the electrician diagnoses it and is able to fix it, the repair will be made as soon as possible. If the electrician has diagnosed the problem but is not technically competent to fix the problem, the electrician will contact the next appropriate level of support. If the problem is identified as occurring in the field device, a TSSU technician would be dispatched to complete the repair. For other problems, such as network connections,

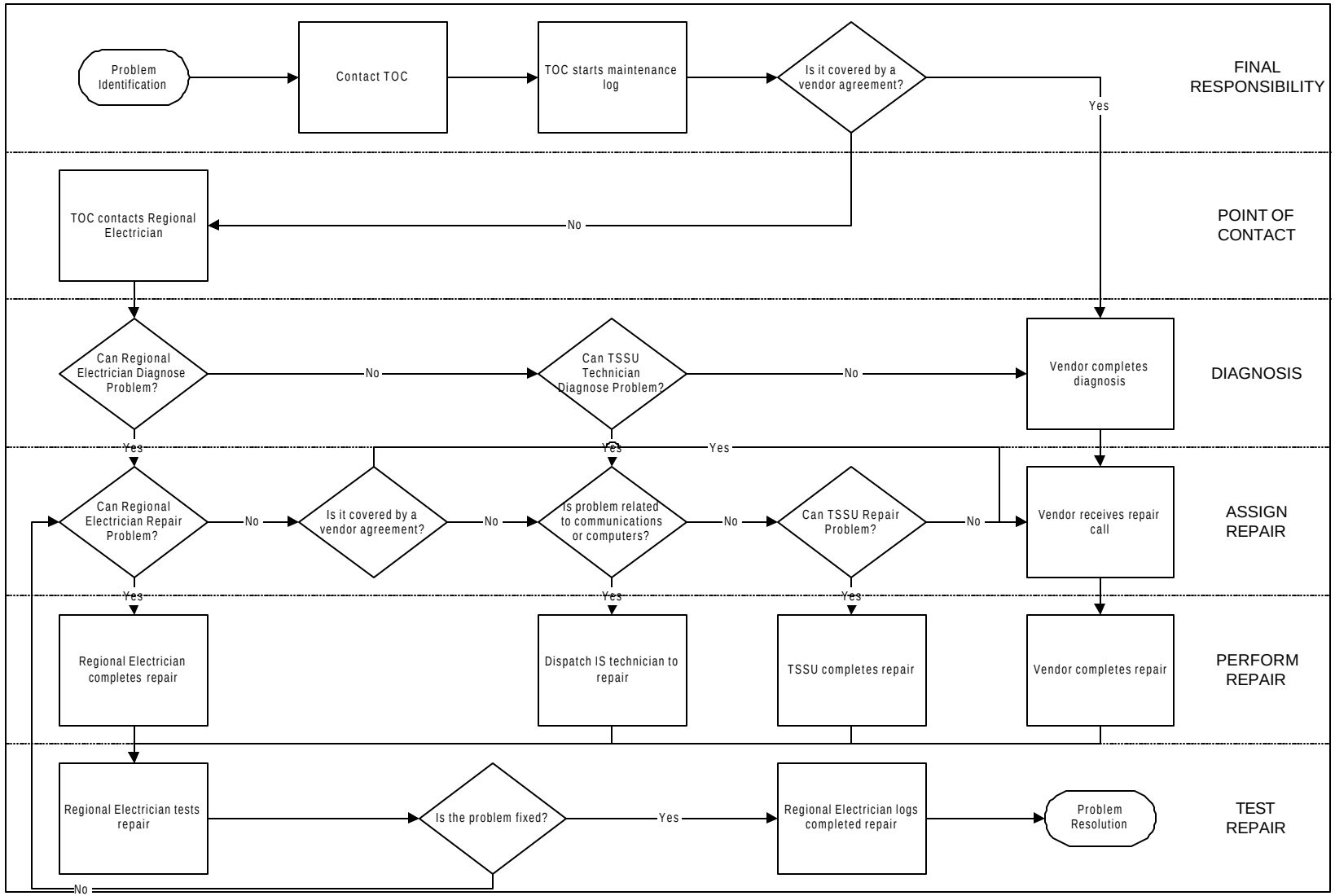

Figure C-1: Repair Process for Regional/District Maintenance Model.

communications support, and computers for back-end ITS support, an Information Services technician would be assigned. If ODOT staff is unable to repair the problem, the vendor is dispatched.

- Solution testing. After the repair has been completed, the next step is to confirm that the repair has been successful. This requires testing the ITS device to ensure that it is working properly. The regional electrician would be in the field to ensure the device is working properly, although they may need to coordinate with others to perform testing (such as sending test messages to a VMS).

- Logging and tracking. Documentation is needed to track the problem from the beginning through the repair process, and onto notification of the TOC. A paper tracking system may be used, where the paper is handed off from one technician to the other during the process, noting all maintenance tasks performed, until the repair is completed. In the long-term, this system may be supplemented or replaced with a purely computerized system, perhaps using personal digital assistants (PDA) to enter and receive data.

Table C-1 indicates roles and responsibilities for various groups within ODOT. For most groups, this model represents a preservation or expansion of existing maintenance roles. The TOCs will become a more central coordinating point for ITS maintenance, having oversight responsibility for the maintenance process. The responsibilities of regional electricians will expand such that they are able to diagnose most ITS problems and are able to test the effectiveness of repairs. They will be responsible for whether a vendor should be called instead of using existing resources. This would be done depending upon the extent of warranty coverage and upon the TOC's determination of the urgency and severity of the repair need. Electricians will also be responsible for tracking maintenance activities once a repair request has been received from the TOC. Other staffing levels perform similar functions to what they currently provide. Information Services will provide, perhaps on an on-call basis, technical support for communications and computer-related ITS repairs outside of the field device. TSSU may be summoned to provide additional technical support for the field device or sensors. Vendors may be brought in once all internal channels are exhausted.

C.2 Coordinated ITS Maintenance

An alternative to integrating ITS maintenance into the existing maintenance process is to remove all ITS maintenance responsibility from the districts and regions and put it into a separate organizational unit. This alternative, called the coordinated ITS maintenance model, would create a new staff position called regional ITS support coordinator. This position would be responsible for coordinating all ITS maintenance-related activities at the regional level. This model acknowledges the current reality that, due to resource constraints, ITS maintenance is not consistently being performed at the regional and district level at a level consistent with device demands. It is hoped that this separate unit would have adequate resources on its own to do ITS maintenance. If successful, this would free regional electricians from ITS activities to perform more traditional maintenance activities.

ODOT Organizational Unit / Title	Primary Role	Primary Maintenance Responsibilities
TOC	Oversight for ITS maintenance	• Initiates the maintenance process • Initiates the maintenance record
District/Regional Maintenance Staff	First line of ITS maintenance	• Determine if vendor should be first point of contact for a particular repair • Perform initial diagnosis • Repair problems to the extent they are capable • Test repairs • Complete repair log • Track entire maintenance process
Information Services	Second line of ITS maintenance	• Repair problems related to communications and computers for back-end ITS equipment including network connections to roadside devices
TSSU	Second line of ITS maintenance	• Diagnose and repair problems beyond capability of regional electricians for roadside devices and sensors
Vendors	Last line of ITS maintenance	• Fulfill vendor maintenance agreements • Diagnose and repair problems beyond ODOT capabilities

Table C-1: Roles and Responsibilities for District/Regional Maintenance Model.

Figure C-2 shows how the reporting process under this model works. Descriptively, this model works as follows.

- Problem diagnosis. Once a problem is reported, the TOC dispatches the regional ITS support coordinator. The support coordinator will be the single point-of-contact for maintenance, making decisions as to which ODOT staff are brought in and when, as well as when contract support should be utilized. The support coordinator will make the first effort at diagnosing the problem. If necessary, the regional support coordinator may seek TSSU support to help diagnose the problem. If the regional ITS support coordinator cannot diagnose the problem, the support coordinator would call in the appropriate vendor.

- Problem repair. The regional ITS support coordinator will fix the device to the extent they are capable. In some cases, they may make simple repairs for which a vendor could be called but is unnecessary to do so, such as re-booting a server. If the support coordinator is unable to fix the problem, they will direct the repair to the appropriate party. It is not expected that the support coordinator will be capable of fixing all ITS

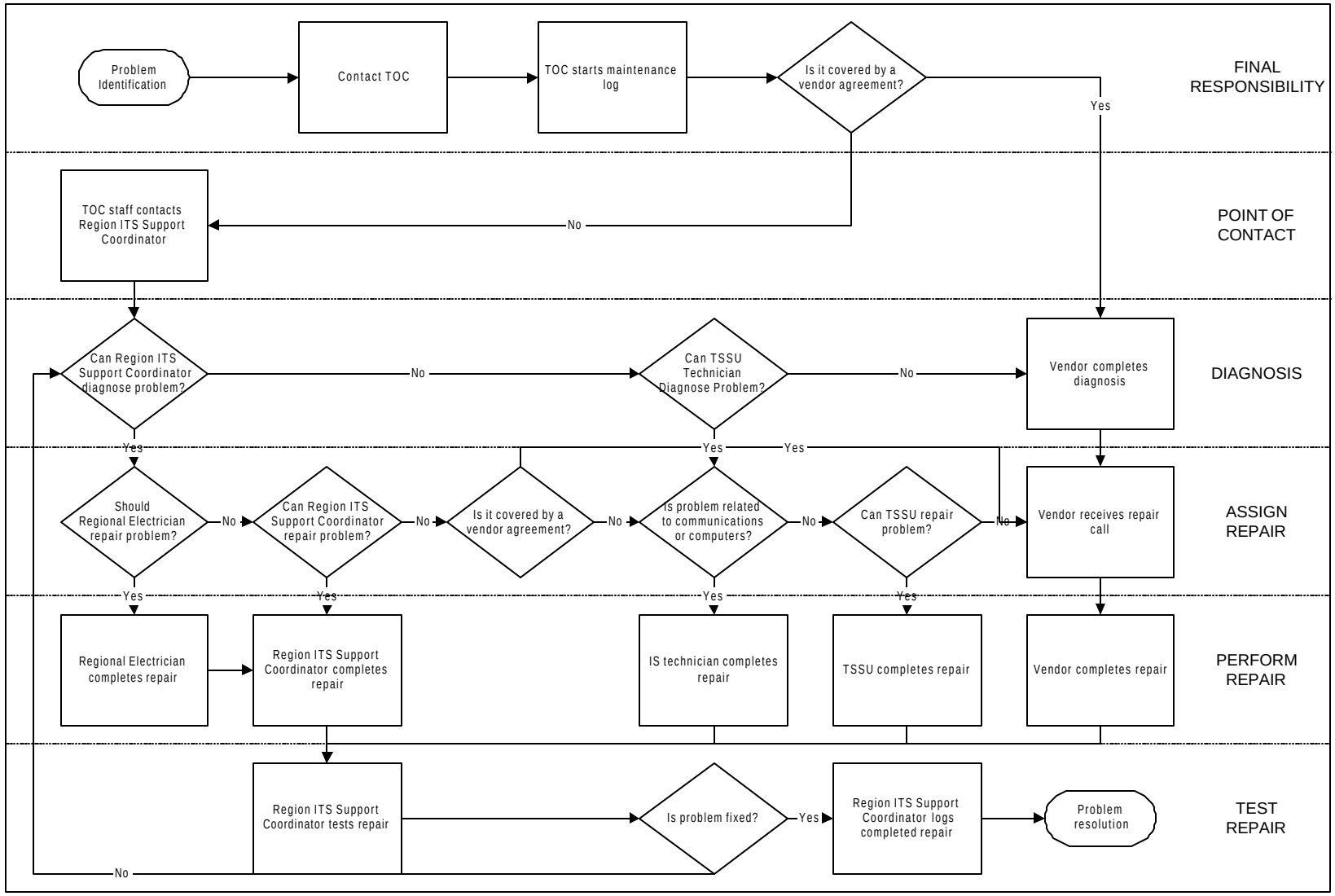

Figure C-2: Repair Process for Coordinated ITS Maintenance Model.

problems, but this individual should be able to readily identify who needs to be brought in to fix problems. As was assumed in the district/regional model, Information Services would be brought in for communications and computer-related problems outside of the field device, while TSSU would be dispatched for problems at the field device level.

- Solution testing. After the repair is completed, the support coordinator is responsible for verifying that the repair has been successful.

- Logging and tracking. The regional ITS support coordinator is responsible for logging and tracking maintenance activities upon being contacted by the TOC. The TOC will initiate a maintenance record, but it is the support coordinator's responsibility to complete the record, identifying actions taken, individuals contacted, and the corrections made.

As shown in Table C-2, the coordinated ITS maintenance model would represent a significant change in the role of the district and regional maintenance personnel in ITS maintenance. Their role under this model would be primarily to report problems, and perhaps to assist in preventative maintenance activities if appropriate, although these would need to be coordinated through the regional support coordinator. The regional electricians would also have involvement in problems for which special training, such as an electrician's license, or specialized equipment, such as bucket trucks, are required. This model puts the regional ITS support coordinator on the front line for ITS maintenance in place of the regional electrician's role under the district/regional model. The support coordinator would be expected to perform most device diagnostics, many device repairs, post-repair testing and logging. This requires a combination of an extensive skill set for the support coordinator and/or the ability to get staff with the appropriate specialized skills from throughout ODOT's organization to address the problem quickly.

C.3 Two-Tier

Instead of an "either-or" system where ITS maintenance either is done entirely within the existing maintenance structure or is done by a completely separate unit, one alternative model would be to combine the strengths of these models for a two-tiered approach based on technology. One tier would consist of "mainstream devices" – i.e. devices which have become standardized within ODOT and for which repair training is adequate for ODOT to be capable of handling nearly all diagnostic and repair capabilities in-house. This would include devices such as traffic signals, ramp meters, and road and weather information systems (RWIS). In some cases, a device may be mainstream in one region but not in another due to broader deployment experience. For example, closed circuit television (CCTV) cameras would likely be mainstream in Region 1, but they may not be mainstream yet in some of the rural regions. The second tier would be comprised of "emerging technologies" – i.e. devices which may be limited or non-standardized in deployment. Emerging technologies would be classified not necessarily as technologically new technologies, but technologies that are relatively new to ODOT. Therefore, this would include new technologies such as travel time estimation and automatic incident detection systems, as well as older but non-standardized technologies such as variable message signs (VMS).

ODOT Organizational Unit / Title	Primary Role	Primary Maintenance Responsibilities
TOC	Oversight for ITS maintenance	• Initiates the maintenance process • Initiates the maintenance record
Regional ITS Support Coordinators	First line of ITS maintenance	• Determine if vendor should be first point of contact for a particular repair • Perform initial diagnosis • Repair problems to the extent they are capable • Test repairs • Complete repair log • Track entire maintenance process
District/Regional Maintenance Staff	Second line of ITS maintenance	• Identify device failures • Provide early notification • Perform maintenance requiring specialized equipment, such as bucket trucks • Perform maintenance requiring specialized training, such as an electrician's license
Information Services	Second line of ITS maintenance	• Repair problems related to communications and computers for back-end ITS equipment including network connections to roadside devices
TSSU	Third line of ITS maintenance	• Diagnose and repair problems beyond capability of support coordinator and electrician for roadside devices and sensors
Vendors	Last line of ITS maintenance	• Fulfill vendor maintenance agreements • Diagnose and repair problems beyond ODOT capabilities

Table C-2: Roles and Responsibilities for Coordinated ITS Maintenance Model.

Over time, perhaps as long as five to ten years, it is hoped that emerging technologies would become "mainstreamed." As devices are mainstreamed, the support coordinators would be responsible for ensuring electricians are adequately trained to perform diagnostic and repair maintenance.

The repair process for this model is shown in Figure C-3. The two-tiered model looks slightly more complicated than the previous alternatives analyzed because it has an additional decision layer based on whether a ITS technology has been mainstreamed yet. However, the model is fundamentally similar to the coordinated ITS maintenance model in that it provides for the support coordinator to be the single point-of-contact once the TOC learns of an ITS device failure. The process itself differs depending upon what type of ITS device is in need of repair.

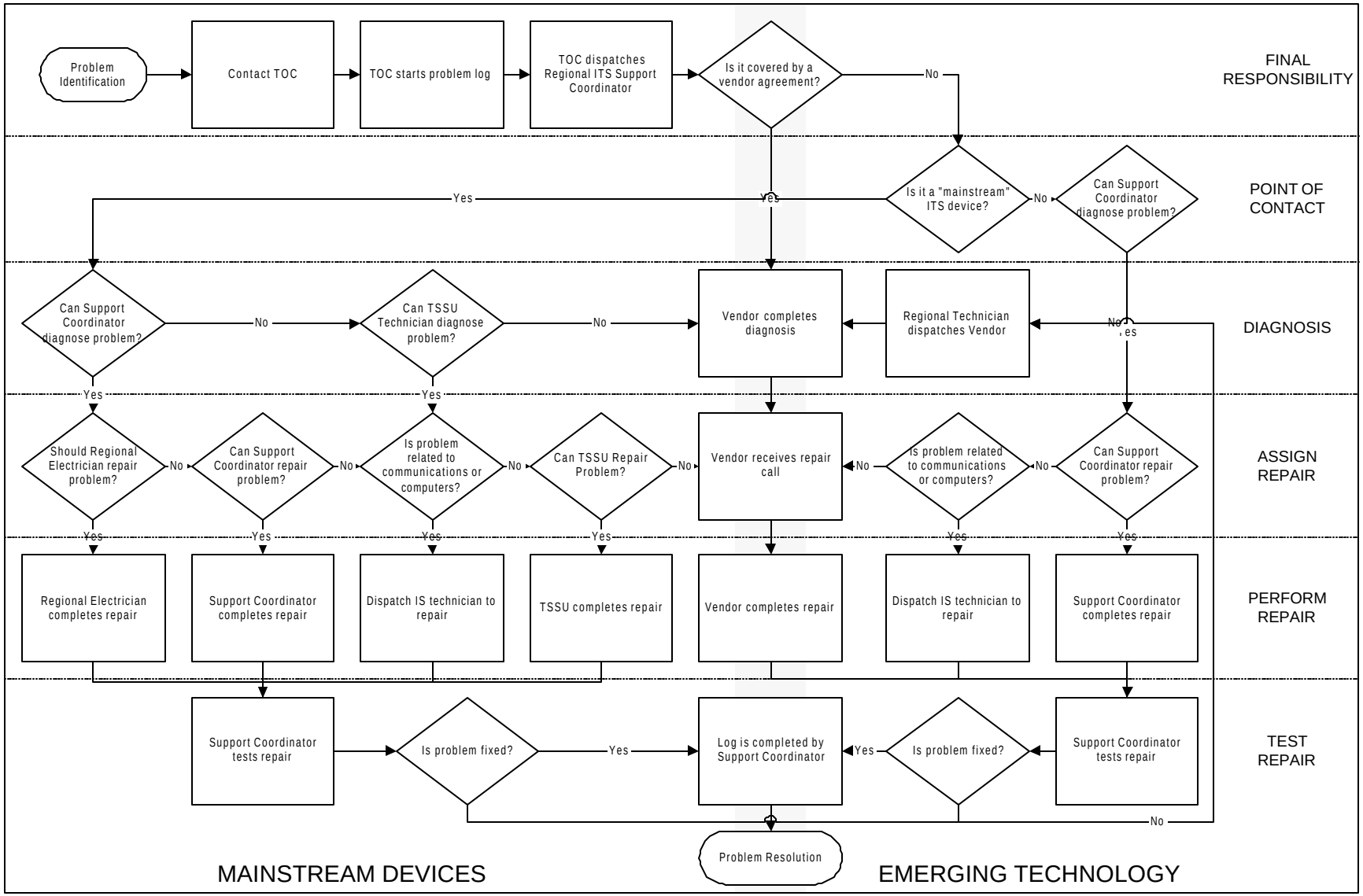

Figure C-3: Repair Process for Two-Tier Maintenance Model.

- Mainstream devices. If the device has been mainstreamed, regional electricians should be able to fully diagnose and repair most problems on most occasions. Once the problem is diagnosed, the electrician will complete the repair, or if the electrician is unable to repair the problem, Information Services, TSSU or ultimately the vendor may be contacted. This parallels current maintenance practices on traffic signals, where TSSU is called in if the regional electricians are unable to satisfactorily resolve a signal malfunction. It should be emphasized, however, that even on mainstream devices the support coordinator is the point-of-contact responsible for tracking maintenance and ensuring that all maintenance activities are accurately logged.

- Emerging technologies. If the device has not yet been mainstreamed, then the regional ITS support coordinator will be the first line of repair. In some cases, non-mainstreamed devices will have vendor warranties covering maintenance for a certain period of time. In most cases, however, the support coordinator may need to be well acquainted with several technologies of the same device in order to be able to perform diagnostics and most simple repairs. For communications and computer-related problems, the support coordinator would dispatch Information Services for support. The vendor would be used as a final line of support.

Table C-3 highlights the roles and responsibilities of ODOT staff under a two-tiered approach. At the district or regional maintenance level, electricians will need to be in a continual learning mode in order to become familiar with technologies as they are mainstreamed. Because increased deployments would place a greater maintenance burden on the districts, this model requires that districts need to be able to expand staffing levels as the number of mainstream devices increases. The regional support coordinators would continue to be the single point-of-contact for maintenance, and would have a role in training the regional electricians, but their larger responsibility would be to handle the maintenance of emerging technologies. Like the regional electricians, the support coordinators will need to be in a continual learning mode in order to stay abreast of current and future ITS deployment technologies.

C.4 Contractor-Based

The final model alternative to be considered parallels what is being done by ODOT's Motor Carrier Transportation Division: rely on a contractor to perform and track all maintenance activities. This would enable ODOT to maintain additional ITS technologies and devices without having to be concerned about staffing constraints. It frees ODOT of the responsibility of learning new technologies, and – as Figure C-4 indicates – it can potentially simplify the maintenance process by reducing the number of hand-offs among ODOT staff.

The Motor Carrier Transportation Division has expressed satisfaction with its current contract maintenance arrangement. They have what is termed an "extended warranty" provided by the original equipment manufacturer to perform maintenance services adequate to keep their devices in good working order. The contract includes performance specifications for reporting, tracking, and response time.

ODOT Organizational Unit / Title	Primary Role	Primary Maintenance Responsibilities
TOC	Oversight for ITS maintenance	• Initiates the maintenance process • Initiates the maintenance record
Regional ITS Support Coordinators	First line of ITS maintenance	• Determine if vendor should be first point of contact for a particular repair • Coordinate repair activities • Track entire maintenance process Mainstream Devices • Lead field repair efforts after unsuccessful repair Emerging Technologies • Diagnose most ITS problems • Repair problems to the extent they are capable • Test repairs • Complete repair log
District/Regional Maintenance Staff	First line of ITS maintenance for mainstream devices; no responsibility for emerging technologies	Mainstream Devices • Perform initial diagnosis • Repair problems to the extent they are capable • Test repairs • Complete repair log Emerging Technologies • No ITS maintenance responsibilities
Information Services	Second line of ITS maintenance	• Repair problems related to communications and computers for back-end ITS equipment including network connections to roadside devices
TSSU	Third line of ITS maintenance for mainstream devices; no responsibility for emerging technologies	Mainstream Devices • Diagnose and repair problems beyond capability of regional electricians for roadside devices and sensors Emerging Technologies • No maintenance repair responsibilities
Vendors	Last line of ITS maintenance for mainstream devices and emerging technologies	• Fulfill vendor maintenance agreements • Diagnose and repair problems beyond ODOT capabilities

Table C-3: Roles and Responsibilities for Two-Tier Maintenance Model.

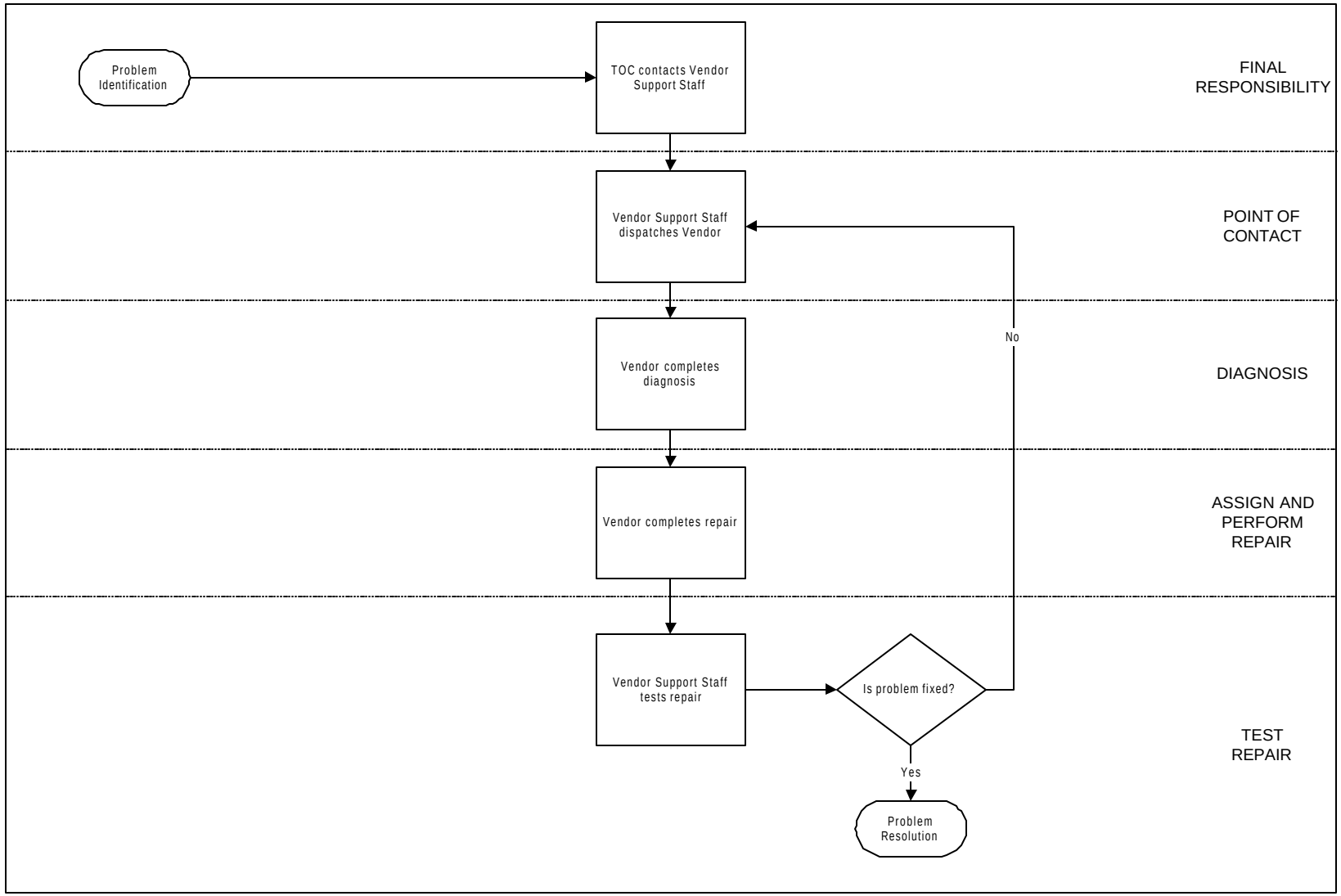

Figure C-4: Repair Process for Contractor-Based Maintenance Model.

ODOT Organizational Unit / Title	Primary Role	Primary Maintenance Responsibilities
TOC	Oversight for ITS maintenance	• Initiate the maintenance process
Contract Support Staff	ODOT interface with ITS maintenance vendor	• Contact the contractor to perform a repair • Identify and coordinate handoffs between contractors, and between vendor and ODOT • Test all repairs to ensure repair has been satisfactory • Track contractor performance in meeting obligations
Contractors	Perform ITS maintenance	• Diagnose all problems • Repair all problems • Log and track all maintenance tasks
Information Services	Perform ITS maintenance related to ODOT's wide-area network	• Perform communications and computer-related maintenance issues as identified by contract
District/Regional Maintenance Staff, TSSU	Limited role in ITS maintenance	• Perform maintenance requiring specialized equipment, such as bucket trucks • Perform maintenance requiring specialized training, such as an electrician's license • Perform basic repairs (i.e. rebooting a server)

Table C-4: Roles and Responsibilities for Contractor-Based Maintenance Model.

Under a contractor-based model, there will be a need for some coordination between contractor-supported infrastructure and ODOT-supported infrastructure. This is especially true for any interfaces that a device has with ODOT's wide-area computer network or proprietary communications links. Consequently, this model includes a contract support staff position who would be responsible for understanding where the contractor's area of responsibility ends and where ODOT staff needs to assist.

As Table C-4 shows, a purely contractor-based model greatly reduces the ITS maintenance responsibilities of ODOT staff. On the other hand, a purely contractor-based model may be difficult to implement on a statewide level without being prohibitively expensive.

C.5 Comparison of Alternatives

Table C-5 presents a table comparing each of the four model alternatives that have been presented. The table summarizes some of the information about each alternative's maintenance process, as well as presenting key advantages and disadvantages of each alternative.

	District/Regional Maintenance Model	Coordinated ITS Maintenance Model	Two-Tier Maintenance Model	Contractor-Based Maintenance Model
Description	Perform all maintenance through districts and regions	Coordinate ITS maintenance activities through a separate ITS maintenance unit	Coordinate ITS maintenance based on whether technology is mainstream or emerging	A contractor performs all maintenance activities
Identification	Once problems are identified, they are reported to the TOC	Once problems are identified, they are reported to the TOC	Once problems are identified, they are reported to the TOC	Once problems are identified, they are reported to the TOC
Initial Handoff	The TOC reports problems to the regional electrician	The TOC reports problems to the regional ITS support coordinator	The TOC reports problems to the regional ITS support coordinator	The TOC reports problems to the contract support staff
Verification – who is involved in diagnosis?	• Regional electrician • TSSU • Vendor	• Regional ITS support coordinator • TSSU • Vendor	<u>Mainstream Devices</u> • Regional electrician • TSSU • Vendor <u>Emerging Technologies</u> • Regional ITS support coordinator • Vendor	• Contractor
Repair – who is involved in repair?	• Regional electrician • Information Services • TSSU • Vendor	• Regional ITS support coordinator • Regional electrician • Information Services • TSSU • Vendor	<u>Mainstream Devices</u> • Regional electrician • Information Services • TSSU • Vendor <u>Emerging Technologies</u> • Regional ITS support coordinator • Information Services • Vendor	• Contractor • Information Services

Table C-5: Comparison of Four Alternative Maintenance Models.

	District/Regional Maintenance Model	Coordinated ITS Maintenance Model	Two-Tier Maintenance Model	Contractor-Based Maintenance Model
Logging and Tracking	• TOC initiates maintenance log • TOC tracks maintenance process • Regional electrician logs all maintenance activity until problem is resolved	• TOC initiates maintenance log • Regional support coordinator tracks maintenance process • Regional support coordinator logs all maintenance activity until problem is resolved	• TOC initiates maintenance log • Regional support coordinator tracks maintenance process <u>Mainstream Devices</u> • Regional electrician logs all maintenance activity until problem is resolved <u>Emerging Technologies</u> • Regional support coordinator logs all maintenance activity until problem is resolved	• The contractor is responsible for all logging activities • Contract support staff tracks maintenance process
Advantages and Disadvantages				
Advantages	• Provides clear maintenance process • Maintains current organizational structure • Allows maintenance priorities to be set and followed at a regional level • Promotes mainstreaming of ITS into transportation system • Makes good use of existing diagnostic capabilities within ODOT	• Provides clear maintenance process • Eases district work burden • Strengthens the relationship between design, operation and maintenance of ITS • Improves statewide coordination for procurement, purchasing, standardization, and vendor management • Establishes single point-of-contact for all regional ITS maintenance activities • Enables specialization of skills at first level of support • Simplifies logging, tracking, performance monitoring and evaluation activities	• Provides maintenance process • Provides some relief to district work burden • Simplifies repair process for emerging technologies by involving fewer parties • Addresses technological evolution and training • Uses existing diagnostic capabilities in ODOT • Improves statewide coordination for procurement, purchasing, standardization, and vendor management • Allows for integration between design, operations and maintenance of ITS	• Provides maximum simplicity for handling maintenance • Gives TOCs greater control over meeting response time through contract • Allows for easier integration of new technology • Enables ODOT to provide adequate maintenance even in event of hiring freezes • Greatly reduces maintenance burden on districts

Table C-5: Comparison of Four Alternative Maintenance Models. (continued)

	District/Regional Maintenance Model	Coordinated ITS Maintenance Model	Two-Tier Maintenance Model	Contractor-Based Maintenance Model
Advantages and Disadvantages (continued)				
Disadvantages	• Requires significant training to address current deficiencies • Increases district maintenance burden unless districts are able to add staff • Discourages resource sharing across regions • Does not recognize statewide aspect of ITS and the connectedness of devices • May underprovide ITS maintenance due to competing priorities with non-ITS maintenance • Preserves disconnection between design, operations and maintenance of ITS	• Adds travel time by duplicating trips made by electricians • Discourages mainstreaming of ITS into transportation system • Limits career path for regional electricians	• Adds additional level of complication to logging and tracking • Requires increase in regional/district staffing levels to maintain increasing number of mainstream devices • Requires identification of which devices are mainstream and which are emerging, and what the transition point is	• Increases difficulty in containing maintenance costs • Significantly underutilizes or reduces in-house technical capabilities • Discourages mainstreaming of ITS into transportation system • Requires high-quality contractors with good service • Assumes one-size-fits-all vertical integration by contractors

Table C-5: Comparison of Four Alternative Maintenance Models. (continued)

C.6 Stakeholder Meetings

A maintenance model can be successfully and effectively implemented onto an existing organizational structure only if there is "buy in" from individuals throughout the organization. Consequently, a series of stakeholder meetings between WTI and ODOT staff were held in August 1999 to discuss and compare alternatives. It was hoped that these meetings would result in a broad consensus regarding a preferred maintenance model. In order to avoid artificially manufacturing consensus, separate meetings were held with different groups in order to encourage dissenting opinions to be aired. Meetings were held with the following five groups:

- Transportation Operation Center (TOC) managers,
- Transportation Data Section (TDS),
- Information Services (IS),
- Traffic Signals Systems Unit (TSSU), and
- Maintenance Leadership Team (MLT).

The meetings focused on ensuring that stakeholders had a working understanding of each of the alternative models, and then soliciting feedback. It was emphasized that these models were not intended to be "finished products," so suggestions for improvements and modifications were encouraged. The following were some of the highlights of the discussion:

- No one expressed any preference for the district/regional maintenance model. This model closely reflects how most ITS maintenance is currently done. Therefore, this reflected a desire among stakeholders across the board to improve the maintenance model.

- Having a single point-of-contact was a popular model component. This ensures that there is follow-through on problems until they are resolved. Even though the two-tier maintenance model is more complicated than the district/regional maintenance model, the extra layers of complication would be transparent to stakeholders because the support coordinator would be responsible for tracking all of the activity.

- A support coordinator position brings a connection between operations and maintenance. Some stakeholders said that ITS device failures are often not viewed as critical maintenance needs because maintenance staff do not understand the operational necessity of the new technology.

- Stakeholders were generally averse to using a purely contractor-based approach. Stakeholders readily cited the benefits of the contractor-based approach, especially its ability to bypass existing staffing resource constraints. However, stakeholders generally agreed that this alternative would be expensive, "scary," difficult to implement because of integration with ODOT's network, and would leave ODOT vulnerable to situations where in-house skill is necessary such as emergencies or contractor bankruptcy. It was agreed that contractors would appropriate in some circumstances, and that none of the other alternatives preclude the selective use of contractors.

- The success of the two-tier and coordinated ITS maintenance models is highly dependent upon finding an appropriately skilled support coordinator. Stakeholders felt that the support coordinator would need to be somewhat of a generalist with enough knowledge about various ITS devices to ask the right questions.

- Stakeholders had a broad consensus in support of the two-tier alternative. Stakeholders commented that this combined the strengths of the district/regional and coordinated ITS maintenance models, while allowing contractors to be used to compensate for skills or resources shortfalls.