Maintenance of Outside Plant (OSP) Facilities

Overview

In order for cable systems to consistently be implemented, including the supporting infrastructure, standards must be developed and consistently adhered to as network implementation goes forward. The quality of the design and construction of the OSP network, along with the creation and adherence to a maintenance plan, are essential for the survivability and reliability of the facilities. Establishing a routine maintenance schedule for the network is necessary to support the network and the customers.

Outside Plant (OSP) Infrastructure Characteristics

A quality-designed, reliable OSP infrastructure that is easily maintained must be based on:

- Sound engineering and detailed design practices.
- Quality construction and the use of premium materials within the OSP infrastructure.
- Complete and detailed as-built documentation, which includes as-built drawings and cable records.
- Provision of spare ducts, optical fiber strands, and balanced twisted-pairs for future growth and expansion.
- Route diversity preventing service failures (enhance survivability).
- Spare equipment capacity to ensure availability for rapid response to service interruptions.
- Adequate equipment spares to minimize the mean time between failures.

Maintenance Practices

The purpose of maintenance is to extend the useful life of the installed plant. Maintenance practices can be divided into several categories. One basic separation is the distinction between routine and demand maintenance. Every OSP infrastructure requires ongoing maintenance. Age, exposure to weather, and other factors may cause the need for maintenance.

OSP products have varying life expectancies. Items such as poles and conduit are expected to last for many years. Cables have a shorter service life, but they still can be useful for 30 to 40 years. It is not uncommon to find treated wood duct still carrying lead-sheathed cables, although for many reasons (e.g., capacity, service, environmental concerns), these are unusual situations.

The initial capital investment is only a fraction of the total cost of maintaining the facility during its useful life. Consequently, there is a strong need to design the OSP in the above manner, starting from the initial design and installation to minimize the long-term cost of keeping it in service. The facility should be maintained during its life cycle with a plan consisting of routine inspection and maintenance for all spaces, pathways, and splice enclosures to extend and enhance the network performance capabilities.

Many current OSP products are associated with analog and digital electronic technology. The development and evolution of these products continue so that each succeeding generation may be smaller, faster, more competent, more robust, or another combination of desirable features.

The decision of when to replace existing OSP is usually an economic one. It may be better to replace a component prior to the end of its service life in order to upgrade the capability of the OSP infrastructure rather than to continue its service and have a comparatively reduced capability.

The choice to augment the existing plant or to remove and replace it is determined by the age and the condition of the facility. This decision is also influenced by the available capacity of the support structure (e.g., joint use or solely owned pole lines, available conduits, utility tunnels, right-of-way [R/W] access).

This chapter is concerned with how to obtain the maximum use of installed components. Determining when to replace OSP that has remaining life is an economic decision and will not be addressed in this chapter. The OSP engineer or information and communications technology designer must be prepared to provide cost justification documentation for the expenditure of funds to augment the network.

Detailed Maintenance Plan

System maintenance starts with a complete and thorough understanding of the network and its associated documentation. A detailed maintenance plan must be established and in place to ensure smooth system maintenance.

At a minimum, the system maintenance plan must address:

- Personnel availability and skill set requirements.
- Product training, including hands-on familiarization with new products.
- Codes, standards, and safety training to maintain skill levels to minimize substandard or unsafe work habits.
- Current documentation with detailed records of circuits, optical fibers, and cables.
- Cable records maintained for the OSP staff to identify potential issues that affect service.
- Up-to-date pathway segment records with mandrel and rodding history.
- Current maintenance hole (MH [butterfly]) detail drawings with call out notes on the master record maps.
- Installed equipment baseline—This includes the current version of installed equipment, documented option settings, port configurations, and other information needed for the repair or restoration of individual circuits.
- Storage and availability of repair materials—This includes the procedures and process necessary for replenishing materials as they are used. Some quantity of materials must be available to the restoration teams on a 24/7 basis. The maintenance plan must address how this material is to be obtained by the restoration team outside the normal working hours of the support center.
- Initial and sustaining training—The maintenance plan must establish guidelines for training of the initial skill sets necessary for normal operations as well as provide a method for ensuring continued development of the workforce needed. Backup personnel must be available for long-term support and operations.
- Restoration procedures—The maintenance plan must establish policies and practices for the routine maintenance and support of the system, demand maintenance, response to requirements driven by public demand (e.g., road moves, customer demands), or natural events (e.g., floods, lightning hits, structural failures). In the event of unplanned system outages along with the policies and practices for routine and demand maintenance, special procedures and policies must be established for emergency or quick system recovery.
- Maintenance schedule for all OSP equipment, including periodic testing and calibration.
- Management escalation procedures with contact information for emergency call out of all of the workforce.
- Warning tapes installed with all new buried and underground construction.

Routine Maintenance

Routine maintenance is the periodic and continued examination of the facilities for abnormal or altered conditions (see Table 9.1). This may be done by physical inspection or by using sophisticated network monitoring and surveillance systems that can detect abnormalities in the facilities, such as:

- Changes in resistivity.
- Indications of degradation and loss of sheath integrity.
- Moisture intrusion.
- The introduction of service affecting factors (e.g., ground potential rise, buried handhole).

Table 9.1
Routine maintenance checklist

Description	Frequency of Maintenance	Actions
Inspect all ground locations and connections.	Ongoing	Report any defective conditions for immediate corrective action.
Inspect building entry points for possible seepage.	Ongoing	Inspect after any work is performed in building entry room.
Inspect all conduit duct systems.	Ongoing	Seal all ducts after any and all work in MHs and EFs.
Inspect and pump MHs, vaults, and PBs.	Ongoing	Perform after all heavy rains and in areas prone to freezing during and after all thaws.
Clean MHs, vaults, and PBs.	Ongoing	Work activity shall dictate; prepare report if required.
Seal all ducts (vacant and occupied).	Ongoing	Work activity shall dictate; prepare report if required.
Inspect outside splice enclosure.	Ongoing	Work activity shall dictate; prepare report if required.
Routinely inspect buried routes for potential damage.	Ongoing	To determine if any activity has impacted the route, prepare report and take corrective action.
Routinely inspect utility tunnels in the route.	Ongoing	To determine if any activity has impacted large campus sites, prepare report and take corrective action.

EF = Entrance facility
MH = Maintenance hole
PB = Pull box

Routine Maintenance, continued

Monitoring systems are designed to be preventive and do not affect service. They are proactive and designed to detect that a failure may be imminent. The network monitoring and surveillance systems enable the targeted dispatch of a technician without the need for routinely spending time covering cable routes that are not in a pre-failure mode.

Routine maintenance frequently gets less support because it is difficult to place a value on unreported issues that require repairs as opposed to the cost of a routine maintenance program. Routine maintenance involves more than looking for potential problems. It ensures that the OSP infrastructure is safe and that employees and the public are not exposed to dangerous conditions.

As a result, maintenance includes ensuring cabling and optical fiber integrity as well as verifying that:

- Poles, guys, and anchors are sound.
- Route markers are in place to protect buried and underground routes of the OSP network.
- No dangerous electrical conditions have developed from unauthorized attachments, defective grounds, or missing grounds. Verification also includes compliance with safety regulations of the authority having jurisdiction (AHJ).

Programs that fall under routine maintenance include:

- T zone inspections for aerial plant—This area includes the cable attached to a pole and extending ≈0.91 meters (m [3 feet (ft)]) to either side (effectively forming a "T" when viewed as a segment), which can be a major area of trouble. This zone normally includes the terminal, service wire attachments, and splices. It is a location for high technician activity. Owners should focus their routine maintenance efforts here, checking that splices and splice cases have integrity, terminals are clean (e.g., no dead service drops, no wasp nests or rodent intrusion, no open covers), poles are structurally sound, clearances are up to standard, and any attachments by foreign companies are authorized and compliant.
- Tree trimming—Periodic tree trimming is necessary to prevent problems of sheath abrasion or damage that degrades transmission capabilities. Routine tree trimming and vegetation management is required in pathways that are off-premises and cross-country or along R/Ws with overhanging tree branches. Annual work is usually required for this process. Chemical foliage management may be utilized, providing the AHJ allows its use and it adheres to environmental regulations.
- Pole inspections—Poles are periodically checked for pole deterioration, sufficient pole height to carry the facilities, unauthorized attachments (this is similar to T zone inspections but does not involve climbing the pole to check for bonding, grounding [earthing], and terminal faceplate conditions), or other abnormalities (e.g., defective guys and anchors or ground wires). Pole inspections ensure employee and public safety and that clearance infractions are reported and cleared.

Routine Maintenance, continued

- Direct-buried cable terminal maintenance—Similar to aerial terminals, the conditions of the terminal and surrounding environment are checked for items like housekeeping (e.g., dead jumpers, stenciling, pea gravel, corrosion, rodent damage) and vandalism. This program includes large cross-connect interfaces and smaller distribution terminals, whereas other programs focus only on serving area interfaces because of normal high activity.
- Maintenance of underground facilities (including underground terminals in MHs)—Debris and contamination can enter MHs and utility tunnels through conduits, cracks in the walls caused by earth movement, and covers not properly sealed. Moisture seepage will enter through joints of prefabricated units (MHs) that are not properly installed. These can damage cables, splices, and MH hardware if ignored, and they can create an unsafe environment for workers.
- Maintenance of OSP identification methods—OSP is labeled or stenciled for easy identification. Over time, labels become damaged, fall off or fade, and become illegible. The OSP's owner should maintain proper labeling. Labels are required for identification and to contact the owner in case of emergency, damages, or relocation needs. The system should be standardized and clear to anyone who needs to know the plant's owner.
- R/W inspections—Routes designed through R/W may become impaired because of tree growth, the facilities of others, or encroachments. R/Ws may be managed by surveillance and routine inspections. Personnel assigned to this task may have to request the removal or relocation of these encroachments on OSP R/Ws. A R/W grant occasionally must be defended.
- Air pressure maintenance—Various air pressure monitoring systems are commercially available to identify the location of air leakage above target levels and to effectively direct labor to locate and fix leaks before cables become wet. Pressure and cable maintenance activities should be consolidated, where practical, for efficiency and to avoid duplication of efforts.
- Defective cable pair recovery program—Depending on the demand for spare pairs, it may be useful to identify locations where a cluster of defects exists and attempt to recover these pairs. Defects usually occur at splice and termination points as opposed to within the sheath. At such locations, minimal effort can recover a number of cable pairs or prevent a potential future failure. Entering splices where a substantial number of bad pairs have been traced may be counterproductive and should be identified as not to be entered.
- OSP pathway structures (e.g., MHs, tunnels, substructures)—These are required to be inspected periodically to ensure their integrity from potential damages from earth movement, ground thaw, earthquakes, or construction activity by others.

Demand Maintenance

Demand maintenance may be caused by requirements such as:

- Responding to facility location requests from underground location services or one-call centers. This is a mandated requirement in many jurisdictions and usually has a finite time frame for the response. It is a significant factor in reducing the amount of service interruptions caused by earth removal.
- Responding to customer service demands.
- Relocation of OSP because of road improvements—OSP located within a public R/W may require relocation at the owner's expense because of road rebuild or relocation. This requirement varies by jurisdiction. With a secured easement, the cost for relocations may allow for billing back to the agency doing the improvements, but the relocation will still be required at the agency's schedule. Property owners have the right to improve or widen within their area.
- Site improvements (e.g., drainage problems).
- Property additions that conflict with existing OSP (e.g., new buildings, driveways), whether underground, direct-buried, or aerial.
- Changes in clearance, separation, and general pole spacing.
- Obligations under joint use agreements—An obligation exists to rearrange the OSP to accommodate the other user, replace the pole for additional height and clearance, and conduct periodic inspections to ensure compliance with joint use regulations. One advantage of joint use agreements is that the cost of occupancy for the parties is reduced.
- Recordkeeping—Recordkeeping is an administrative requirement since both the user and the owner want to be sure that the costs are properly allocated. Joint use administration is generally processed and the records updated through a third-party organization (e.g., joint pole authority). The administrative costs are shared by the member parties, and the obligations under each of these situations are understood when the agreement is negotiated. These obligations may include:
  - Rearrangement—Whenever the OSP is located on joint use pole lines, the requirements of other authorized tenants or the pole owner may necessitate rearrangements of the cables. This may be as simple as transferring and raising the facilities or as complex as relocating to newly located poles. An OSP engineer or designer should be assigned to address these requests and to handle design, negotiation, and administrative requirements.
  - Pole replacement—Poles may need to be replaced because of damage, clearances, or other reasons. Depending on the agreement, the pole owner may do the replacement and plant transfers for all parties or may require each tenant to do its own.

    NOTE: Replacement and plant transfers by pole owners are rarely done because of safety issues handling the facilities of others.

    The pole replacement requirement should be understood in advance. Joint use documentation should spell out what is to be done by the occupants of the pole in question. If the owner of the pole does the work, then this cost will be billed back to the OSP owner. If the OSP owner performs the work, then an appropriate contractor workforce should be available on demand to provide this service.

Demand Maintenance, continued

- Response to network monitoring and surveillance systems that indicate imminent trouble to a pressurized cable. Pressure monitoring equipment will provide valuable information for locating potential damages before an outage occurs.
- Changes in road elevation (e.g., repaving, rerouting) that require changes in the thickness (depth) of the MH collar.

Demand maintenance also can be caused by damage to the facilities through weather, motor vehicle collisions, road washouts, floods, and physical degradation (see Table 9.2). The damage may or may not create an out-of-service condition. Hazards to the public or the risk of losing the facility will require an immediate response. These conditions are addressed in detail later in this chapter.

Table 9.2
Demand maintenance

Description	Frequency of Maintenance	Actions
Network monitoring and surveillance systems.	Ongoing	All detection reports reviewed and dispatched, if required.
All reports logged and disposition.	Ongoing	All incident reports cleared and recorded.
Inspect and pump MHs, vaults, and PBs.	Monthly	Perform after all heavy rains and in areas prone to freezing during/after all thaws.
Clean MHs, vaults, and PBs.	Ongoing	If the MH/PB is entered, it should be left clean; incident report written and logged for follow-up work.
Seal all ducts vacant and occupied.	Ongoing	Incident report written and logged for follow-up work.
Inspect outside splice enclosure.	Seasonally	Visual inspection only unless cause for breaking the seal.
Inspect buried routes for potential damage.	Ongoing	Report excavation activities near the buried routes. Report wash out areas or similar terrain changes.
Inspect utility tunnels in large campus sites.	Ongoing	Work activity shall dictate; prepare a report if necessary to involve other utilities.
Inspect and tighten all bonding and grounding (earthing).	Ongoing	Work activity shall dictate; prepare a report if necessary to involve other utilities.
Inspect poles.	On-demand	Tag unsafe conditions.

MH = Maintenance hole
PB = Pull box

Emergency Restoration Procedures

Overview

Proper emergency restoration procedures and training can minimize the impact of unforseen events on the organization's network. With good planning and budgeting, the OSP facility will be able to recover from outages in a timely manner. If implemented correctly, these emergency restoration procedures will positively affect performance and longevity and reduce the maintenance costs for the life of the OSP infrastructure.

Critical Elements

One of the more important parts of the maintenance plan is the section dealing with out-of-service emergency restoration procedures.

Critical elements that an emergency restoration plan must address include:

- Identification and contact of essential personnel—During system outages, there must be no delay in contacting key personnel who, in turn, must respond quickly and possess the proper skill sets to repair the outages. These personnel must have predefined duties and roles that are both understood and well practiced.
- Accessing and obtaining materials—Materials set aside for emergency restoration should be easily accessible, readily available to restoration teams, and of sufficient quantities and types of material required.
- Troubleshooting procedures—Basic emergency troubleshooting procedures must be documented in a clear and concise manner. Restoration teams must be familiar with the necessary tasks and duties expected of them. A step-by-step format is recommended for documenting these procedures.
- Restoration tools—Emergency restoration tools and equipment should be set aside and readily available for access by the restoration teams. Reserved equipment should be checked on a regular basis to guarantee its readiness and proper functionality. Do not use worn or obsolete equipment for emergencies. Do not use emergency equipment as a substitute for routine use equipment. Even short-term use of emergency reserves for normal operations with planned replacement in the near future must not be tolerated.
- Circuits—Critical circuits that must be restored promptly must be documented as part of the emergency restoration plan. Priority circuits should be clearly marked and identified. These circuits are the first to be restored. The first goal is to return the OSP infrastructure to operations in a staggered, but prioritized, manner. The secondary goal is to return the system to normal operations and restore it as closely as possible to the original or improved operational parameters when the outage or emergency occurred.
- Test equipment—Emergency restoration test equipment should be set aside and readily available for access by the restoration teams. Reserved equipment should be checked on a regular basis to guarantee its readiness and to verify current calibration as required.
- Connections—Temporary bonding and grounding (earthing) connections are required during emergency work operations to minimize service interruptions and to ensure employee safety.

Critical Elements, continued

The emergency restoration plan must identify and include procedures for permanent restoration and repair. These procedures must provide detailed information showing and explaining the steps necessary for restoring the system to normal operational parameters after an emergency restoration operation has been completed. This may involve creating a plan for systematically cutting over a cable section to a new replacement section. It is insufficient to revert to the normal routine once the service has been restored; the system itself must be returned to normal.

Temporary repairs cannot be left in a provisional status; they must be made permanent. One problem with establishing priorities for the assignment of maintenance resources is that conditions affecting service normally take precedence over conditions that are not affecting service. Once an out-of-service condition is fixed, it drops in priority even though the OSP condition is not returned to its original condition. The entire event must be treated as one, and the permanent repair must be made before it is considered fixed.

While expensive to do, a trial run of the emergency restoration plan should be conducted periodically to ensure that it operates properly. Finding flaws in the plan during its execution under abnormal conditions is not acceptable. The trial run should ensure that:

- All parties know what they are expected to do.
- Records are available and complete.
- Materials, tools, and equipment are ready.

The emergency restoration plan must provide procedures and guidelines for documenting the restoration that occurred, circuit reassignments that may have occurred, and long-term system configuration after all permanent repairs have been completed.

Update the emergency restoration plan following the completion of the after-action report, explaining in detail what caused the outage or emergency condition, and the long- and short-term actions taken to repair the OSP infrastructure. The after-action report must identify any OSP infrastructure documentation that must be revised and replaced. Most importantly, the report must provide an analysis of the occurrence with recommended actions and plans for preventing similar incidents in the future.

These reports must remain in an OSP infrastructure historical file for trend analysis, and copies are to be provided to other support regions to help prevent similar occurrences in those regions. If similar incidents occur, the OSP infrastructure must be evaluated and possibly redesigned to prevent future outages or problems.

Material or equipment resources (e.g., breakdown/maintenance kits) that were expended in the restoration must be replaced.

Restoration Issues

Maintenance will keep OSP in service, but there are occasions when a system or facility failure occurs. Customers expect that outages will be infrequent and of short duration. A plan for addressing any outage must exist and must be understood and implemented by the responsible parties (see Table 9.3).

Table 9.3
Emergency restoration issues

Description	Requirement	Actions
Infrastructure records.	Ongoing, keep current information.	Maintain CAD files and send updates to the field forces; access provided to the restoration forces on demand.
Work order activity marked on the records.	Ongoing, keep current information.	Maintain CAD files and send updates provided to the restoration forces on demand.
Facility records.	Ongoing, keep current information.	MACs updated daily; access provided to the restoration forces on demand.
On-call information.	Ongoing, keep current information.	On-call responsible party has the necessary contact information at all times.
All emergency agencies, fire, medical information.	Ongoing, keep current information.	MACs updated daily; access provided to the restoration forces on demand. Develop a safety plan.
Contractor on-call person.	Ongoing, keep current information.	Develop a contractor roster or a priority list of accredited contractors, their details and competent skill sets.
Outside supply source list.	Ongoing, keep current information.	Visual inspection only unless cause for breaking seal.
Notification of critical users in case of outage.	As soon as possible.	Develop a list of critical users and prioritize notifications. Estimated time of restoral to be as soon as possible.
Placement of temporary air supplies if required.	As soon as possible.	Remove temporary air supply (e.g., nitrogen tanks) after damages have been repaired.

CAD = Computer-aided design
MAC = Move, add, or change