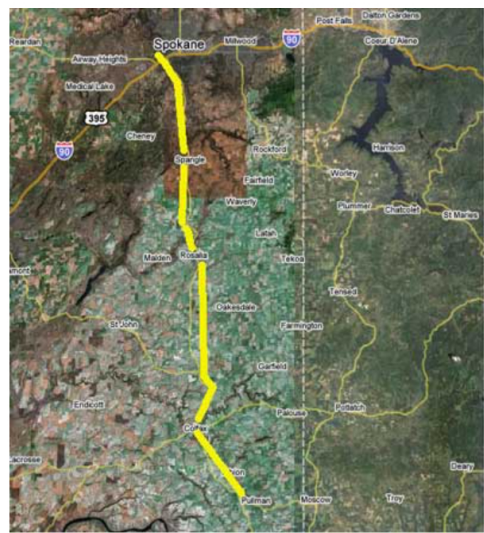


really looks like and then mark up drawings to reflect reality, especially all obstacles to running cabling and hardware and walls requiring firestopping that are not on the current drawings. Take pictures if you can. For buildings under construction, a site visit is still a good idea, just to get a feeling of what the final structure will be like and to get to know the construction managers you will be working with. They may be the best source of information on who the local authorities are who will be inspecting your work and what they expect.



OSP network route on satellite map

With all those options on OSP installations, where do you start? With a good map. Not just a road map or a topographical map, but satellite images overlaid on roads is much better, like “Google Maps” can provide. Creating a route map is the first step, noting other utilities along the route on that map, and checking with groups that document the current utilities to prevent contractors from damaging currently installed pipes and cables.

Once you have marked up maps, the real “fun” begins: finding out whose permission you need to run your cabling. OSP installs are subject to approval by local, state and federal authorities who will influence heavily how your project is designed. Some cities, for example, ban aerial cables. Some have already buried conduit which you can use for specific routes. Since many municipalities have installed city-owned fiber networks, they may have fiber you can rent, rather than go through the hassle of installing your own.

Unless you are doing work for a utility that has someone who already has the contacts and hopefully easements needed, you may get to know a whole new set of people who have control over your activities. And you have to plan for adequate time to get approval from everyone who is involved.

Call Before You Dig



Digging safely is vitally important. The risk is not just interrupting communications, but the life-threatening risk of digging up high-voltage power lines. Some obstacles may be found during site visits, where signs like these are visible. There are

high voltage or gas lines. Some obstacles may be found during site visits, where signs like these are visible. There are several services that maintain databases of the location of underground services that must be contacted before any digging occurs, but mapping these should be done during the design phase and double-checked before digging to ensure having the latest data.

If all this sounds vague, it is. Every project is different and requires some careful analysis of the conditions before even beginning to choose fiber optic components and plan the actual installation. Experience is the best teacher.

Choosing Components

Choosing Components For Outside Plant Installations

The choice of outside plant fiber optic (OSP) components begins with developing the route the cable plant will follow. Once the route is set, one knows where cables will be run, where splices are located and where the cables will be terminated. All that determines what choices must be made on cable type, hardware and sometimes installation methodology.

Cables

When choosing components, most projects start with the choice of a cable. Cable designs are optimized for the application type. In OSP installations, cables may be underground, direct buried, aerial or submarine (or simply underwater.)

Underground cables are generally installed in conduit which is usually a 4 inch (10 cm) conduit with several innerducts for pulling cables. Here cables are designed for high pulling tension and lubricants are used to reduce friction on longer pulls. Automated pulling equipment that limits pulling tension protects the cables. Very long runs or those with more bends in the conduit may need intermediate pulls where cable is pulled, figure-8ed and then pulled to the next stage or intermediate pulling equipment is used. Splices on underground cables are generally stored above ground in a pedestal or in a vault underground. Sufficient excess cable is needed to allow splicing in a controlled environment, usually a splicing trailer, and the storage of excess cable must be considered in the planning stage.

Direct buried cable is placed underground without conduit. Here the cable must be designed to withstand the rigors of being buried in dirt, so it is generally a more rugged cable, armored to prevent harm from rodent chewing or the pressures of dirt and rocks in which it is buried. Direct burial is generally limited to areas where the ground is mostly soil with few rocks down to the depth required so trenching or plowing in cable is easily accomplished. Splices on direct buried cables can be stored above ground in a pedestal or buried underground. Sufficient excess cable is needed to allow splicing in a controlled environment, usually a splicing trailer, and the storage of excess cable must be considered.

Aerial installations go from pole to pole, but the method of securing cables can vary depending on the situation. Some cables are lashed to messengers or other cables, such as CATV where light fiber cables are often lashed to the heavy coax already in place. Cables are available in a "8" configuration with an attached steel messenger that provides the strength to withstand tension on the cable. Some cables are made to directly be supported without a messenger, called all-dielectric self-supporting cables that use special hardware on poles to hold the cables. Optical ground wire is used by utilities for high voltage distribution lines. This cable is an electrical cable with fibers in the middle in a hermetically-sealed metal tube. It is installed just like standard electrical conductors. Splices on aerial cables can be supported on the cables or placed on poles or towers. Most splices are done on the ground, although it is sometimes done in a bucket or even on a tent supported on the pole or tower. Hardware is available for coiling and storing excess cable.

Sometime OSP installations involve running cables across rivers or lakes where other routes are not possible. Special cables are available for this that are more rugged and sealed. Even underwater splice hardware is available. Landings on the shore need to be planned to prevent damage, generally by burying the cable close to shore and marking the landing. Transoceanic links are similar but much more complex, requiring special ships designed for cable laying.

Since OSP applications often use significant lengths of cables, the cables can be made to order, allowing optimization for that particular installation. This usually allows saving costs but requires more knowledge on the part of the user and more time to negotiate with several cable manufacturers.

To begin specifying the cable, one must know how many fibers of what type will be included in each cable. It's important to realize that fiber, especially singlemode fiber used in virtually all OSP installations, is cheap and installation is expensive. Installation of an OSP cable may cost a hundred times the cost of the cable itself. Choosing a singlemode fiber is easy, with basic 1300 nm singlemode (called G.652 fiber) adequate for all but the longest links or those using wavelength-division multiplexing. Those may need special fiber optimized at 1500-1600 nm (G.653 or G.654). For premises and campus cable plants, OM3 type laser-optimized 50/125 multimode fiber is probably the best choice for any multimode OSP runs, as its lower attenuation and higher bandwidth will make most networks work better.

Including more fibers in a cable will not increase the cable cost proportionally; the basic cost of making a cable is fixed but adding fibers will not increase the cost much at all. Choosing a standard design will help reduce costs too, as manufacturers may have the cable in stock or be able to make your cable at the same time as others of similar design. The only real cost for adding more fibers is additional splicing and termination costs, still small with respect to total installed cost. And remember that having additional fibers for future expansion, backup systems or in case of breaks involving individual fibers can save many future headaches.

Common traits of all outside plant cables include strength and water or moisture protection. The necessary strength of the cable will depend on the installation method (see below.) All cables installed outdoors must be rated for moisture and water resistance. Until recently, most people chose a gel-filled cable, but now dry-water blocked cables are widely available and preferred by many users. These cables use water-absorbing tape and power that expands and seals the cable if any water enters the cable. Installers especially prefer the dry cables as it does not require the messy, tedious removal of the gel used in many cables. greatly reducing cable preparation for splicing or termination.

OSP cable construction types are specifically designed for strength depending on where they are to be direct buried, buried in conduit, placed underwater or run aerially on poles. The proper type must be chosen for the cable runs. Some applications may even use several types of cable. Having good construction plans will help in working with cable manufacturers to find the appropriate cable types and ordering sufficient quantities. One must always order more cable than route lengths, to allow for service loops, preparation for termination and excess to save for possible restoration needs in the future.

Like cable types, cable plant hardware types are quite diverse and should be chosen to match the application type and cable types being used. With so many choices in hardware, working with cable manufacturers is the most expeditious way to choose hardware and ensure compatibility. Besides cable compatibility, the hardware must be appropriate for the location, which can be outdoors, hung on poles, buried, underwater, inside pedestals, vaults or buildings, etc. Sometimes the hardware will need to be compatible with local zoning, for example in subdivisions or business parks. The time consumed in choosing this hardware can be lengthy, but is very important for the long term reliability of the cable plant.

Splicing And Termination Hardware

Splicing and termination are the final category of components to be chosen. Most OSP singlemode fiber is fusion spliced for low loss, low reflectance and reliability. Multimode fiber, especially OM2, 3 and 4, is also easily fusion spliced, but if only a few splices are necessary, mechanical splicing may provide adequate performance and reliability.



Finished splices are placed in a splice tray and placed in a splice closure outdoors or optionally in trays on patch panels indoors. They are sealed to prevent moisture reaching the splices and are designed to be re-entered for repair or re-routing fibers. Splice closures are available in hundreds of designs, depending on the placement of the closure, for example underground in a manhole or vault, above ground in a pedestal, buried underground or mounted on a pole. Closures must also be chosen by the number and types of cables being spliced and whether they enter at both ends or only one. The numbers of cables and splices that a closure can accommodate will determine the size of the closure, and those for high fiber count cables can get quite large.

Splice trays generally hold twelve single fiber fusion splices but may hold fewer ribbon or mechanical splices. Each splice tray should securely hold the splice and have a cover to protect the fibers when stacked in the closure.

Singlemode fibers are best terminated by fusion splicing factory-made pigtails onto fibers in the cable and protecting the splices in a closure or patch panel tray. If termination is done directly on multimode OSP cables, breakout kits will be necessary to sleeve fibers for reliability when connectors are directly attached. This takes more installation time than splicing pre-terminated pigtails on the cables, as is common with singlemode fiber cables, and may not save any costs. Even complete preterminated outside cable plant systems are becoming available, reducing the time necessary for termination and splicing. Talk to the cable manufacturers to determine feasibility of this option.

Outdoor terminations are sometimes housed in pedestals or equipment housings such as those used for local phone switches or traffic control systems. Some of these closures may not be fully sealed from dust and moisture, in which case it is recommended that the fiber connections be inside a more protective housing to prevent future unreliability.

Choosing the proper components for OSP installations can take time, but is important for system operation. Once components are chosen, the materials lists are added to the documentation for purchase, installation and future reference.

Choosing Components For Premises Installations

Premises cabling and outside plant cabling will coexist in the entrance facility or the equipment room where the two are connected. The choice of premises fiber optic components are affected by several factors, including the choice of communications equipment, physical routing of the cable plant and building codes and regulations. If the design is a corporate network (LAN), the design will probably include a fiber optic backbone connecting computer rooms to wiring closets. The wiring closets house switches that convert the fiber backbone to UTP copper for cable connected desktops and either copper or fiber to wireless access points. Some desktops, especially in engineering or design departments, may require fiber to the desktop for its greater bandwidth. Extra cables or fibers may be needed for security systems (alarms, access systems or CCTV cameras) and building management systems also.

Design of the fiber optic cable plant requires coordinating with everyone who is involved in the network in any way, including IT personnel, company management, architects and engineers, etc. to ensure all cabling requirements are considered at one time, to allow sharing resources.

As in OSP design, consider the fiber choice first. Most premises networks use multimode fiber, but many users now install hybrid cables with singlemode fibers for future expansion. The 62.5/125 micron fiber (OM1 fiber) that has been used for almost two decades has mostly been superseded by the new 50/125 laser-optimized fiber (OM3), as it offers substantial bandwidth/distance advantages.

Virtually all equipment will operate over 50/125 OM3 fiber just as well as it did on 62.5/125 OM1 fiber, but it's always a good idea to check with the equipment manufacturers to be sure. Remember in the design documentation to include directions to mark all cables and patchpanels with aqua-colored tags, indicative of OM3 fiber.

Cable in premises applications is generally either distribution or breakout cable. Distribution cables have more fibers in a

Cable in premises applications is generally either distribution or breakout cable. Distribution cables have more fibers in a smaller diameter cable, but require termination inside patch panels or wall mounted boxes. Breakout cables are bulky, but they allow direct connection without hardware, making them convenient for industrial use. Fiber count can be an issue, as backbone cables now have many fibers for current use, future expansion and spares, making distribution cables the more popular choice. The cable jacket must be fire-retardant per the NEC, generally OFNR-rated (Riser) unless the cable in air-handling areas above ceilings, where OFNP (plenum) is needed. Cable jacket color for OM3 cables can be ordered in aqua for identification as both fiber optics and OM3 50/125 fibers.

If the cable is going to be run between buildings, indoor/outdoor designs are now available that have dry water-blocking and a double jacket. The outer jacket is moisture-resistant for outdoor use but can be easily stripped, leaving the fire-rated inner jacket for indoor runs.

Fiber optic connector choices are also changing. STs and even SCs are succumbing to the success of the smaller LC connector. Since most fast (gigabit and above) equipment uses LC connectors, using them in the cable plant means only one connector needs to be supported. The LC offers another big advantage for those users who are upgrading to OM3 fiber. The LC connector is incompatible with SC and ST connectors, so using it on 50/125 fiber cable plants prevents mixing 50 and 62.5 fibers with high fiber mismatch losses.

Premises fiber optic cables need to be run separately from copper cables to prevent crushing. Sometimes they are hung carefully below copper cable trays or pulled in innerduct. Using innerduct can save installation time, since the duct (which can be purchased with pull tapes already inside) can be installed quickly without fear of damage and then the fiber optic cable pulled quickly and easily. Some applications may require installing fiber optic cables inside conduit, which requires care to minimize bends, provide intermediate pulls to limit pulling force or use fiber optic cable lubricants.

The hardware necessary for the installation will need to be chosen based on where the cables are terminated. Premises runs are generally point-to-point and are not spliced. Wherever possible, allow room for large radii in the patch panels or wall-mounted boxes to minimize stress on the fibers. Choose hardware that is easy to enter for moves, adds and changes but lockable to prevent intrusion.

In premises applications, it's worth considering a preterminated system. These use backbone cables terminated in multifiber connectors and preterminated patch panel modules. If the facility layout is properly designed, the cable manufacturer can work with you to create a "plug and play" system that needs no on-site termination and the cost may be very competitive to a field-terminated system.

Creating A Materials List

For every installation, a complete materials list must be created listing each component needed and quantities required. This list will be used by the installation crew, but first it will be used to estimate the cost of the project.

It is very important to list every component. Some components can be estimated based on other quantities. Ducts for example will be ordered in lengths similar to the cable pulled into them. Each fiber needs termination on both ends of the cable plant. Splice trays and closures must be ordered according to the numbers of fibers in the cables.

You should include extra quantities for installation. Every splice point, for example, needs 10-20 meters extra cable for splicing in a splice trailer, stripping for the splice and service loops. Extra cable should also be ordered to be kept for possible future restoration. Extra connectors or pigtails are needed to replace those improperly installed during installation. Some contractors routinely order 2-5% more than they estimate is necessary for the job.

While ordering more components than necessary can be costly, it's less expensive than being short during the actual installation, especially for special order items like cables or patchcords. Excess components should be packed and stored as part of a restoration kit.

Cable Plant Link Loss Budget Analysis

Loss budget analysis is the calculation and verification of a fiber optic system's operating characteristics. This encompasses items such as routing, electronics, wavelengths, fiber type, and circuit length. Attenuation and bandwidth are the key parameters for budget loss analysis. The designer should analyze link loss early in the design stage prior to installing a fiber optic system to make certain the system will work over the proposed cable plant.

Both the passive and active components of the circuit can be included in the budget loss calculation. Passive loss is made up of fiber loss, connector loss, and splice loss. Don't forget any couplers or splitters in the link. If the system electronics are already chosen, active components such as wavelength, transmitter power, receiver sensitivity, and dynamic range can be considered. If the electronics are not known, industry generic or standard loss values can be used for the loss budget. Prior to system turn up, test the insertion loss of the cable plant with a source and power meter to ensure that it is within the loss budget.

The idea of a loss budget is to insure the network equipment will work over the installed fiber optic link. It is normal to be conservative over the specifications. Don't use the best possible specs for fiber attenuation or connector loss to allow some margin for installation and component degradation over time.

The best way to illustrate calculating a loss budget is to show how it's done for a typical cable plant, here a 2 km hybrid multimode/singlemode link with 5 connections (2 connectors at each end and 3 connections at patch panels in the link) and one splice in the middle. See the drawings below of the link layout and the instantaneous power in the link at any point along it's length, scaled exactly to the link drawing above it.