OPTICAL FIBER MANAGEMENT for REVENUE GROWTH and PROFITABILITY

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INTRODUCTION

Public networks for voice, video, and data are using ever more optical fiber. Fiber-based communications networks have clear advantages over other media in cost, reliability, and capacity, spurring increased deployment. All public network applications - long-haul trunking, metro rings, and local distribution - are making wide-spread and growing use of fiber. This growth, coupled with the now-common and accelerating use of Dense Wave-Division Multiplexing (DWDM), means that thousands of fibers are terminating in Central Offices (COs) and cable-TV headends.

These fibers carry valuable traffic. As speeds and multiplexing increase, the value of the traffic on each fiber multiplies. The interruption of signal on just one fiber for a few seconds can cost a carrier's customer thousands of dollars, and can cost the carrier that customer. Consequently, high network availability is vital to protecting revenue. Further, if a carrier can demonstrate to its customers that it has superior availability, it may be able to charge premium prices or win additional business. So, network availability contributes directly and significantly to a carrier's ability to generate and protect revenue.

Signal interruptions can result from failures in or damage to optical cable plant, and the duration of an interruption can depend on how long it takes to correct the damage or failures. That optical cable plant includes the hundreds (even thousands) of fiber jumpers and connections found in COs and headends, as well as the cables buried in the ground. Besides the obvious interruptions caused by backhoe dig-ups or disconnecting the wrong jumper, even the subtle degradation caused by jostling adjacent connections at a patch panel can cause serious network availability-affecting incidents. Similarly, the speed with which a carrier can provision or re-arrange a circuit can make the difference between having a customer and not.

Consequently, these thousands of fibers must be administered effectively, to maximize availability and, thereby, help protect and grow revenue. Effective fiber administration also offers carriers the opportunity to reduce costs, by minimizing the time needed to trace and re-arrange circuits, to test and shoot trouble, and to provision service. OFS's LGX® Fiber Distribution System and associated optical cable management products comprise a complete system of hardware and application guidelines that address the effective management optical fibers in COs and headends, to help carriers maximize network availability and minimize costs.

This note will acquaint the reader with the characteristics desired of any optical cable management system, how those characteristics can translate into improved network profitability, and how those characteristics are embodied in OFS products.

EFFECTIVE FIBER MANAGEMENT

With the above considerations in mind, effective management of fiber in a CO or headend includes:

* protecting cables, fibers, connectors, and splices from physical damage
* maintaining minimum bend radii and minimizing bend sensitivity
* facilitating fast, flexible, and easy testing, re-arrangement, and provisioning
* facilitating easy access to connections (for cleaning and re-arrangement), while maximizing density and minimizing adjacent-fiber disturbance and other fiber movement
* minimizing technician error
* facilitating the monitoring of the condition of the fiber network
* promoting fast discovery, identification, and restoration of outages

* facilitating accurate and easy-to-use record-keeping, of CO/headend and outside plant fibers
* minimizing capital, operational, and maintenance costs
* minimizing space used, while maximizing capacity
* facilitating growth
* meeting safety and building standards

Physical damage can cause complete signal loss or can add loss, which itself can cause signal degradation or complete disruption. So, fibers, connectors, and splices should be physically protected. Bent fibers have higher loss, and that loss can cause signal degradation or complete disruption. So, patch panels, cables, and the fiber itself should be designed to maintain minimum bend radii and/or to minimize bending-loss sensitivity. Fibers that move can have increased loss (from bending); so, minimizing fiber movement is desirable Fast and flexible circuit administration can speed bringing up new service and restoring lost service. Any feature that minimizes the risk of error or speeds identification and locating of problems is similarly useful. Space is costly (to own/rent and to supply with power, AC, etc.); so, maximizing the efficiency of its use is beneficial. The deployment of fiber will grow; so, a network that can grow gracefully - by minimizing moves and changing of equipment - is desirable.

All of these factors have gone into and continue to guide the design and evolution of OFS fiber management products and systems. These factors affect not only the design and configuration of the parts, but also how the parts are arranged and connected into a complete, end-to-end optical fiber management system. All OFS fiber management components are designed and tested as integrated systems, to assure network compatibility and integrity. In such an end-to-end system, components match and work well together, thereby maximizing performance and capability. Installation and engineering can go more smoothly and faster, facilitating faster service turn-ups. Training and administration can be more uniform and less costly. Upgrades and expansions are less likely to encounter dead-ends and/or expensive surprises.

OFS FIBER MANAGEMENT SYSTEM

The principal components and subsystems of OFS's Fiber Distribution System are currently:

* LGX Fiber Distribution System
* Pre-cabled LGX Shelves
* Optical Cable Entrance Facility (OCEF)
* Fiber Administration System software
* Jumpers, attentuators, and accessories

These components and sub-systems are deployed as shown in Figure 1.

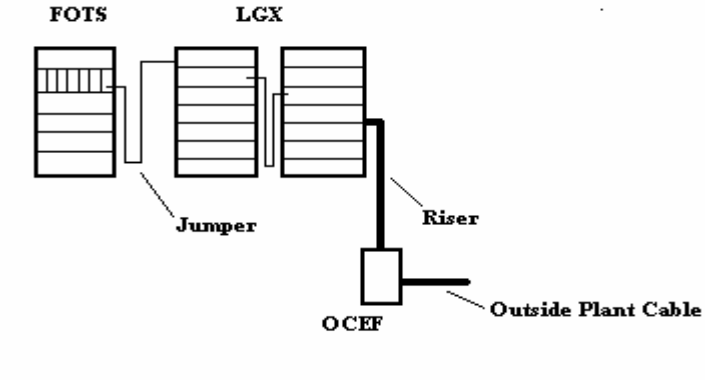

Figure 1.
Typical Deployment of Fiber Management System

LGX Fiber Distribution System

The LGX began in 1985 with the introduction of 11"-deep termination and splicing shelves for 7' bay frames, with 12" footprints. A termination shelf comprised a box, with snap-in panels with connector couplings mounted on them. A splice shelf comprised a box with slide-in-and-out splice trays, which held the splices and organized bare fiber slack. Theses shelves could be stacked in a 7' frame, and frames could be added side-to-side to create a fiber management point as large as needed. Same shelves could be mounted in 23" or 19" frames/racks, or could be wall-mounted with full front access. See Figure 2 for a drawing of a typical shelf.

The LGX was introduced to replace products & methods that greatly limited capacity, wasted space, and were difficult to grow. The LGX was modular, allowing easy, pay-as-you-go growth. It was designed specifically to be configured as a cross-connect, which greatly enhanced the speed and flexibility of circuit provisioning, testing, and re-arrangement. By being designed to grow modularly and in cross-connect configuration, the LGX was/is the optical equivalent of a main distributing frame.

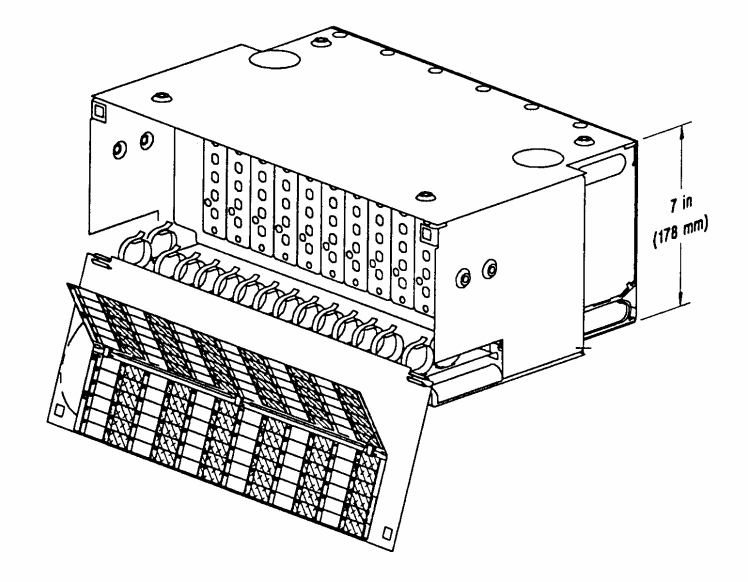

Figure 2.
Typical 72-Fiber LGX Shelf

For the first time, all fiber circuitry could be conveniently and speedily administered from a single frame location, by as few as one person. Previously, terminations tended to scattered about a location, wherever space permitted or electronics happened to be. The consolidation of the LGX brings the means to reduce time and technician requirements for administration of fiber networks, while improving space utilization. In an SC-connector configuration, a single 7' LGX bay can accommodate up to 648 terminations (1008 in high-density format), and a line-up can accommodate up to 12,960 terminations. In an LC® Connector duplex configuration, a single bay can accommodate up to 2016 terminations, and, in a 20-bay lineup can accommodate up to 40,320 terminations.

Further, by its shelf design and the use of special troughs and guides, the LGX greatly improves jumper routing, which minimizes jumper congestion, while facilitating greatly increased density of connections on each panel. The design philosophy is to *minimize the need for slack*, rather than make (and waste) space for slack - space that might not be available or may be constrained by the site. In addition to wasting space, slack tends to pile up and become entangled, making provisioning, tracing, and re-arrangements difficult

and time consuming, and can contribute to added bending loss due to the weight of jumpers impinging on those below.

With the LGX, the minimal slack is stored within the frame, obviating slack-storage shelves and avoiding the cost and wasted space of them. Besides minimizing slack, such an arrangement greatly reduces the number of different jumper lengths needed to populate even a long line-up of frames, which helps reduce inventory requirements. Just a few standard lengths of jumpers can be used for all circuit patching. Despite the space efficiency, jumper routing is easier compared to other systems, even at maximum frame capacity. See Figure 3 for a drawing of a typical line-up of LGX frames.

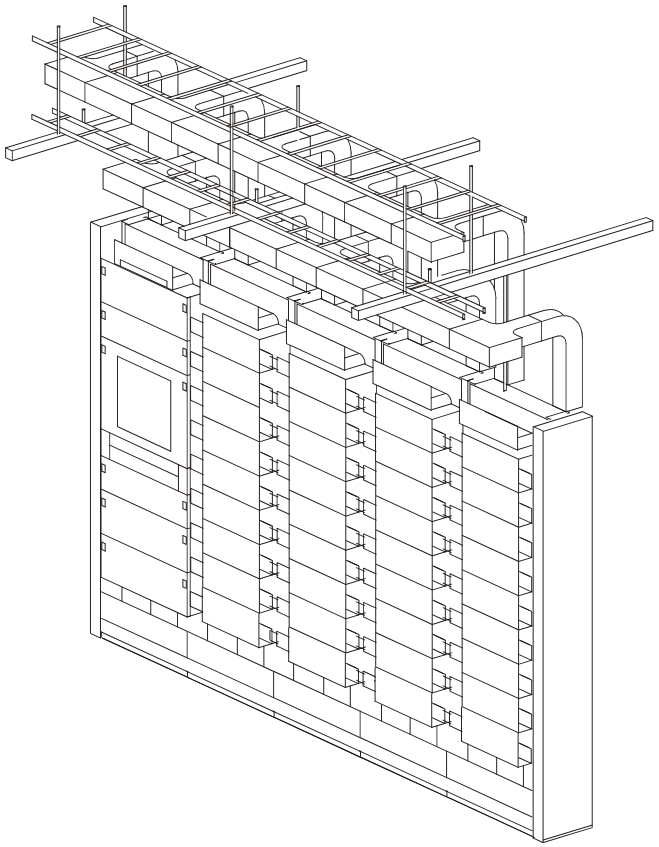

Figure 3.
Typical LGX Line-up

Splitter Modules

The OFS LGX also accommodates a line of splitter modules. These modules plug into one or two open slots in any 7" LGX termination shelf and can be mixed with termination panels in the same shelf. The line comprises both wavelength and powers splitters, in a cassette design. The power-splitter modules can be

used for convenient test and/or monitoring access to the network. The wavelength splitters can also be used for combining and/or splitting multiple traffic signals onto single fibers. These capabilities make these modules potential enablers of both cost-savings (fast, easy test & monitor access) and revenue producers (add/drop/combine traffic). All are dual-band, useful for both 1310 nm and 1550 nm windows. See Figure 4 for a drawing of a typical power-splitter module.

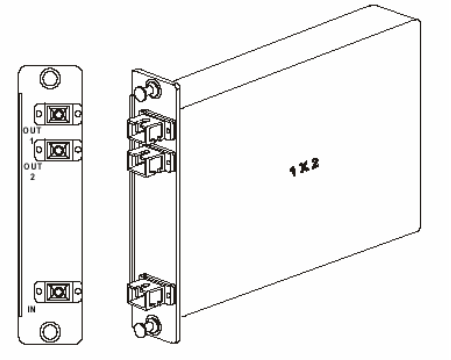

Figure 4.
Typical Plug-In Module

Pre-Cabled Shelves

A major addition to the LGX family was made available in 1990 with the introduction of pre-cabled shelves. These are LGX shelves with up to 144 ports in a single 7" shelf or 216 ports in a 9"-high shelf, factory terminated to an optical riser cable stub. Shelves can be shipped to the site, for fast, ready-to-go, plug-in installation into a frame, dropping the stub into the vault for splicing to the outside plant cable. Before, connectors had to be field-terminated to the riser cable or field-spliced to pigtails (except when ribbon fanout modules were used). Pre-cabled shelves, therefore, greatly help speed installation and engineering, make ordering easier, and greatly reduce the risk of having poor optical terminations. See Figure 5 for a typical pre-cabled shelf.

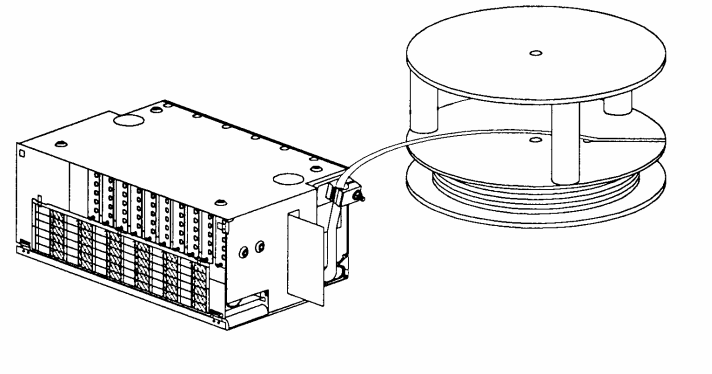

Figure 5.
Pre-Cabled LGX Shelf with Shipping Reel

Multi-Access Modular Unit - MAMU

There are applications where high fiber counts must be accommodated at a cross-connect point, in locations where there is no vault or space does otherwise not permit a separate outside-plant-to-CO splice enclosure. For these applications, OFS introduced the Multi Access Modular Unit (MAMU). A MAMU comprises a

slice shelf and several termination shelves in a single unit. Fanouts in each of the termination shelves have 12-fiber ribbon pigtails that drop to the splice shelf for mass-fusion splicing to outside plant fibers.

MAMUs are currently available in 10 configurations: 216/288-port, 432-port and 864-port, with depressed-clad or AllWave™ Advantage fiber, and accommodating either/both mass-fusion or single-fiber-fusion splicing. See Figure 6 for a drawing of a MAMU.

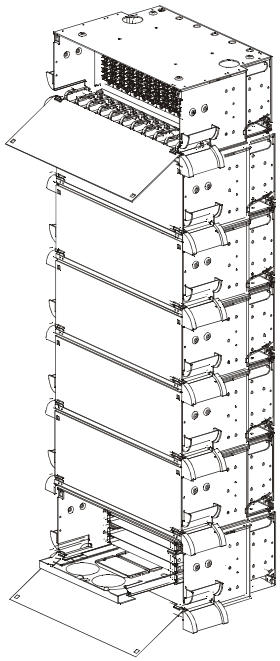

Figure 6.
432-Fiber MAMU

Optical Cable Entrance Facility

The Optical Cable Entrance Facility (OCEF) is a robust cabinet-like, UL Listed box located separately from the LGX line-up, to act as the demarcation point between outside plant and the CO/headend. An OCEF is usually located in the CO/headend *vault*, has outside plant cables entering one side, spliced to riser cables exiting to the LGX line-up on the other. This arrangement removes and isolates outside plant cables from the LGX line-up, thereby enhancing safety and reliability - outside plant cables are usually sheathed in flammable material and have electrically-conducting strength members.

This arrangement also permits terminating many cables in one vault-located cabinet, obviating many vault closures. Using an OCEF also frees space in the LGX for more connections, while consolidating splicing in one (or a few) easy-to-access-and administer splice point. OCEFs are available in two sizes: 576-splice and 1440-splice, either with top/bottom or side entry. See Figure 7 for a drawing of an OCEF.

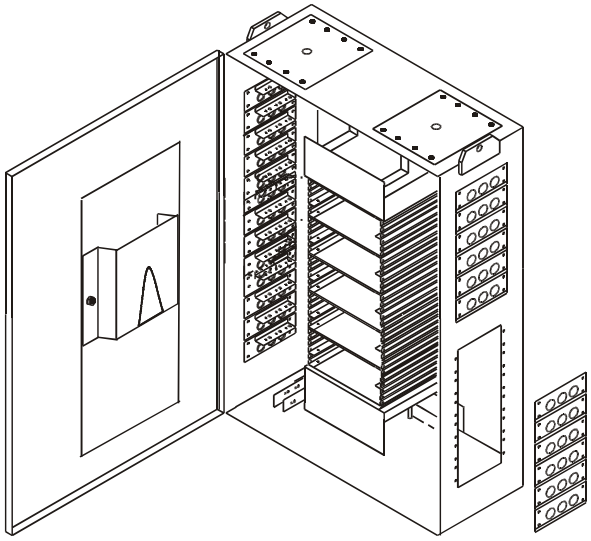

Figure 7.
OCEF

Other Features and Accessories

OFS has many other products and features that are important contributors to proper fiber administration and management. Those products and features include:

* LGX can accommodate virtually all commonly-used optical cable constructions, types, and diameters.
* LGX can accommodate ST, SC, LC, and FC connections, or any mix of them.
* LGX can accommodate mass-fusion, fusion, or mechanical splicing, ribbons or single-fiber
* LGX accommodates the OFS "buildout" system for attenuation, which, as well as easy addition and changing of attenuation, permits the mating of dissimilar connector types, *obviating hybrid jumpers*.
* LGX works best with OFS's optical jumpers, which use *depressed-clad fiber for minimized bend sensitivity.*
* LGX accommodates OFS's small-cross-section "Mini-cord" jumpers, which reduce jumper congestion in high-jumper-density applications.
* LGX has components for implementing *AllWave™ Advantage* applications.

SUMMARY

OFS's Fiber Management System incorporates all the features and capabilities consistent with effective management of fiber networks. It is a system of matched, end-to-end components that meets carriers' current needs and has growth capability for future needs.

For more information about OFS's optical fiber management and connection products, please refer to OFS's **Optical Products Catalog,** OFS's **LGX Fiber Distribution System Reference Guide** or log onto **www.ofsoptics.com.**