White paper

Value of flexibility in fiber telecommunication networks

by Kristof Vastmans

Staying competitive and guarding long-term profitability – these are two crucial drivers for today's network operators. To assure their profitability, operators must optimize their networks – and carefully control both capital and operational expenses (CAPEX and OPEX).

As they build out new networks and upgrade older ones, operators choose products with the end-to-end network in mind. They must select products for diverse environments from central offices and points-of-presence (POP) (both active equipment such as optical line terminals, as well as passive connectivity such as optical distribution frames), through the access network (above ground cabinets, underground sealed enclosures), to last-mile connection boxes inside and outside the customer premises. While choosing products for deployment in their network, they must keep in mind the products' total cost of ownership, taking into account not only the products' initial cost, but also their future functionality. More than ever before, each point in the network needs to be accessible for diagnostics and maintenance, and must provide an open platform to accept emerging technologies, such as NG-PON2 systems using transmission wavelengths up to 1625 nm.

Put simply, each product must provide flexibility required to achieve the whole network's long-term profitability. However, in some cases the requirement for flexibility brings with it installation complexity – and operators have an increasingly limited pool of trained personnel to execute either this installation, or to perform on-going operations of the network. To resolve this contradiction, operators and planners should migrate to product platforms that offer plug-and-play installation and operations, allowing standardization of installation and operational practices, and a simple migration path to new technologies.

An optical distribution frame (ODF), housed in a central office or POP house, is perceived as a fundamental flexibility point in the network – and should be chosen to guarantee cost-effective current functionality as well as future adoption of new technologies and expansion of the network's reach.

Network challenges

Before considering the role played by flexibility points in general, and ODFs in particular, in assuring long-term profitability, let's examine the operators' main challenges.

Establishing a "green image" – and reducing overall costs

To be considered a green company, operators must save energy at all points of the network. This requires reconsidering the amount of space occupied by central offices and POPs, as well as the recurring costs associated with this real estate, costs that including energy, rent, or truck rolls. Very large operators may have as many as 2000 central offices; today, they are reducing this number to as few as 900, representing an overall reduction of central offices by 55-percent. Operators reduce their real estate footprint by consolidating several central offices into a single office – and this consolidation demands product solutions with higher densities.

Availability of trained, skilled technical staff

While high-density solutions help save space and energy costs, they can be more difficult to install and, even more importantly, to use during routine operations. At some operators today, if an intervention operation will take more than an average of 10 minutes, management allows the installer to simply disable the current link and replace it with another. This can lead to a cable pile, containing both used and unused fiber links – and after some years of service, an unmanaged and unmanageable network element. Not only is space wasted by excess fiber cables, but the total cost of owning and operating that equipment will have increased.

Today's access network requires more than 100 time the amount of fiber as in the trunk network. All these fibers require fast, error-free termination. Trunk networks, built according to a "construct and forget" philosophy, primarily employ spicing as the connectivity technology. Splicing requires skilled technical staff – increasingly difficult to find. Splicing also takes time; on average, mass splicing takes three minutes, and discrete splicing takes an average of six minutes each. In order to support the number of fibers necessary in both the central offices/POPs and in the access network, operators are turning to new, simpler technologies that enable fast, easy, fool-proof installation. These new technologies include modular, building-block products (plug-and-play) and multi-fiber push-on (MPO) connectors. Depending on the choice of connectivity, time savings can reach more than 60-percent over splicing. And because these new technologies require less training to use properly, operators save significantly on labor costs for both installation and operations.

Network reliability and network reach

All operators need and want a reliable network. Customer satisfaction and retention depend on consistent delivery of good service. Deployment of plug-and-play connectivity solutions and the use of lower skilled

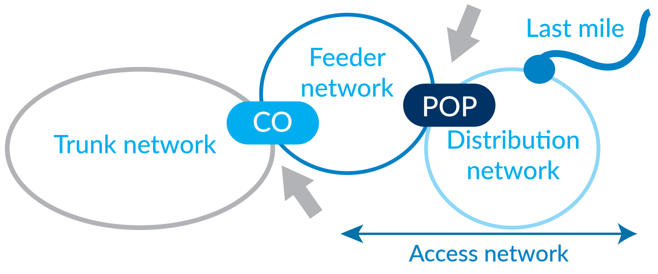


Figure 1: Network segments & consolidation points

installers balances the operators' need to control costs, maintain a reliable network, and work with a pool of lower-skilled (lower responsibility level) technicians.

The rollout of high bandwidth services involves heavy investment and obviously an element of risk. Operators must make a business case with solid take rates in order to justify the costs associated with investments not only in laying fiber cables and installing equipment in the access network, but also either building new or upgrading older central offices and POP stations. However, take rates in population areas of medium to low density can be as low as around 15-percent. By extending their network's reach and increasing the take rate closer to 30-percent, operators can build a profitable network.

Choosing the right connectivity (low-loss connectivity rather than consumer grade, or limiting the number of connections) has a big impact on network reach. Today, an average of nine connection points per customer are found inside a large central office (an office serving more than 50,000 customers). This large number is largely due to poor migration planning and poor documentation of existing fiber links.

ODFs play a critical role in improving and maintaining network reliability and reach. They also provide a platform for adoption of new technologies that extend the network's reach. As new active equipment is introduced, incorporating higher powered, lower cost lasers, ODFs provide a platform for easier customer connections. Optical splitters can be replaced by xWDM modules, delivering more bandwidth to more customers for advanced service offerings.

The choice of ODFs, their design and placement in the network, help address these challenges and contribute directly to the reliability, functionality and profitability of the network.

Keeping these requirements and challenges in mind, let's explore the role of flexibility points at the ODF in

- Controlling both CAPEX and OPEX
- Managing optimum use and assignment of all levels of technical staff
- Expanding network capacity and reach as technologies change and business grows

Layout of central offices and POPs

A total communication network consists of trunk, feeder and distributions networks up to the last mile. A central office (CO) or point-of-presence (POP) can reside at each intersection of these network rings (see Figure 1).

Typically, COs and POPs house active equipment (i.e. DSLAMs) and passive equipment to support copper- and/or fiber-based technologies. In fiber-based networks, active equipment rooms are referred to as "hot islands" and passive equipment rooms as "cold islands". Two types of ODF solutions can connect the hot and cold islands; interconnect and cross-connect. Because of their significant flexibility, this paper will focus on cross-connect ODFs (see Figures 2 and 3).

In essence, cross-connect ODFs achieve full flexibility between two fixed points, establishing an "any to any connection" between the two points. For example, in a POP house, the OSP cable is connectorized and these connections are parked at fixed positions; the same is done on the equipment side. A jumper links each connector from the OSP side to the equipment side. While this type of ODF occupies more space, operators prefer cross-connect ODFs in the following circumstances:

- Separation of the hot and cold islands: The cross-connect ODF delivers the highest energy efficiency. When active and passive equipment is housed together in the same room, the operator must cool the entire area. Separating them into hot and cold islands, allows the operator to localize air conditioning to the equipment most in need.
- High flexibility and re-configurability is required: During network interventions, operators need to limit network downtime. Contractually they must guarantee the quality of service at all times to avoid huge penalties.
- Future expansion is unpredictable
- Scarcity of highly skilled workers: Cross-connect ODFs support easier Day 2 operations, allowing lower skilled technicians to perform routine day-to-day operations, and reserving higher skilled technicians to the specific tasks requiring their expertise. Carefully selected and designed ODFs ensure:
  - Standardized way of working (e.g. the same trays deployed in different network access points, using visual indications for installation and fiber management)
  - Fast and intuitive access to connectors by full accessibility to trays from the front
  - Tool-less installation of optical modules with a plug-and-play approach
  - Reduction of overall weight of ODF elements in order to ease installation and protect installers (e.g. ergonomically designed elements)
  - Upgrade of passive elements and optical modules for a "build-as-you grow" model
  - Adaptability to new connector and fiber technologies with low investment

Assessment of central office flexibility and functionality

As a flexibility point in the network, ODFs perform four basic functions:

1. Protection and identification of incoming and outgoing cables: ODFs organize and fix cables entering the building from outside plant flexibility points.

2. (Mass) fiber connection point: ODFs provide a transition point from outside plant rated cable to cables rated for indoor applications (e.g. low smoke zero halogen, UV and chemical resistant [e.g. resistant to kerosene or oil]). Splicing technology (such as SMOUV or ANT style splice protection) creates the transition from outdoor to indoor cables.

3. (Mass) flexibility point: Connector technology, known in the optical industry as mating/de-mating points, delivers flexibility at the ODF. These flexibility or access points facilitate moves, adds and changes, testing and diagnostics, and migration for emerging technologies (e.g. NG-PON2). SC/UPC and SC/APC connectors are most widely used for connector access points. The trend towards small-form-factor types such as LC/UPC and LC/APC and low loss MPO connectors is mainly driven by equipment manufacturers and will eventually impact the connector technologies used at the ODF.

4. Organization & identification of fiber connections (what's connected to what): Proper fiber overlength storage and maintenance of controlled bend diameter contribute to a mechanically and optically reliable network. Even emergent fiber types such as ITU-T G657A1- A2 – B require careful storage and handling to prevent micro- and macro-bending. Attenuation caused by macrobending is wavelength dependent (see Figure 4).

For the same bend, the increase in attenuation will be higher for the longer wavelengths. As specified in the standards IEC 61756-1 [1] and ITU-T L.13 [2] the recommended minimum permanent storage radius for the conventional single-mode fibers (ITU-T G652D) is 30 mm, however, in local cases a radius of 20 mm is allowed (for example a bend at a connector boot). Future wavelengths up to 1625 nm will increase the importance of bend control to maintain network reliability and guarantee access at critical points.

Bad fiber management directly impacts profitability. It is estimated that approximately 14-percent of active ports can no longer be accessed and are in essence stranded, either under-utilized or not utilized at all. This has a direct negative impact on CAPEX. A recent study traced the main cause of network losses and failures to improper routing by technicians of the functional overlengths of fibers and cables in an ODF.

Flexibility and functionality assessment of a cross-connect ODF

When considering flexibility we come naturally to a discussion of where and why flexibility is required in a central office or POP. All unused "flexibility" has a high impact on density and operating cost of an optical distribution frame. In general, flexibility is required to provide:

- Test access
- Migration paths for future technologies (e.g. NG-PON2)
- A migration path for new active equipment or additional providers
- Each flexibility point performs a basic function.

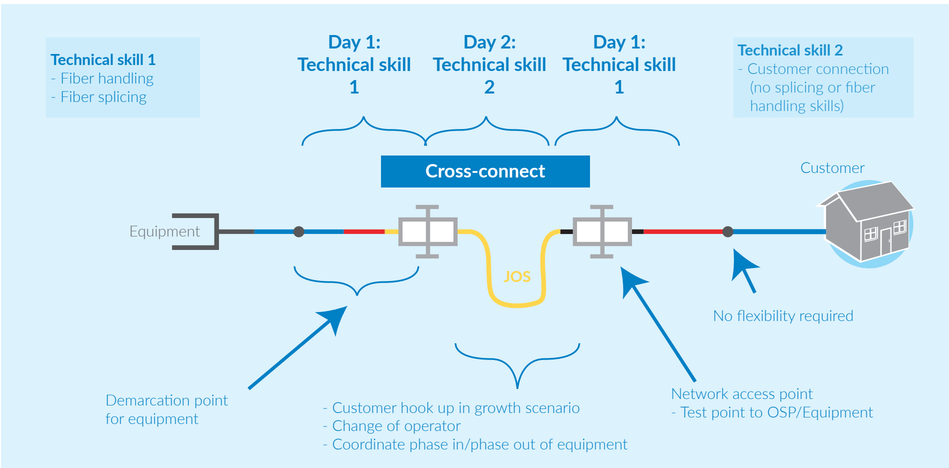


Figure 2: Central office with cross-connect ODF

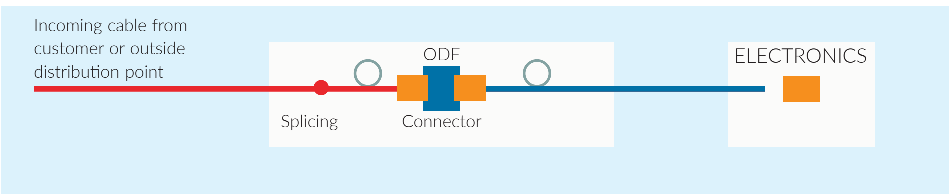


Figure 3: Simplified representation of the functions of an ODF

A flexible and expandable optical island set-up in practice

As we have shown, operators building a network have many decisions to make and all cannot be made Day 1. They have to take into account many unknowns, on many different levels; they must consider existing and future network layouts, available real estate, the customer base, types of services, etc. Lowering overall risk, assuring flexibility and expandability and optimizing their total cost of ownership drives future success and profitability.

Here is an example of a flexible and expandable optical island that one operator has recently deployed.

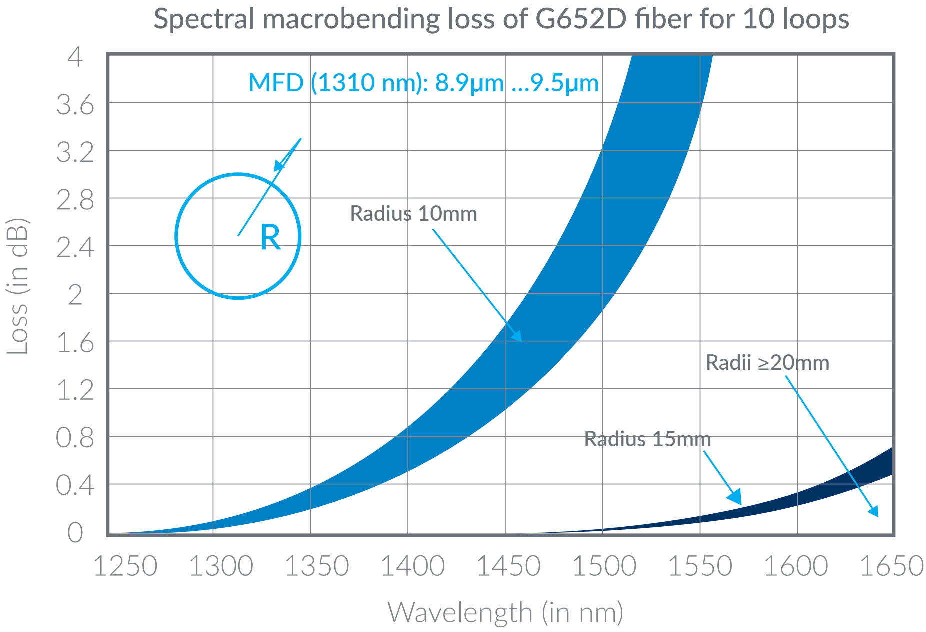


Figure 4: Wavelength dependence of macrobending loss

The optical island contains three main blocks.

1. Active equipment at the right: Houses different equipment sizes/ options, including those from different operators.

2. ODF lineup at the left side: Mirrors the equipment set up and foresees connection paths to the OSP. The top part represents mirror of equipment ports. In that section, WDWM technology could be placed to ease introduction of NGPON test wavelengths. The optical connectivity is based on connector technology to support plug-and-play solutions. The bottom provides connectivity and contains splices as well as connectors. The OSP connectors could be connected with one fixed jumper cord length to the equipment ports, using the jumper overlength storage.

3. Future expansion in the middle: Reserved for expansion of the optical island as the customer base grows. The expansion area was purposefully located in between the first ODF and the equipment rack. While the temptation would be to set the first ODF immediately next to the equipment rack, and then expand the ODF lineup to the left, in the real world, very often that space "reserved" for the lineup expansion gets used for other things – from power racks to more equipment racks to miscellaneous functions nobody considered initially. Without this space, the new ODF could very well be placed some distance away from the original, either on the same floor or even on a different floor within the central office building. Such a situation complicates record keeping, connection tracing, and daily operational tasks; upgrading connections or services to a customer becomes more complex than necessary.

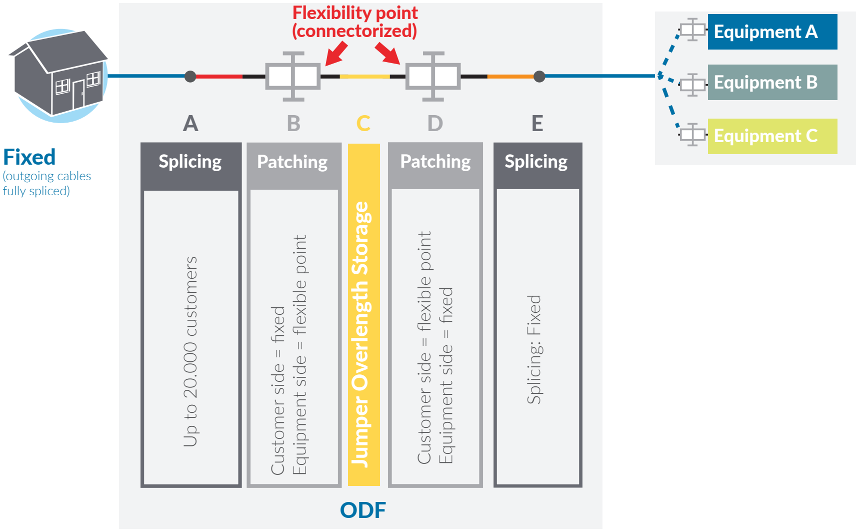
The planned layout fulfills the immediate requirements for a reliable network, and also provides a flexible platform for expansion as the business (and revenue) grows, and technologies change.

A final word – plan for future

Cross-connect ODFs provide an easier migration path to new technologies and additional subscribers. With proper planning, the ODFs will grow with the operator's business, imiting the need to obsolete and replace them.

Flexibility, adaptability and expandability in a cost-driven framework have an important common denominator – connectivity. When applied to optical distribution frames, the connectivity solutions deployed must consider the available skill sets of the labor force, and an operators specific requirements for density, speed and reliability.

An ODF is "just" a piece of passive equipment – and it is easy to think that their selection and layout have no significant impact on long-term profitability and growth. "Passive equipment is such a small part of my capital expenses. Why should I care?" is a frequent comment. However, when an ODF's function is considered, along with the rapid changes in communications technologies and networks, it becomes easy to see this passive equipment



Function

- Transition from OSP-rated cable towards inside-rated cables (e.g., cabling to meet V0 – LSZH requirements)
- Establish transition from 250µ fiber bare end to connectorized end (SC – LC connector)
- Establish identification and registration on tray level for OSP fibers
- Provide a demarcation point between technical staff level (skill level 1 to skill level 2)

Flexibility

- Transition point requires a reliable connection, but limited flexibility. Connection to fiber cable in the access network is a fixed, or static point, in the overall network.
- Disconnection is made in case of bad splice, repair of damaged splice or damaged cable

POINT A: Splicing point of incoming outside plant cables (distribution side)

Function

- Parking place for incoming connectors in adapters (fixed position)
- Network access for testing and diagnostics of distribution side
- Registration and identification of distribution side cables/fibers

Flexibility

- Allows moves/adds/changes of connections paths
- Flexibility to change active equipment or even operators, should customer demand arise

POINT B: Patching (distribution side)

Function

- Bend control protection for fibers (40 – 60mm diameter)
- Jumper overlength storage system to achieve a full cross-connect
- Reduction of pigtail logistics; standardization on pigtail lengths minimizes number of lengths ordered and kept in inventory

Flexibility

- Allow moves/adds/changes of patch cords with fixed lengths. Stored patch cord lengths can be recovered from the jumper overlength storage system. Recovered jumper patch cord can be used to establish connection to a different optical island

POINT C: Jumper Overlength Storage

Function

- Demarcation point of equipment:
  - Parking place for connectors in equipment side adapters (fixed position)
- Test point of network equipment side
- Flexibility point for the end customer's choice of operators
- Upgrade of equipment (moves/adds/changes)

Flexibility

- Equipment side connector is in a fixed position and connected with a specific provider
- OSP connector will be replaced when customer requests another provider
- Supports equipment upgrades
- Supports migration paths to new equipment or second operators

POINT D: Patching (equipment side)

Function

- Adapt to building layouts: Allow high fiber count of smaller sized cables to be guided through walls (open-ended cables).
- Establish transition from 250µ fiber bare end to connectorized end (SC – LC connector)
- Establish identification and registration on tray level for equipment side: "Mirror" of equipment
- Provide a demarcation point between technical staff level

  (skill level 1 – skill level 2)

Flexibility

- Splice point requires a reliable connection, but limited flexibility
- Disconnection is made in case of bad splice, repair of damaged splice or damaged cable
- Mirroring, or duplication of equipment connections, allows separation of technical staff not only with different skill sets, but also different levels of authorization or responsibility. The mirrored sets of equipment connections mean that sensitive (and highly valuable) active equipment is only worked on by staff with the appropriate level of training and authorization; this not only safeguards the expensive equipment, but protects network reliability and service delivery.

POINT E: Splicing (equipment side)

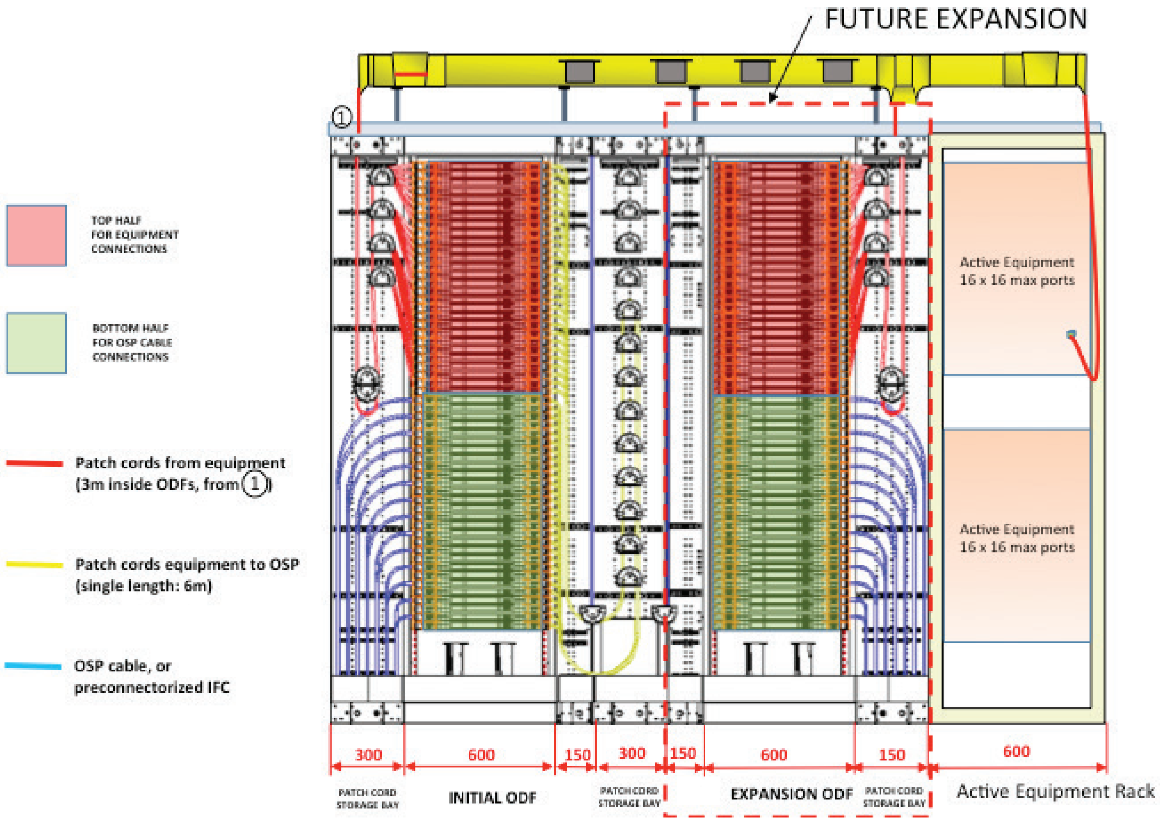


Figure 5: Functions of a cross-connect ODF

as a flexible, cost-effective platform to future expansion and migration to new technologies.

Connectivity solutions based on SC connectors represent today's most deployed single, demateable connection technology. In order to meet demands for higher density solutions, active equipment suppliers are turning to small-form-factor connections (most often, LC connectors). But even these standard connection types are giving way to single-mode multi-fiber connectors (MPO connectors) for both indoor and outdoor use. In the not too distant future, MPO connectors will be the new standard. While they will address the need for OPEX reductions and maintenance of high service quality, they will not obviate the need for careful planning and continued attention to proper cable routing and management, and connector identification.

In addition to housing new connector types, the overall function of connector panels is changing. For the most part, today's connector panels simply hold the connectors. In the future, these will include not only the connectors, but the system required around them, integrating the cable and the cable overlength storage. Technology systems such as "rapid panels" meet the requirements for high density, fast installation and management of cable logistics, from the ODFs' optical island, rather than the equipment side.

ODFs are no longer "just a piece of passive equipment." Operators deploying products chosen with consideration to the total cost of ownership – beyond Day 1 installation to Day 2 operational functionality and Day X upgrades – will achieve greater long-term profitability to stay competitive.

About the author

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Kristof Vastmans is Senior Product Manager for Central Office/ Data Center Fiber for CommScope in EMEA and drives innovative ODF platforms in the distribution and access network. He joined the company in 2000 in R&D as a product development engineer and became a certified Black Belt in Lean Design in 2006. From 2007, he has lead a development team to drive innovations and new platform systems for outside plant and last mile in-building applications.

References

1 Federal Communications Commission, undated

2 Hoernig, Jay et al, December 2010

3 OECD, 2011

4 For more on the importance of proper cable management, please see CommScope's white paper, "Elements of Fiber Cable Management," Daniel Daems, January 2015.

[1] IEC 61756-1 Fiber optic interconnecting devices and passive components - Interface standard for fiber management systems - Part 1: General and guidance

[2] ITU-T L.13 Performance requirements for passive optical nodes: Sealed closures for outdoor environments

Everyone communicates. It's the essence of the human experience. *How* we communicate is evolving. Technology is reshaping the way we live, learn and thrive. The epicenter of this transformation is the network—our passion. Our experts are rethinking the purpose, role and usage of networks to help our customers increase bandwidth, expand capacity, enhance efficiency, speed deployment and simplify migration. From remote cell sites to massive sports arenas, from busy airports to state-of-the-art data centers—we provide the essential expertise and vital infrastructure your business needs to succeed. The world's most advanced networks rely on CommScope connectivity.

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