A White Paper from the Experts
in Business-Critical Continuity

What fiber network expansion solutions will you choose to deliver the lowest cost of ownership and operation?

EMERSON
Network Power

Executive Summary

Incumbent providers face turbulent times as the industry rushes headlong into the digital home networking market. Faced with the need to extract maximum service from their copper networks, they must quickly decide how, when and which technology to use to expand their fiber networks to handle the ever growing market for broadband services. Fortunately, they are not alone. Emerson Network Power is equally determined to leverage its traditional incumbency in the telcom market while, at the same time, developing and introducing integrated fiber connectivity solutions that will offer providers a "one-stop shop" and maximum value.

I. There's good news and bad news on the network.

The good news is that the opportunities for aggressive providers have never been so great and they can only get better. The bad news is that incumbents are losing a significant portion of their core voice traffic each year to other technologies.

At the same time, competitive pressures are forcing the incumbents to reduce their overall pricing structure. They are also losing staggering amounts of unrealized income to competitors who have taken away their business by offering attractive bundles of broadband services.

In the next few years, broadband subscriptions are projected to grow by leaps and bounds, as new applications are developed and the appetite for broadband services increases from kilobytes to megabytes to gigabytes. Clearly, this appetite will not be satisfied by the conventional copper or coax network infrastructure, even using Asymmetric Digital Subscriber Line (ADSL) technologies. And consumers won't be satisfied with the relatively poor quality of today's early versions of High Definition Television (HDTV) and 2-way interactive television.

But yearning for a unified fiber network capable of providing voice, data, video, Internet Protocol Television (IPTV), Video-on-Demand and other services does not eliminate the need to deal with the realities of today's mix of architectures. Conventional wisdom suggests that providers must be willing to invest in fiber for the future while coping with competition and getting maximum utilization out of their existing infrastructure.

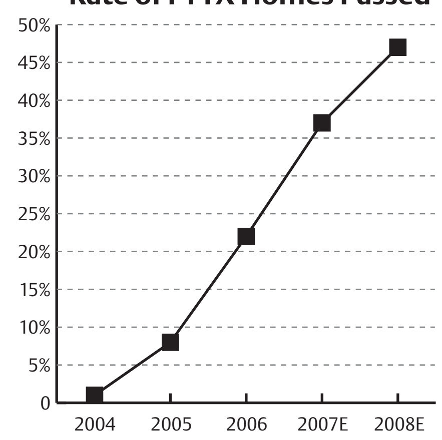
Will you benefit from, or be a victim of, the "Triple Play"?

Whether it is fiber or copper, the direction of the market is toward providing the basic "triple play services" of voice, data, and video. The Multiple Systems Operators/cable companies (MSOs) have managed to take a big chunk out of the Regional Bell Operating Companies (RBOCs) by offering telephony along with cable television and data. Fiber transceiver technology is extending reach and enabling improved delivery of triple play services. The RBOCs must respond with their own triple play and higher-speed data services in this "life and death" race to protect their customer base and capture as much market share as possible.

While land lines are being lost to wireless competitors, wireless has limited data capacity. However, wireless providers are working to create a backbone that will support such services with "fiber to the cell" and are continuing to improve their services with new offerings like WiMax and WiFi mesh. So, everywhere you look, you see providers making provisions for convertibility to fiber and the penetration of fiber deeper into the network.

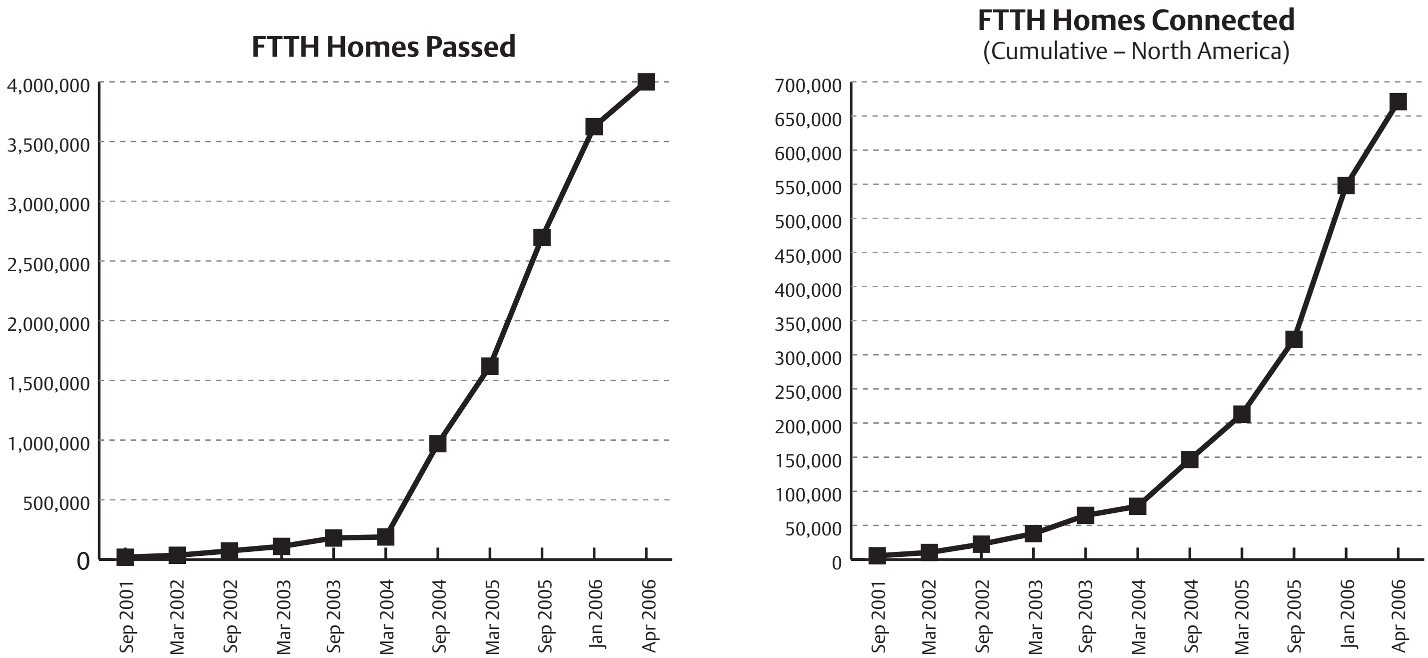
Today, the number of "addressable" homes (potential customers for fiber) is approximately 75 million. In two years, 33 million of those homes will have been "passed" (will be close enough to a fiber distribution point for connection), and it is estimated that 16 million will be "taking" *(see Figure 1).*

Figure 1: **Cumulative Take Rate of FTTX Homes Passed**



Sources: JP Morgan, UBS, Lehman Brothers, ADC, Company Reports

Figure 2



Source: RVA Render Vanderslice & Associates

Today, the take rate is relatively small, but it is doubling each year as appetites and the fiber network grow *(see Figure 2).*

These are not easy questions, but they must be answered.

Few disagree that a migration to fiber is the way to go, but as equipment suppliers begin to offer answers, providers are still formulating their questions. Basic questions a provider must ask before charting a path to fiber include:

- What services will I/must I bundle and offer to remain competitive and keep my customers?
- Where do I stand regarding my existing network and capabilities?
- Should I spend more money now on capital expenditures or more money later on operating and maintenance expenses?
- Should I replace my aging copper, overbuild it, or implement some combination?
- What can I do with copper broadband Very high-speed Digital Subscriber Line (xVDSL) technologies to minimize capital expenditures?
- Should I deploy a passive optical network or an active optical network?
- How far should I extend fiber into my network?
- How should I handle remote areas with relatively few customers?
- How will I re-divide my distribution area?
- How much flexibility will I need/want to add for future applications?

II. While the present is fuzzy, the future is fiber.

Today's broadband network architecture can best be described as eclectic. Most legacy (copper) plants utilize some flavor of Digital Subscriber Line (DSL) technology, capable of delivering up to about 12Mbps. While these immediate solutions help to satisfy the demand for broadband services, copper suffers from reach limitations, cross talk, corrosion and the other ailments that fiber does not.

Partial fiber solutions such as Fiber To The Node (FTTN), favored by SBC to match today's demand for broadband, bring fiber to within about 3,000 feet of the customer's premises; but copper is stilled relied upon for the last leg. Some providers choose rehabilitation to minimize capital expense when there is insufficient justification for Fiber To The Home/Premises (FTTH/P). They can maintain copper for voice and data, provide video on existing coax, and place Optical Network Units (ONUs) in close proximity should there be a need for high-speed data.

Others may justify their decision to overbuild (overlay fiber on top of existing copper) because of aging copper infrastructure, high projected take rates, competitive pressures and a requirement for higher bandwidth than copper can

Figure 3: Fiber to the Node (FTTN)

Fiber to within 3,000 feet of home on average; 5,000 feet maximum

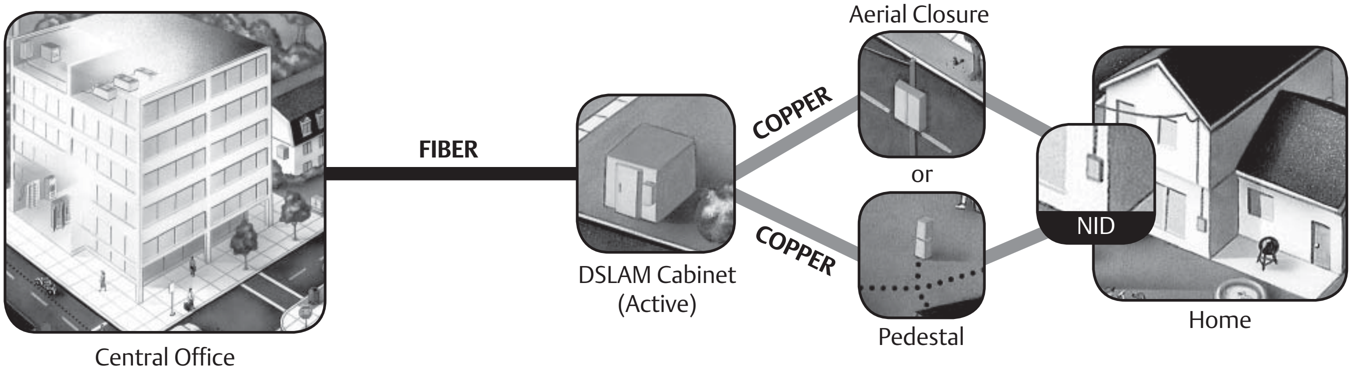


Figure 4: Fiber to the Curb (FTTC)

Fiber to within about 500 feet of home

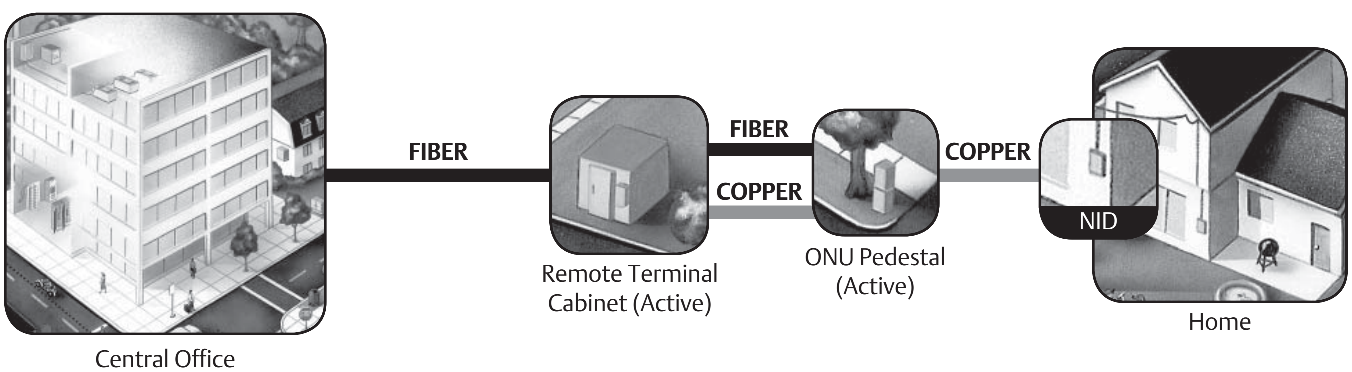
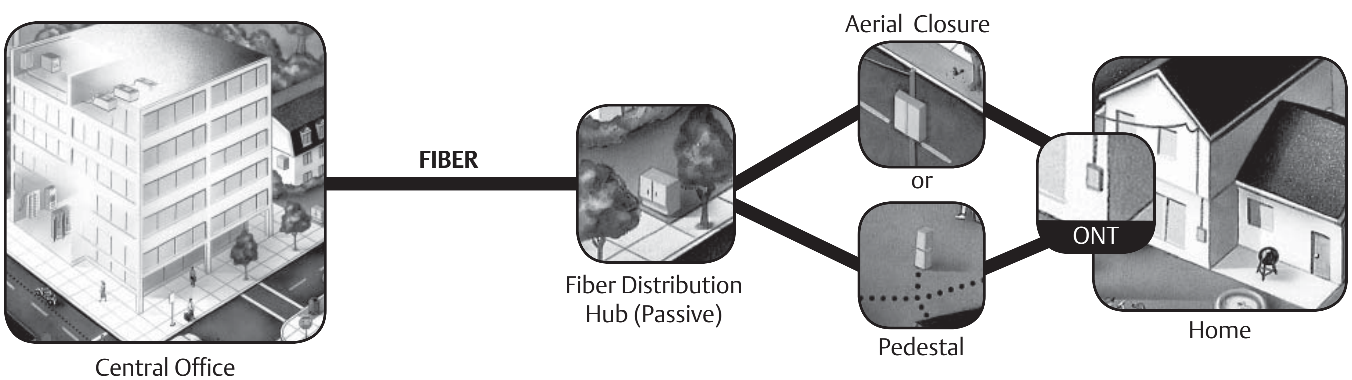


Figure 5: Fiber to the Premise (FTTP)

Fiber from the central office to the home



provide. This can facilitate a gradual transition of all customers to FTTH/P as copper and active infrastructure such as the Digital Loop Carrier (DLC) architectures are retired.

Total fiber solutions such as Verizon's FTTP/H strategy are found in new (greenfield) builds and Multiple Dwelling Units (MDUs) where the cost of burying fiber is about the same as burying copper. Verizon is going full-speed on fiber to the home, hoping to get a jump on competitors. They have been criticized for spending some $2 billion a year on it, but appear committed to continue. Verizon may not need all that capacity today, but they consider it "future-proofing."

Figure 6: **PON Downstream Data Rates per Subscriber***
Minimum Assuming Full PON Utilization (non-blocking)

	PON Downstream Date Rate (Mbps)			
Split Ratio	**622 BPON**	**1000 EPON**	**1244 GPON Today**	**2488 GPON Std max**
32	13.6	21.9	27.2	54.4
16	27.2	43.8	54.4	108.9
8	54.4	87.5	108.9	217.7
4	108.9	175.0	217.7	435.4

MPEG2 HDTV Channels Supported (20 Mb/s each)

0	1	2	4

Assumes 70% throughput efficiency. Higher or lower efficiency possible depending on equipment.

It takes more than guesswork to pick a topology.

All the providers use fiber at some point in their architecture. It's just a matter of how close they get to the home or premises with it. Starting at the home and going back toward the Central Office (CO), head-end or other signal emanation source, the lines begin to converge. At some point (X) where enough of them converge, it makes sense to start using fiber. But in terms of architecture, what makes sense to one provider may not make sense to another.

The telcos are either going to have FTTN (Node), FTTC (Curb), or FTTH/P (Home/Premises). Some will be active networks (that require power) or have some active elements. Others will be passive networks (no power added between the CO and the customer). With FTTC, for example, fiber goes some distance from the CO to a powered ONU approximately 500 feet from the home. From there, the signal is distributed on coax or twisted pairs to the home *(see Figures 3, 4 and 5).*

With FTTN, fiber is fed to an active (powered) Digital Subscriber Line Access Multiplexer (DSLAM) that will be about 3000 to 5000 feet from the home and will serve about 500 homes with high-speed digital data access and analog telephone service over the same twisted-pair telephone line.

Active network proponents cite the fact that customers are served with dedicated fiber (providing higher bandwidth) and no splitters. A switch connects the user to the network, and the user doesn't have to share fiber with other users at the expense of reduced speed. The powered network supports the IEEE Ethernet standard protocol, and interoperability between different vendors is possible.

Active Ethernet incorporates active electronics in the distribution network and includes Remote Terminals (RTs) that house Ethernet switching equipment and switched IP video equipment. From there, drops distribute the signal to the home or premises. While the active elements of the network require maintenance, the Active Ethernet-based network can reach out almost 70 km from the signal source.

Passive network proponents are pleased that there is no need to power any of the Outside Plant (OSP) equipment and happy with the relative simplicity of the Passive Optical Network (PON). A PON is a system of fiber optic cabling and passive splitters and couplers that distribute an optical signal. The signal travels through fiber segments in a branched-tree topology to connectors that terminate each fiber.

Passive Optical Networks are now going home.

PONs were initially designed for small business applications; the APON (ATM PON) uses Asynchronous Transfer Mode (ATM) encapsulation of transported data.

The BPON (Broadband PON) is an expanded version of the APON that includes Wave Division Multiplexing (WDM) support for video overlay and greater upstream bandwidth capability.

EPON (Ethernet PON), ratified in 2004, supports IEEE standard 802.3, using Ethernet packet data rather than ATM data encapsulation. It provides speeds up to 1.25 Gbs symmetric and is ideal for data services.

GPON (Gigabit PON) is the next evolution of PON technology and is expected to be the basis for FTTH/P. It supports Internet Protocol (IP) and is the choice for high-volume Hyper Text Transfer Protocol (HTTP) users. It incorporates the best attributes of BPON and EPON at gigabit rates. It does not require active powering points anywhere along the access network and enables triple play of video, voice, and data. With FTTH/P, two PON topologies are or will be used: GPON and EPON *(see Figure 6 on page 5)* .

PONS give varying degrees of reach to the network.

GPON is basically fed to cross connect cabinets or pedestals housing 1 X 32 splitters and may be located up to 20 kilometers from the CO. Out of the cabinet, 32 homes can be fed from each splitter. Although the bandwidth will be shared by each connected home or premises, there will normally be more than enough speed to satisfy each subscriber.

FTTN is a phase-by-phase approach where an optical link is deployed to the ONU in a service area. The ONU converts the optical signal to an electrical signal and services are transferred on to the customer over existing copper facilities. From the ONU to the customer's Network Interface Device (NID), the network is passive. With shorter distances between the ONU and the premises, providers are able to offer higher bandwidth services without deploying fiber all the way to the premises. As bandwidth requirements grow, an FTTN network can be upgraded to FTTH/P.

FTTC incorporates a pedestal (ONU) that is located about 500 feet from the home or premises. The ONU, serving multiple homes, provides economies of scale, spreading out the cost of the conversion from optical to electrical signals. With FTTH/P, there is a dedicated Optical Network Termination (ONT) electronic conversion unit at each home. But there is less bandwidth capacity. FTTH/P topology incorporates a fiber feed from the CO to a passive Fiber Distribution Hub (FDH) which houses splitters (typically 1 X 32). From there, the fiber goes to a distribution terminal near the home, and a drop from the distribution terminal plugs into a ONT at the home or premises. These distribution devices may be preterminated or require splices. There are no active devices between the CO and the ONT. Initially, the cost of FTTP/H networks limited their use to new builds or greenfield areas. Now that infrastructure costs have decreased and bandwidth demand has increased, communities and service providers are willing to overbuild and "future-proof" legacy networks.

Local competition is a key to network technology selection.

The issue of competition between service providers serving the same local area also has an effect on the type of architecture that may be selected. As the cost of FTTH/P deployment decreases, facilities-based competition becomes unlikely in FTTH/P. However, non-facilities based competition in FTTH/P architecture is possible at the data link layer and in higher layer services. While PONS do not support competition at the data link layer or in broadcast video delivery, they do support competition in voice, data and switched digital video services.

Incumbent Local Exchange Carriers (ILECs) have been lobbying for legislative/regulatory changes that would relieve them of providing Unbundled Network Exposure (UNE) on new fiber network deployments. They are also lobbying to be relieved of Open Access requirements.

MSOs don't currently offer fiber to the home or premises. They are committed to coax with their current infrastructure. Their "last mile" is approximately 1000 feet of coaxial cable. The original signal travels from the CO to a Radio Frequency (RF) node that supports a hybrid fiber/coax (HFC) network. Out of the RF node, signals can typically be distributed to up to 500 homes with coax. In the last four years, the MSOs have spent billions of dollars overbuilding their networks. It was called Next Generation Network architecture. Coax does not have the distance limitations that other media face, but once transmission rates evolve to the gigabits per second that will be required for IP Video and switched video, HDTV, security and other services, coax may face limitations.

Also, while a cable modem can transmit faster than twisted copper pairs, users must share one main cable with their neighbors. When the cable is busy, transmission rates can slow down to about the same rates as a DSL line. With a dedicated DSL phone line, the speed remains the same, no matter what the neighbors are doing. However, the HFC network does work and it offers great flexibility for today's triple play services.

III. Emerson Network Power is your source for integrated solutions.

Emerson Network Power is an OSP connectivity solutions company, with a large embedded base of telco copper products, both passive and active. We continue to leverage our incumbency in the market with innovative fiber connectivity solutions to help the network transition from its current state of copper, to hybrid fiber/copper (FTTN, FTTC), and eventually to all fiber (FTTH/P).

While we face competition from other equipment manufacturers who produce various connectivity components, we offer complete OSP distribution solutions including both active and passive cross connect cabinets as well as pedestals – NetSpan™ Integrated FTT*x* Solutions.

Forward/backward compatibility puts you in the driver's seat.

Our NetSpan™ connectivity products are designed to facilitate both forward and backward compatibility. Providers will be able to put them in their present copper network to be backward-compatible with the network infrastructure. In addition, they provide transition paths already provisioned into them, in terms of integrated design and features, that will allow providers to easily transition to fiber – without incurring additional infrastructure costs.

Leveraging our connectivity competencies will not only give providers an economical forward migration route, but at the same time, it will shorten their time to market.

NetSpan™ fiber expanders for copper cross connects, are used on top of an existing copper network as the provider moves to a hybrid fiber-copper network. There is no need to negotiate for a new right of way or install a new pad. From an install standpoint, it's much easier as service providers will be able to leverage their existing infrastructure. From a time-to-market standpoint, these solutions are much more cost effective, much more time-efficient.

As part of our NetSpan™ integrated cabinet solution, we are introducing hardened Planar Light Circuit (PLC) splitters with preterminated tails. These compact splitters will conserve cabinet space and further enhance efficiency and reliability.

NetSpan™ Integrated FTT*x* Solutions also include complete fiber cross connects with innovative optical components for FTTH/P deployment.

By leveraging our strength in active power and competency at almost every point of the OSP network, we offer cabinets for active FTTN networks that can be converted to FTTH/P cabinets as future network expansions dictate. The cabinet, in its FTTN configuration, is able to serve Fiber To The Loop (FTTL) networks now.

In 10 years, when the provider wants to go to FTTH/P, the provider will be able to remove a copper distribution module from an end chamber and replace it with a fiber distribution bulkhead including optical components.

At the pedestal, we are offering similar flexibility. Today most pedestals in brownfield areas distribute only copper to the home or premises; in many greenfield areas, only fiber. Tomorrow, the pedestal may need to support a mix of copper and fiber for some extended period before FTTH/P becomes the norm. So we offer three configurations packaged in one solution.

Integrated solutions make Emerson a "one-stop shop" for value-conscious providers.

Our technical connectivity solutions are integrated solutions, prepackaged and ready to go. They are designed to impact our customers' value chains in a very positive way, a way that will help them reduce costs and improve time-to-market from a network deployment standpoint. These solutions reduce the number of parts the vendor has to order, the number of POs they have to issue internally, the number of parts they have to warehouse and the number of technicians needed to handle and assemble these parts.

To deploy a pedestal today, a provider must buy components from separate suppliers and, somehow, integrate all these components before the pedestal can be installed. We have developed an integrated solution with all the components and features required. It is a "one-stop shop." One part number instead of several, one purchase order, and no need to integrate and preassemble the pieces before the cabinet is installed in the network. From a component integrity and package standpoint, there will be much higher reliability. In addition, it will speed up the time to market when every lost day can mean $$$ in lost revenue.

Pretermination is a determining factor in installation and maintenance costs.

Deployment cost savings are available throughout the OSP network by using preterminated connections instead of splices. The use of connectorized cable between the service terminals and the ONTs at the home or premises greatly reduces the time and skill required for drop installations. We offer preterminated drop solutions that will eliminate the need for splice cases and conserve cabinet space. We also provide cabinets utilizing conventional fiber splice components.

The result is an overall lower network installation cost and extensive operational savings over the life of the network as services are expanded and customers are added or removed from the network. While it can be argued that pretermination increases inventory costs for fiber lengths and leads to more optical losses than splices, the overall effect on the provider's value chain is positive: Faster turn-up, faster troubleshooting and maintenance, fewer splice technicians and fewer service calls.

We welcome you to the world of fiber plug-and-play.

In today's world of "plug-and-play", through our NetSpan™ Integrated FTT*x* Solutions, we at Emerson Network Power are doing all we can to leverage all of our strengths and competencies to make available a broad set of integrated solutions that will accommodate a broad set of applications across different markets – and have a significant positive effect on our customers' value chains.

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