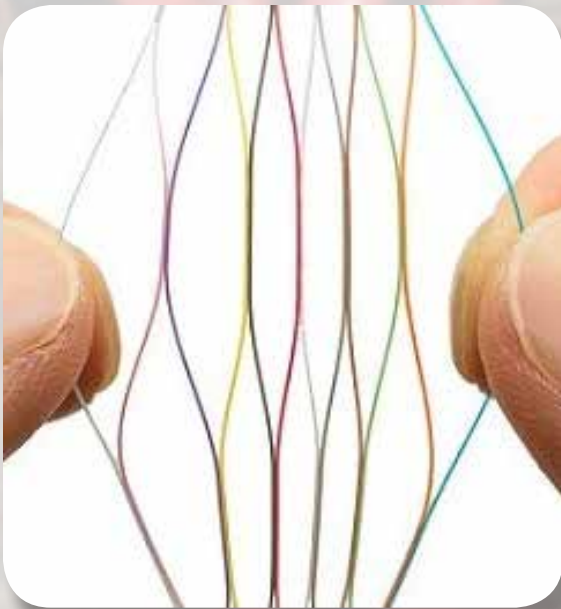


LIGHTWAVE®



EDITORIAL GUIDE

Supporting Gigabit Broadband

Fiber to the premises offers the most future-proof approach toward gigabit broadband delivery. New technologies are emerging to support 1-Gbps services now and perhaps even more robust services in the future. This editorial guide examines the current state of gigabit broadband networks, including their installation and maintenance within this competitive context.

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Testing Broadband Service Speeds

By **RICARDO TORRES**, VeEX

I**NTEREST IN HIGH-SPEED** broadband services, specifically 1 Gbps and beyond, continues to rise at a very fast pace. A wide variety of traditional telecom and cable TV service providers, as well as smaller and local internet service providers (ISPs), now offer these services, each with different technologies and deployment strategies. Example access technologies include point-to-point Ethernet, FTTx plus copper, GPON, and DOCSIS 3.1; in some markets, 10-Gbps broadband services are being delivered using [10G-EPON](#), [XGS-PON](#), or [NG-PON2](#).

Regardless of the technology used and deployment strategy, all service providers face the challenge of proving that their broadband service is indeed being delivered to their customers as promised. To meet this challenge, service providers need reliable and repeatable test methodologies and devices to properly support their service efforts.

Service Assurance

The technologies that enable broadband services at gigabit speeds are great for consumers and for competition among service providers. Supporting these technologies from an operational point of view is key to their success. Consumers can be very proactive when contracting their new services. Upon service delivery, they can carry out their own service “tests” using networking devices such as tablets, smartphones, and laptops. Software applications and websites that measure broadband service speeds, such as Speedtest® by Ookla®, the industry’s de-facto standard technology to measure internet connection speeds, are easily accessible.

In some cases, a problem occurs when the consumer tests their service with an older laptop that has a slower CPU and is unable to achieve 1 Gbps over its copper

RJ-45 10/100/1000Base-T interface. Once they realize that their laptop is only measuring 200-300 Mbps out of a 1-Gbps service, they can become frustrated and may file an unwarranted complaint with their service provider. This complaint in turn will generate a ticket that could turn into a truck roll, an unnecessary operational expense for the service provider.

The above scenario happens more often than you might think. It can be aggravated and become a nightmare for service providers when the service goes beyond 1 Gbps, as there is really no consumer laptop available today with a 10-Gbps interface. For example, the consumer can pay for a 2-Gbps DOCSIS 3.1 service but measure only 1 Gbps with their top-of-the-line video gaming laptop.

For this reason, service providers are starting to go beyond the traditional RFC2544 and ITU-T Y.1564 testing, which are test suites mainly developed for testing at Layer 2 and Layer 3 services, during service turnup. They are adding test methodologies for stateful TCP testing, like RFC6349, and simple download and upload testing to FTP and HTTP servers. All of these methods are TCP-based and help test from a quality of experience (QoE) point of view, which is what the consumer cares about at the end of the day.

Testing Strategy

QoE test strategies vary by service provider, as some prefer a RFC6349 approach, while others prefer a Speedtest type approach. It all depends on the network resources available. Service providers that already have Ookla servers deployed within their footprint would generally opt for the Speedtest by Ookla method, especially if their servers can handle gigabit speeds. Certain not-so-technical subscribers may also appreciate the simplicity of Speedtest results.

The RFC6349 approach has been preferred by service providers delivering Carrier Ethernet services. Similar to the Speedtest by Ookla method, where servers and field portable test sets are required, the RFC6349 approach will require the deployment of dedicated TCP servers within the service provider footprint or dedicated rackmount test equipment that can operate as both a TCP server and TCP client, in addition to carrying out other traditional Ethernet test methodologies like ITU-T Y.1564 and RFC2544 (see Figure 1).

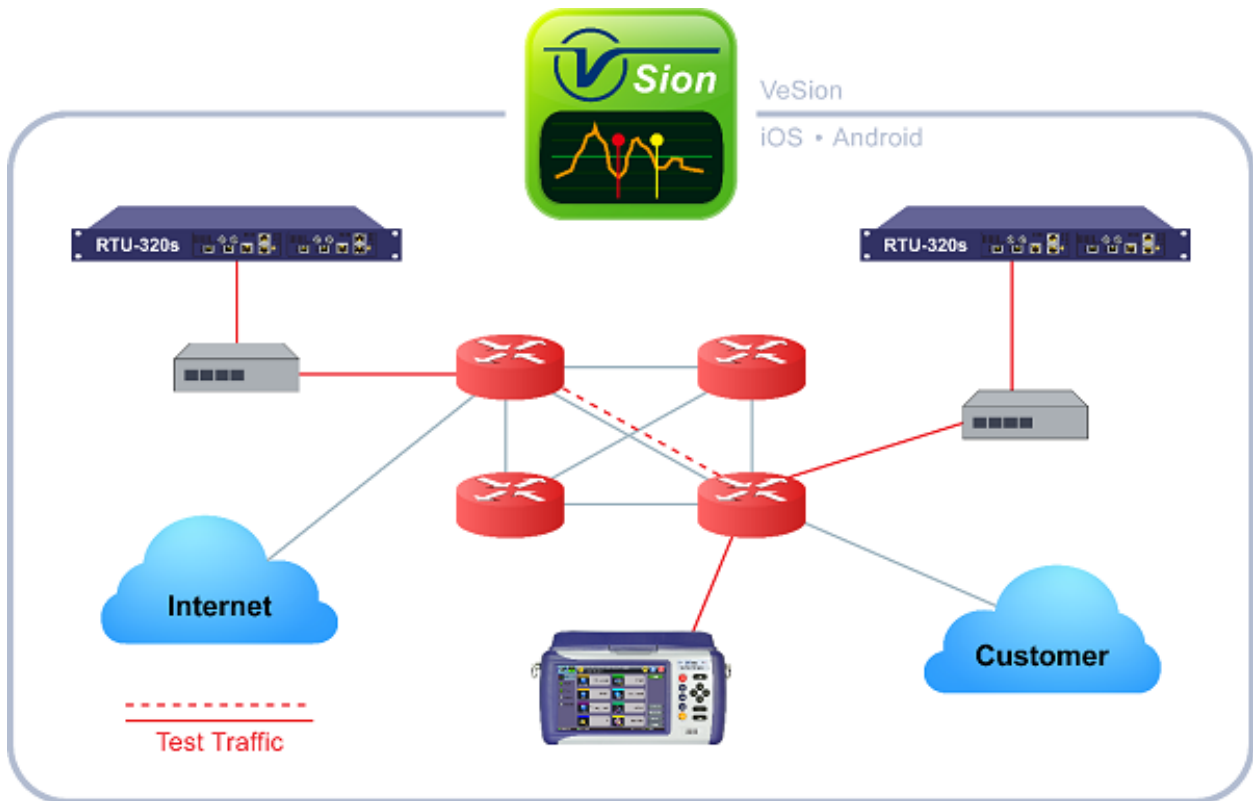


FIGURE 1. Example of a service provider network with deployed test heads.

Dedicated Test Tools

Since it is the responsibility of service providers to present undeniable proof to their customers that each service meets the service level agreement (SLA) at turnup, they require reliable verification tools. Also, as tablets, smartphones, and low-performing laptops do not always provide reliable results, especially when testing 1-Gbps and beyond services, field service technicians and engineers require dedicated test tools to successfully deliver an accurate proof-of-service speed for their customers.

Dedicated test tools are designed for specific tasks. Hardware/logic, CPU, and RAM resources are all used exclusively for testing a specific application: RFC6349 (stateful TCP), Speedtest by Ookla, FTP upload/download, ITU-T Y.1564, etc. These dedicated hardware and software resources help provide repeatability and reliability in the testing methodology and procedures. This is important during the installation and delivery of new services. In addition, these tools provide the required physical interfaces to test the services: 10/100/1000Base-T, 1000Base-X, 10GBase-X, and DOCSIS 3.0 and 3.1.

Comparison tests conducted in the field with a dedicated test tool and software-based clients yielded interesting results that help make the case for dedicated hardware-based instruments for Layer 4-7 testing. Similar tests were performed in a controlled environment in the lab. The test results are presented below.

The devices under test were the following: hardware-based dedicated test set, laptop 1, and laptop 2. Note: Laptop 1 and laptop 2 had the same RAM and CPU speeds, but different operating systems. All three devices had a 1-Gbps port.

The test setup: One high-performance server running a TCP server and HTTP server applications. Each device under test connected directly to the server during testing. One additional test was carried out in the case of the TCP Throughput test between two dedicated test sets (see Figure 2).

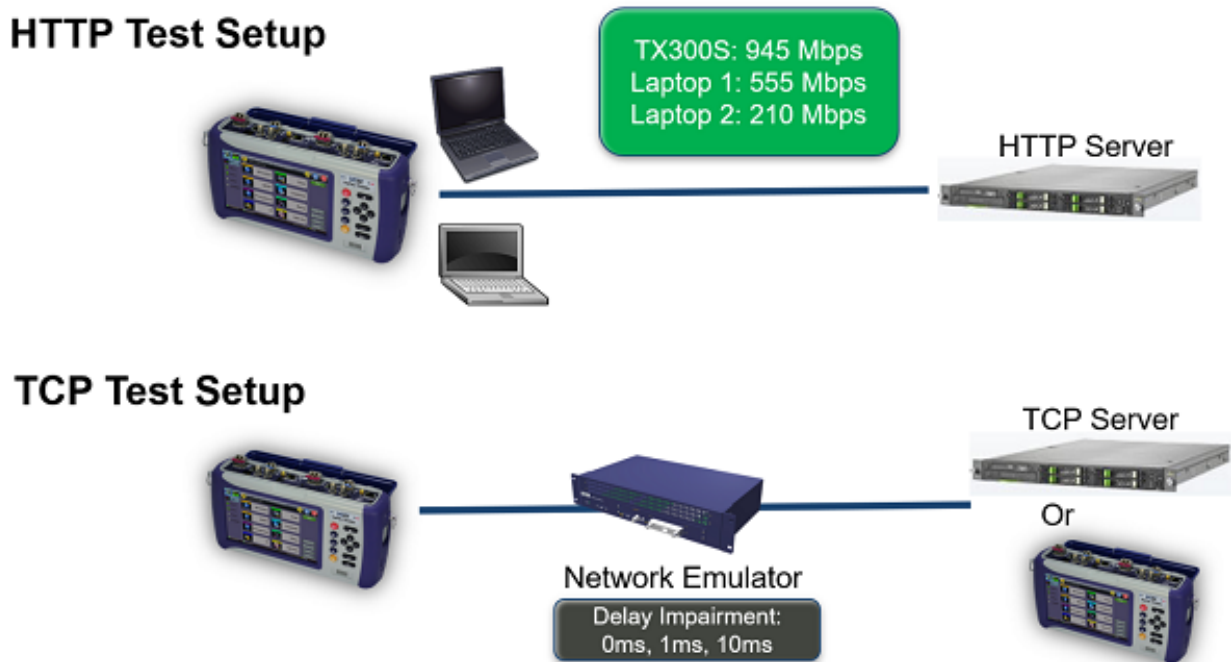


FIGURE 2. Comparison test setup.

The simple tests carried out in the lab show that dedicated test tools that perform TCP-based applications performance testing can produce consistent and reliable results when the implementation is completed on hardware (FPGAs), compared to alternatives that depend on CPU speed, RAM, and operating system performance. A step further into the testing introduced network impairment equipment in-line

with the device under test and the server. The network impairment equipment can introduce impairments such as packet delay, jitter, packet loss, etc. TCP-based applications are dependent on several factors such as window size, round trip time (delay), and buffer size.

When a 1-msec delay was introduced, the test set's TCP and HTTP throughput dropped by less than 10%. However, the TCP and HTTP throughput performance of the laptops dropped by more than 50%. The performance of the TCP server also dropped significantly. This substantial difference in performance shows that the hardware/FPGA-based approach that is not dependent on CPU speed, RAM, or operating system, is more resilient and reliable in broadband service testing of 1 Gbps and beyond (see Figure 3).

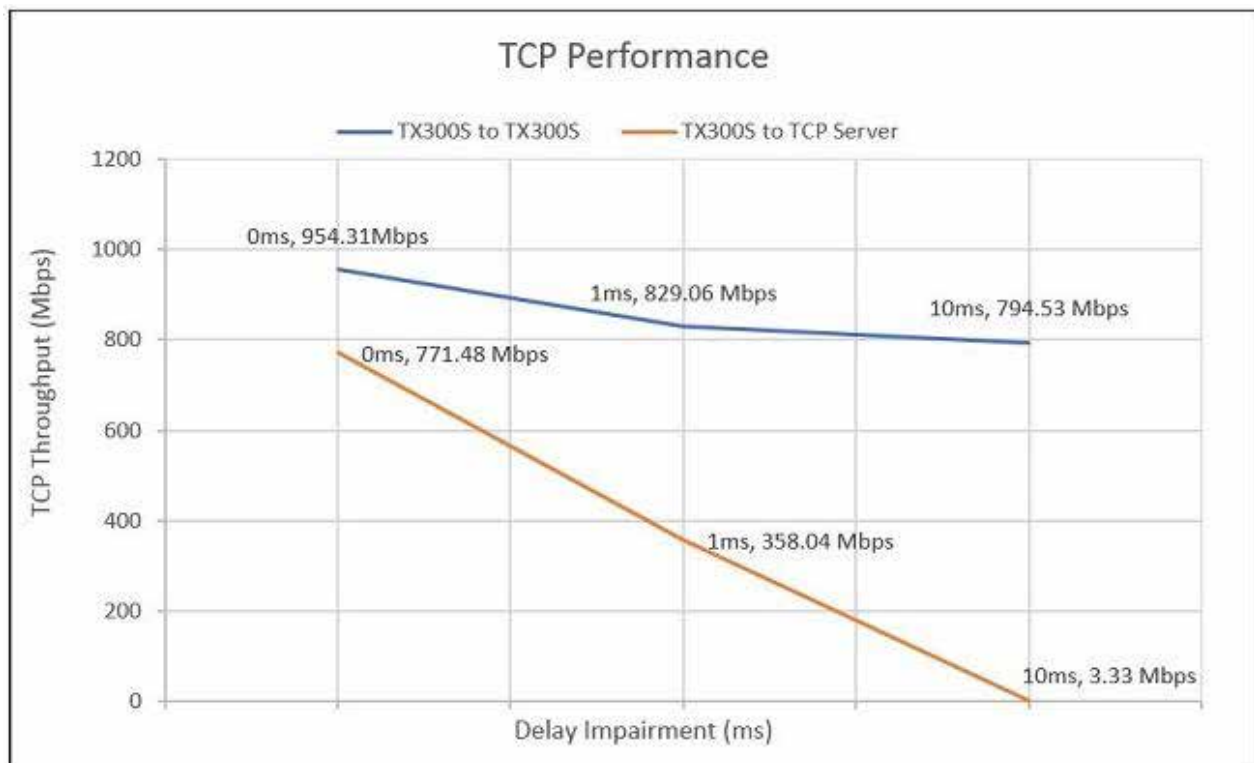


FIGURE 3. TCP Throughput Performance vs. Delay (0 ms, 1 ms, 10 ms)

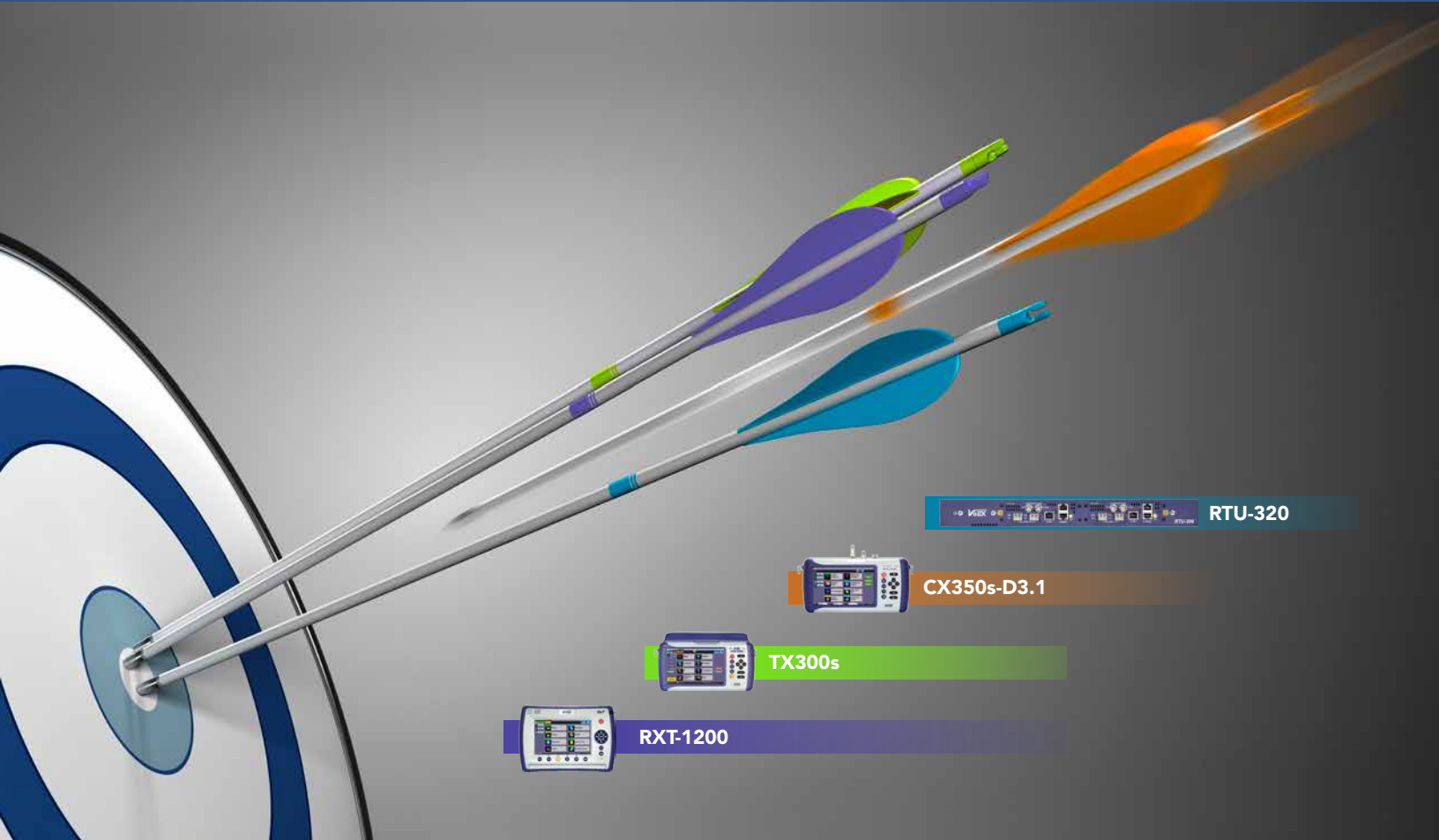
Based on the results conducted in the lab and similar results discovered in the field, you can clearly see the need for dedicated test tools for TCP-based applications when testing 1-Gbps broadband services and beyond. Most laptops and tablets with software-based clients can only reach a certain level of reliable

throughput performance. None of them can reliably verify SLAs for broadband services at or beyond 1 Gbps as well as dedicated hardware/FPGA-based instruments do. Service providers need to take this into account as they enter the gigabit services market.

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Target Your Broadband Testing



VeEX Solutions Keep You On Point

Broadband service delivery can be hit and miss, since evolving technology can be a moving target for service verification teams. Service providers face tight deadlines to deploy capable infrastructure, technicians are intimidated by the technology and complexity of services to be tested, and demanding customers expect better than a satisfactory experience. VeEX works closely with service providers to develop best in class test solutions to maximize operational efficiency. VeEX has the right tools to pinpoint your specific testing requirements and environmental needs.

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Broadband testing

Gigabit Broadband Approaches to Realize a Better Connected World

By **JACK ZHU**, Huawei

A **N INTELLIGENT WORLD** is emerging, and the need for ultra-broadband networks to accelerate this new world is growing at an unprecedented pace. There are currently 350 deployed gigabit network projects across the globe, and it is becoming increasingly accepted that gigabit broadband will be the cornerstone of the intelligent world.

Gigabit broadband networks as well as relevant services and applications will provide many opportunities in areas such as healthcare, education, employment, transportation, agriculture, trade, and government services, and will greatly enhance the growth of the global economy. In the 21st century, gigabit broadband networks have already influenced our lives in many ways and are fast becoming an indispensable infrastructure like roads, railways, water supply, and electricity supply networks.

Gigabit broadband networks have accelerated the development of new experiences and created business opportunities such as Alibaba Group's "Buy+" virtual reality (VR) online shopping platform, Mobike's app-driven bike-sharing services, Airbnb's hotel sharing network, and Amazon and JD.com's revolutionary online shopping services. [Analysts now predict](#) that the number of gigabit subscribers could hit upwards of 100 million by 2020.

This trend is also ushering in a new era of "Gigabit Cities" that use next-generation [PON](#) technologies to deliver gigabit coverage for the cities' communities. For example, Shenzhen has become the first city in China to deliver gigabit broadband connectivity to 900,000 homes. Services will be available for residential users, government agencies, and enterprises, and will be capable of

enabling advanced services including 4K video and VR film streaming, Gigaband hotels, and passive optical LANs (see Figure 1). Based on the experience with the rollout, this first project in China is expected to define the standards for a Gigaband City, paving the way for future deployments.

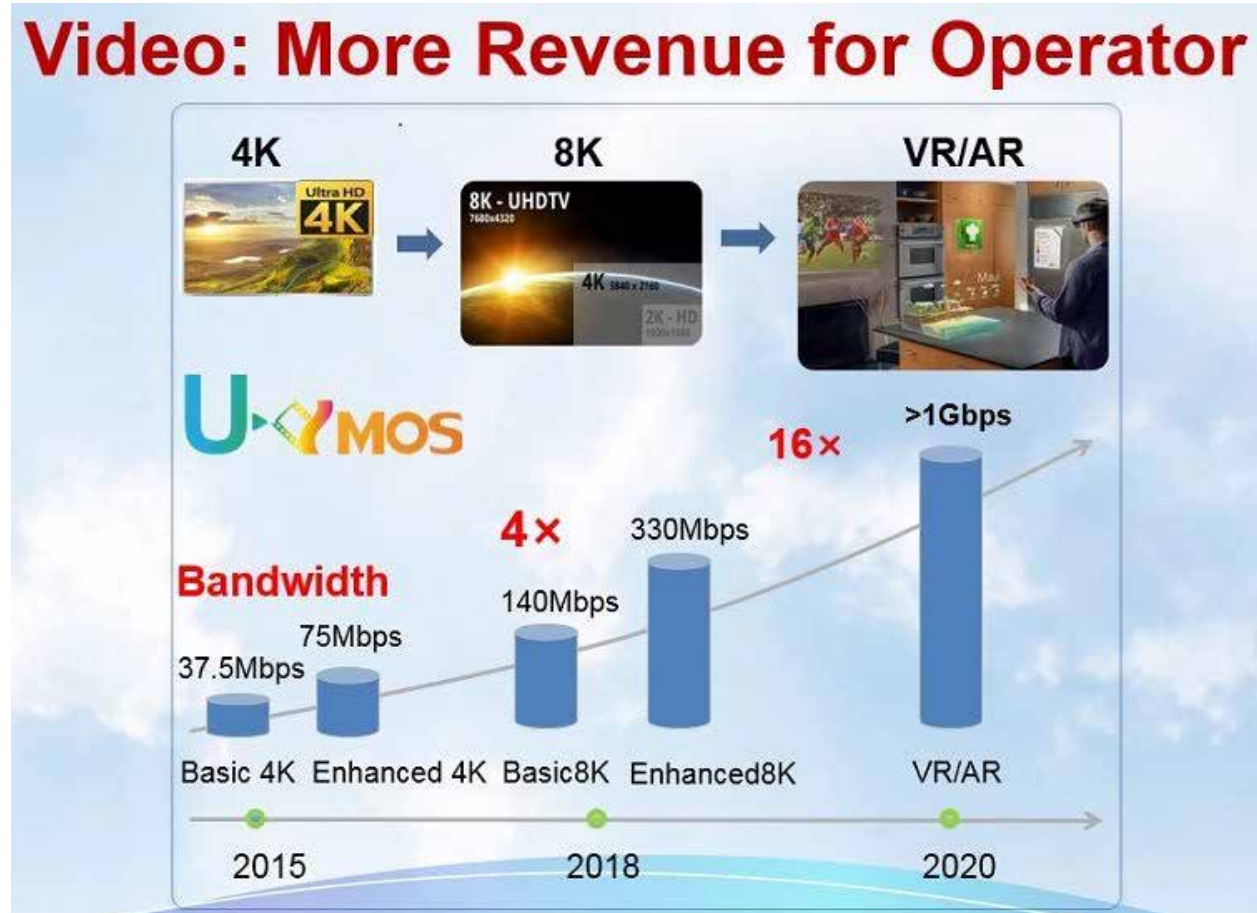


FIGURE 1. The delivery of enhanced video services will be one of the main benefits of gigabit broadband.

Gigaband Cities will strive to keep pace with consumer demand for new internet applications such as 4K/8K video, VR and augmented reality (AR), Gigaband campuses, and smart homes. Gigabit broadband networks will also foster digital innovation within vertical industries such as healthcare, financial services, transportation, manufacturing, and more.

Government Approaches to National Broadband Projects

ICT and broadband infrastructure have become core economic competencies, critical for national competitiveness. At the same time, broadband has become

a basic need for citizens, who cannot imagine their lives without a broadband network and applications.

As a result, governments across the globe have made national broadband programs an imperative to ensure high-speed internet is accessible and affordable to everyone. However, the development of broadband initiatives varies greatly around the world. In Asia-Pacific, for example, Japan, Republic of Korea, and Singapore are world leaders with a broadband penetration of 95%. However, in countries such as Myanmar, Bangladesh, and Cambodia, less than 5% of the population has access to broadband. In these countries, government and policy support is essential to accelerate infrastructure growth and increase external connectivity.

Governments in these countries and around the world play an instrumental role in advancing national broadband initiatives to improve services for citizens. They can lead infrastructure development by building alliances among different government departments and industry, as well as creating broadband-friendly industrial policies.

Governments can also improve infrastructure synergy and find ways to simplify the process of obtaining rights of way. They can ensure new buildings and renovation projects include fiber connections, produce explicit standards for compensation for eminent domains, and start universal service funds. Governments can also legislate comprehensive frameworks for ICT; expand international fiber links; loosen restrictions on carriers, investors, and infrastructure builders; release more spectrum; and make more efficient use of spectrum resources.

Gigabit broadband can provide many benefits to both businesses and residents. For businesses, it helps them to innovate and expand into different markets. It also has the potential to increase efficiency and drive down costs. These business gains will help accelerate economic growth and prosperity for the country.

For residents, they will have improved access to online shopping, banking, healthcare, and public services. They also will connect seamlessly with family and friends and enjoy new levels of home entertainment. Providing fast and

effective gigabit broadband will drive social empowerment, helping citizens thrive in their work and home lives.

Telecom Operator Approaches to Accelerate Gigabit Broadband

To remain competitive telecom operators need to take advantage of new and advanced technologies such as next-generation PON over fiber, G.fast over copper, and DOCSIS 3.1 over coax that enable greater bandwidth, agility, and scalability to meet the demands of the gigabit era. However, according to Ovum, operators face many network transformation challenges, such as choosing the best technology strategy and understanding its impact on future upgrades, identifying new revenue opportunities, and meeting rollout targets and network optimization goals.

With the development of cloud computing, the internet of things (IoT), and 4K video industry chains, the fixed broadband industry has entered a new round of rapid development.

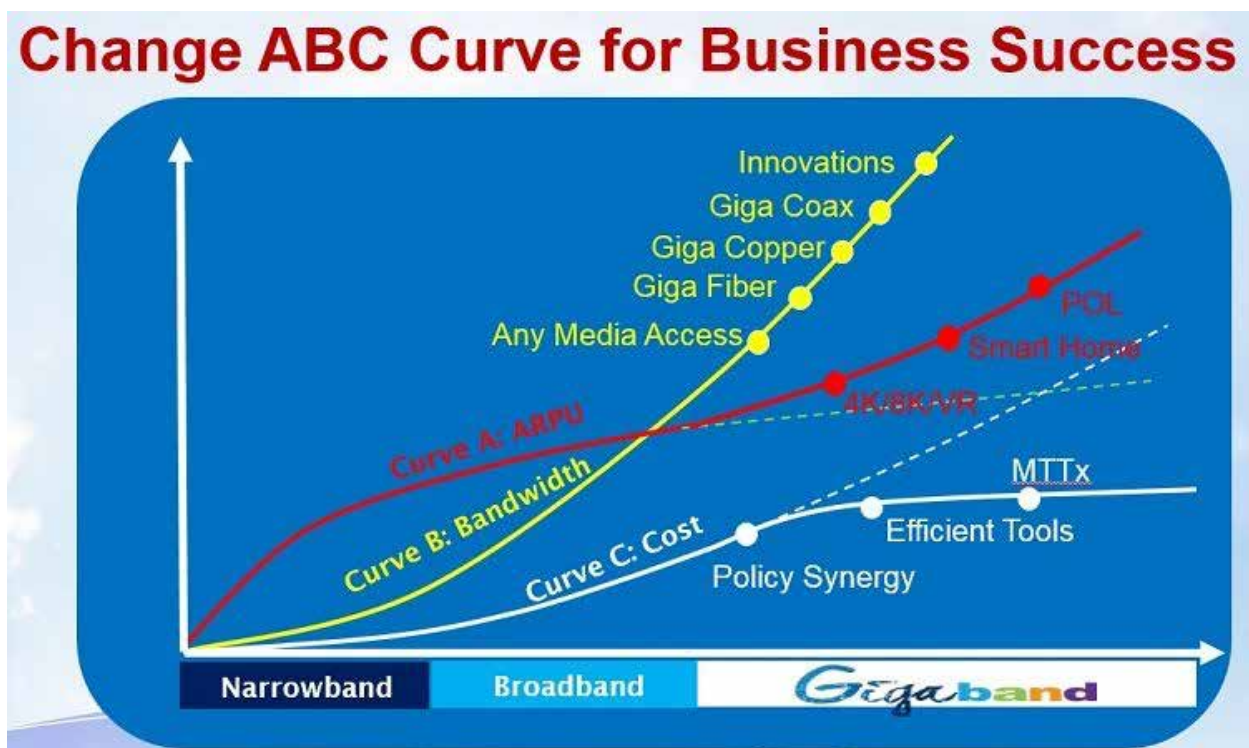


FIGURE 2. There are several approaches to Gigaband. And multiple factors influence the choice of technology.

Globally, fixed broadband has become a focal point for investment in the ICT industry. We now see demand for access devices for fiber to the building (FTTB), fiber to the cabinet (FTTC), fiber to the door (FTTD), fiber to the home (FTTH), and Distributed CCAP (D-CCAP) scenarios as well as matched outdoor cabinets, and ODN products for offering “one-stop” Gigabit access to customers (see Figure 2).

Video services are the most important business opportunity for telecom operators today. Many global telecom operators have a well-developed video strategy, which is designed to drive the growth of broadband services and increase the number of broadband customers and the average revenue per user (ARPU), instead of merely positioning video services as a value-added service.

Looking forward, the industry’s digital transformation is another strategic opportunity for operators. Operators should rethink their positioning and business scope in the B2C, B2B, and IoT markets. As enterprise customers require integrated ICT services that can provide a Real-time, On-demand, All-online, DIY, and Social (ROADS) experience instead of just basic communications service, operators need to “cloudify,” and transform themselves into cloud service providers. Only then will they be able to meet enterprise customers’ ever-growing demand for digitalization.



FIGURE 3. Several advances can speed the deployment and reduce the costs of all-fiber gigabit broadband networks.

Evaluating Gigabit Broadband Success

In terms of coverage, we can expect gigabit broadband networks will cover over 90% of households by 2020, making the ubiquitous ROADS experience possible. Operators will need to invest in broadband infrastructure to provide low latency, high bandwidth, and advanced customer experiences to all their customers.

Implementing a gigabit broadband strategy requires the joint efforts of ultra-broadband industry players and governments. Industry policies must change from encouraging competition to promoting investment, and municipal infrastructure can be opened to operators, helping operators reduce FTTH and deployment difficulties (see Figure 3). For example, China implements fiber-from-the-home for new buildings to facilitate FTTH. Operators also need to formulate network development strategies to support a gradual evolution and build [data center](#)-based simple and agile ultra-broadband networks. Operators should increase investment in innovative gigabit applications to realize the value of gigabit networks and form a healthy ultra-broadband industry circle.

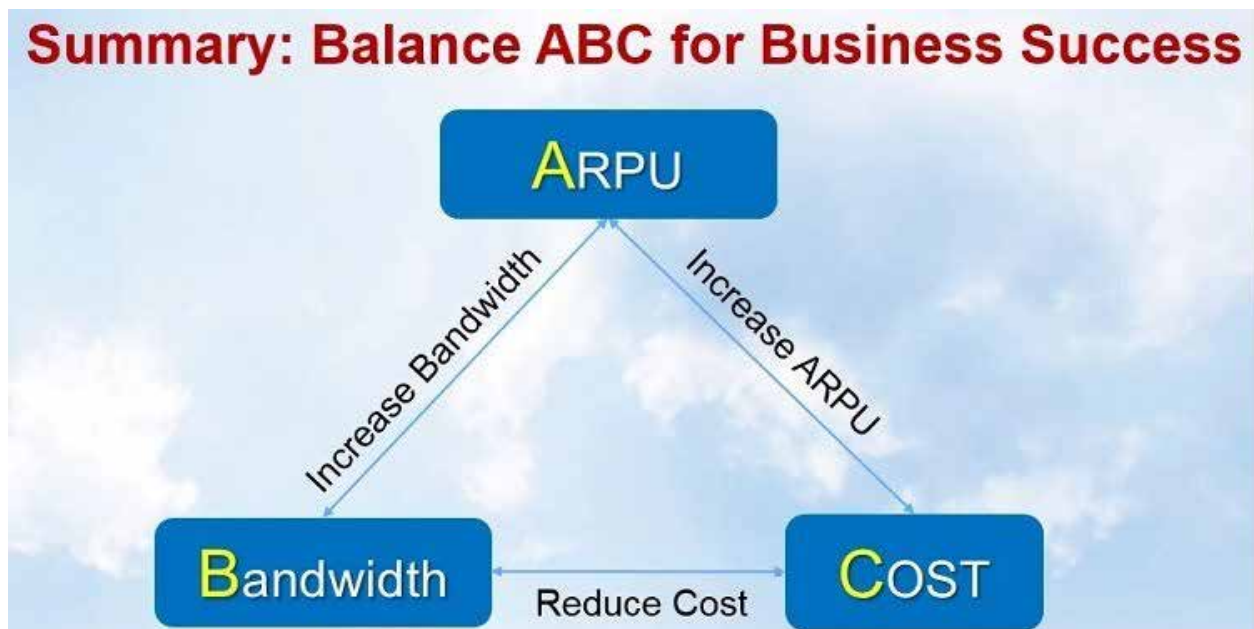


FIGURE 4. Success with gigabit broadband is as easy as ABC.

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JACK ZHU is vice president, Access Network Product Line, at [Huawei](#).

Rolling in Fiber

By **MARK BOXER**, OFS



Placing higher fiber counts in crowded duct spaces is important for today's network operator.

We're all using more bandwidth than ever, and that trend is anticipated to continue for the foreseeable future. That means more fiber is being installed than ever before.

Although there appears to be infinite demand for bandwidth, there definitely is a limit to the space available to place optical fiber. Placing more fiber in less space can be very important to today's network operator, especially in crowded metro areas.

Rollable fiber ribbons can enable roughly twice the density versus existing outside plant cabling methods, making them a very valuable tool in the network designer's toolbox.

A history lesson

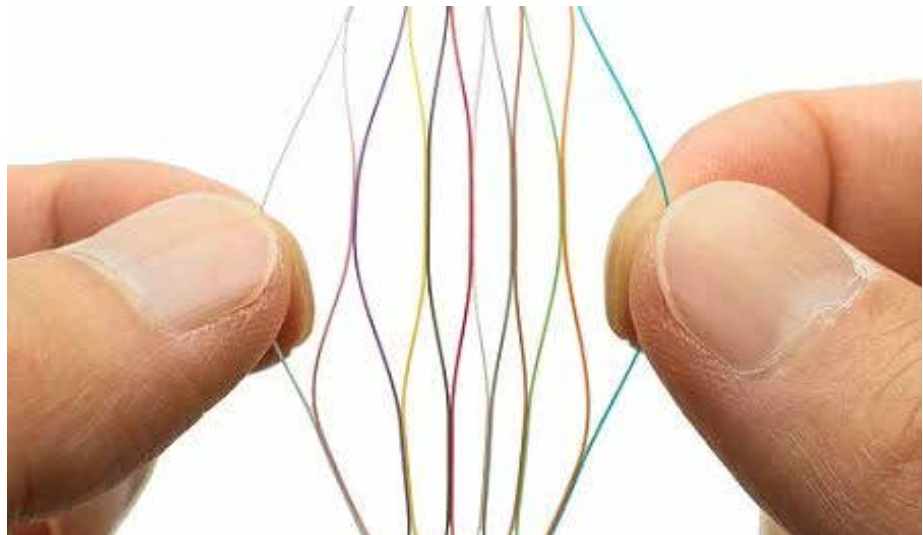
Although the United States has been the engine for many fiber-optic innovations, Japan has contributed several fundamental technologies used in today's networks. These advances include the SC connector as well as Vapor Axial Deposition (VAD) fiber manufacturing, the manufacturing method used to make much of the world's single-mode fiber.

The classic Japanese method for fiber innovation includes a problem that is proposed and addressed by multiple manufacturers. Fiber density is one such problem, and in the early 2000s, Japanese companies began working on the concept of rollable fiber ribbons. So the concept for such fibers is not new, but it has only recently begun to be used in North America.

The initial application of rollable ribbon cable products in North America has been mainly to connect data centers within a campus or metro area with high fiber count cables over short distances of up to a few kilometers. Now, interest is expanding to other applications, such as fiber to the home ([FTTH](#)) and mobile network backhaul and fronthaul.

What is a rollable ribbon?

A rollable ribbon is a fiber-optic ribbon that can be rolled into a tight cylinder, in contrast to a classic flat ribbon, which is designed to stay flat while in the cable and during splicing.



Rollable ribbons are flexible and can be spliced using flat ribbon splicing techniques.

Where a flat ribbon is connected by matrix material between fibers down the entire length, the fibers in a rollable ribbon are only connected at regularly spaced points down the length of the fiber, which makes it more flexible and “rollable.” This design enables the fibers to be spliced using ribbon splicing techniques and equipment while providing much higher density.

What’s the big (or small) deal?

In dense metro environments, many ducts are crowded. Following the laws of supply and demand, crowded ducts can be more expensive. Fiber is comparatively less expensive, so service providers correctly want to increase duct efficiency (and decrease per fiber duct costs) by placing as many fibers in a duct as possible. Rollable ribbon cables double the fiber density for a typical 1.25- or 2-inch duct, enabling thousands of fibers go to into spaces that were previously too small for such numbers.

Rollable Ribbons Enable **2X Fiber Density** (More Fiber, Less Space) Enables Double the Fiber In a Given Duct Size

		
Max Fiber Count	1 1/4" Duct	2" Duct
Flat Ribbon	864	1728
Rollable Ribbon	1728	3456

Rollable ribbon cables can enable 2x the fiber count in a given duct size.

Smaller size provides many other benefits:

- Lighter weight, for longer pulling/blowing distances, decreasing installation costs
- Smaller coiling diameters, for potentially smaller handholes
- Smaller cables can enable longer lengths on a reel. Longer lengths can reduce the number of splice points and splicing costs, while the use of longer lengths and lighter cables can reduce shipping costs

Rollable ribbon cables are gel-free. Removing gel also decreases weight, but its main benefit is to accelerate and simplify the splicing process.

Taking the splicing process into account, the list of rollable ribbon benefits gets even longer:

- Rollable ribbons can be spliced using ribbon splicing techniques, maintaining the productivity and restoration speed benefits of ribbons.
- It's easier to break out individual fibers from the ribbon structure.
- There's potential to use smaller splice trays, which improves closure density, since rollable ribbons are cylinders instead of flat.
- In comparison to ribbonizing loose tube structures, it's almost impossible to cross-splice fibers in a ribbon. Cross-splicing fibers when ribbonizing a loose tube cable can be very difficult to troubleshoot.

Totaling up the benefits, rollable ribbon cables can significantly reduce overall installation costs.

Let the buyer beware

So, rollable ribbons will solve all network problems, right?

Those who have been around the telecom/outside plant/fiber industries long enough know that new technologies should be carefully evaluated. There are a few considerations that need to be mentioned:

Although the basic idea has been around for a while, rollable ribbon cables have not been delivered anywhere close to the scale of either standard flat ribbons or loose tube cables. This means that the cables are typically more expensive than comparable options. That said, the right design can offer benefits that can result in a lower installed cost than for either standard loose tube or flat ribbon cables.

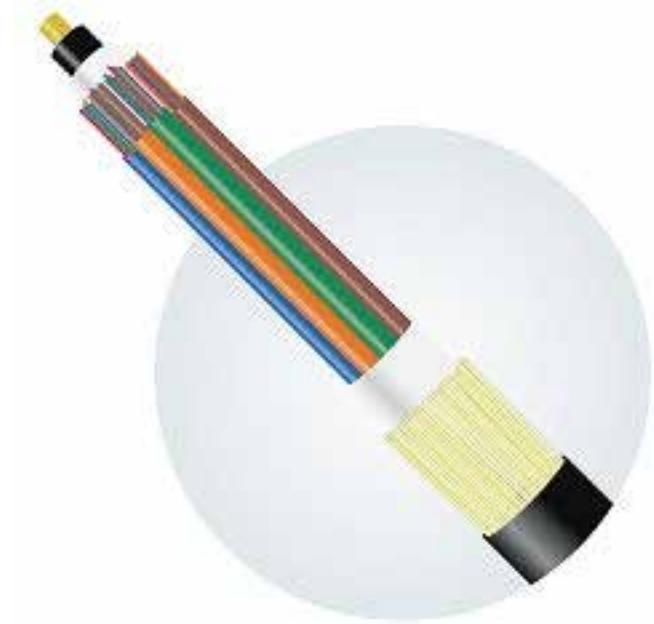
Although ribbon splicing techniques are used, there are some subtle operational differences between splicing rollable ribbons and flat ribbons. This means there's a small learning curve as splicers work with it for the first time.

There are limited sources and availability of products.

Finally, cable and ribbon designs are not as standardized as more traditional designs and there are significant differences between ribbon and cable designs from manufacturer to manufacturer. Since these cables are used more with higher fiber count designs, the financial consequences of picking the wrong product can be substantial.

Details matter

The industry is in its early days of rollable ribbon deployments. Keep in mind that most of the development to this point has occurred in Japan, so it's logical that the first cable designs to be promoted are designs that are more popular in Japan. Two such designs are “wrapping tube” and “slotted core” cables.



Rollable ribbon in loose tube designs brings many advantages.

A third design, “ribbon in loose tube” (RILT), is a more familiar and field-proven design in North America, with several manufacturers offering products with this structure for over 15 years. The RILT design offers several advantages over the alternative designs:

Cable pulling

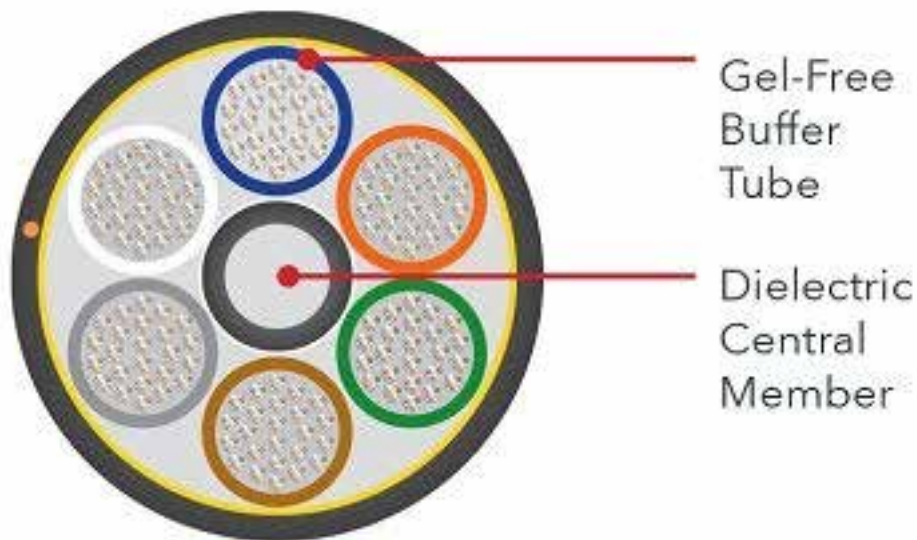
- The absence of a preferential bending plane versus linear strength element designs (such as wrapping tube) can enable easier coiling, handling, and slack management
- Less concern about jacket damage after pulling versus slotted core designs
- More layers of fiber protection and easier fiber management versus wrapping tube cable designs.

Cable prep for splicing

- RILT provides easier ribbon and mid-span access than either slotted core or wrapping tube cable designs. This can be significant, especially for FTTH and

mobile fronthaul/backhaul networks requiring frequent cable access and connections.

- Loose tubes provide additional protection to fibers during the preparation process; it's less likely a technician will nick or cut fibers during cable stripping versus other cable designs.
- Fibers are grouped in color-coded dry buffer tubes, making splicing and mid-span access easier versus string binder groups.



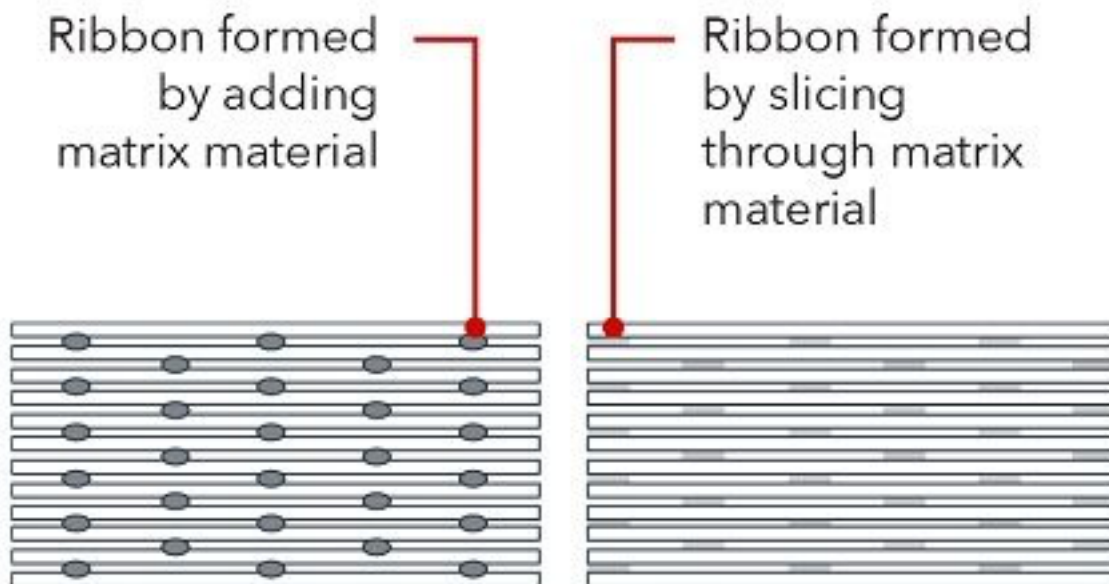
Ribbon in loose tube cable designs provide easy ribbon and mid-span access.

Splicing and testing

- How the ribbons are made is important. A shorter distance between fiber attachment locations provides flatter, more controllable ribbons during splicing. This results in a ribbon that springs back into shape better, aiding the splicing process.
- The wrapping tube design requires string binders to group ribbons together. The RILT design uses traditional color-coded buffer tubes and numbered and striped ribbons for easier identification.
- The RILT design features optical fiber with a $9.2 \pm 0.4 \mu\text{m}$ (1310 nm) and $10.4 \pm 0.5 \mu\text{m}$ (1550 nm) mode field diameter to provide G.657.A1 bending performance with seamless splicing to the installed base of fibers, versus other designs requiring a smaller mode field diameter that can cause “gainers” and elevated losses during OTDR testing.

Long-term performance

- There are different ways of making rollable ribbons. One way is to add matrix material to form the attachment points. Another way is to slice open existing flat ribbon. However, this second approach brings the risk of damaging fibers or fiber coatings, which could compromise long-term reliability. The process of adding material to manufacture optical fiber ribbons and cables has been proven for decades, with millions of miles of cable in reliable service.



The process of adding matrix material to manufacture optical fiber ribbons and cables is field proven for decades.

Summary

Rollable fiber cables are one of the most exciting developments in outside plant cabling technology in years. Benefits include smaller cable diameters and weights, lower transportation and installation costs, and the use of a gel-free, ribbon-spliceable package.

Although initial applications have focused primarily on data center interconnections, rollable ribbon cables are now being considered for applications requiring frequent access, such as FTTH and mobile backhaul and fronthaul.

Rolling in Fiber

Out of the various available cable designs, the RILT cable structure is ideal for use in applications requiring frequent access and has many additional advantages.

Is it time for your network to begin rolling in fiber?

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MARK BOXER is an applications engineering manager at [OFS](#).



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