

Ribbon-winning networks

Discovering new ways to efficiently connect our fast-paced, ever-changing world.

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The need for more data is coming. Millimeter wave 5G and WiFi 6e are going to revolutionize our personal lives and the way we do business. Perform a quick Google search and you'll see a plethora of CEOs, CTOs, market managers and industry analysts discussing the trends leading to bigger, more accessible data. Considering recent events, the need for more data is here and now. Consider the greatly increased number of video conference calls over recent months due to

COVID-19 restrictions. Web pages and apps that once ran seamlessly now act as if their speed is being throttled. Virtual private networks (VPNs) struggle to keep up when accessing corporate networks from home. The question is, "What are we doing to prepare for the coming trends and in response to the spike in demand?" Are we future-proofing greenfield or updating brown-field networks to leverage these new platforms and handle this digital "new normal"? If infrastructure designs and

installation methods are not better suited to handle the increased demand, we will fall behind.

One tangible way to prepare and respond is by rethinking fiber solutions—not rethinking fiber, but rather how fiber is packaged and how it's deployed. Simply put, rather than using single-fiber solutions, networks built with collapsible ribbon fiber will be better suited for future capacity needs with the added benefit of cheaper network deployments. More fiber is needed for upgrading existing and deploying new networks; collapsible ribbon technology is the most efficient way to meet that need.

For the sake of putting the whole picture together, let's ask, "Why mmWave 5G/WiFi 6e?" Why the need for faster and more data? Several technologies that are data drivers including Industrial IoT, augmented reality (AR), cloud services, gaming, and autonomous vehicles to name a few.

It's not science fiction

These sound like fancy terms to lure people into spending more money, painting a picture that sci-fi fantasies will become our reality. However, it doesn't take long to see that these waves of big data are coming, albeit slower and more practically than the media suggests. Several applications are in use today and others in the near future are or will use these big, fast data platforms.

First, healthcare is an area making significant changes in utilizing large, fast data for today and future applications. For example, glucometers, EKGs,



Applications from autonomous vehicles to healthcare and agricultural operations are beginning to demand widespread, low-latency connectivity.

and other vitals-monitoring equipment with connection to the cloud already exist for real-time access. Doctors can monitor and collect data on patients even while the patient is at home. Another shift is the rise in popularity of remote healthcare. More people are avoiding lines and driving to hospitals by participating in remote digital meetings. With the largest driver for telehealth being COVID-19, this trend is likely to continue as people will be leery of waiting rooms and hospitals will be concerned with preventing additional illness. Lastly, and more futuristic, are remote surgeries by doctors operating robots to perform the physical steps. China completed its first successful remote surgery in the fall of 2020 over a 5G connection 30 km away from the subject being operated on—in this case, a pig cadaver.

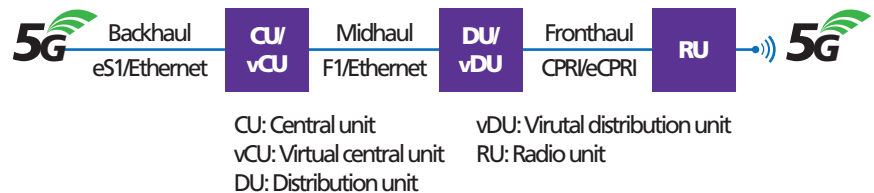
Another application currently online is augmented reality (AR) shopping. With this application, browsers can scan a room and drop in various furniture pieces. Then while using a smartphone like 3D glasses, life-sized furniture comes to life as if it were in a room.

Lastly, in another sector, is a leading agricultural company that wants to use mmWave 5G to enable connected farm equipment. The results will allow a single farmer to operate multiple pieces of machinery at the same time and view real-time data and analysis of fields at any given moment.

Applications that need more data are here now, with many more on the horizon. mmWave 5G and WiFi 6e are not just platforms for tomorrow, but can be used today. However, our networks must be ready to handle the increased data demand they bring.

Architecture drivers

So what are the architecture drivers for using ribbon fiber? Why can't we use the same fiber with faster hardware? Lots of



To send data faster than before, networks must split many of the physical modules responsible for various routing and transport functions. For example, a typical baseband unit in a cellular network that served multiple data link layer functions is now being split into two newly named devices called a centralized unit (CU) and distribution unit (DU).

details can be explored to answer this question, but at a high level, the driver is as expected: “More data on more devices.” Fiber plays an important role for two reasons.

1. The switch to higher frequency spectrum
2. Disaggregation of the data link and physical layers

Switching to a higher frequency spectrum is a limitation due to the properties of electromagnetic waves. Essentially, higher frequency wireless signals (which mmWave 5G and WiFi 6e will be utilizing) do not travel as far at the same power. Higher frequency waves are more easily blocked by various objects: walls, roofs, furniture, etc., and more easily absorbed by various compounds in the air. Higher frequency signals are also more difficult to provide the same signal pump power. It is scientifically more difficult to provide the same power for higher frequency transmitters than lower frequency ones. This means to have the same coverage area, more access points need to be deployed, which means more lines need to feed the increased number of access points in a LAN, small cell sites, or antennas in an active DAS.

Recent market research estimates around 800,000 small cell sites will be needed to support mmWave 5G where roughly 600,000 are yet to be built. This doesn't imply ribbon will be needed at

each device, but that the various distribution hubs—closets, frames, etc.—will serve more access points and more of these hubs will need to be built. More fiber per hub and more hubs.

If the network can be thought of as a tree, the trunk is getting bigger, sprouting more limbs, and each limb is sprouting more branches. This will be a larger contributor to growth in the size of main distribution frames (MDFs) and growth in size and number of intermediate distribution frames (MDFs) for enterprise networks.

Data link/physical layer disaggregation

The disaggregation of the data link and physical layers is the larger driver globally. Think cellular data. The amount of traffic on the internet has grown substantially over the years and continues at an astounding rate. Along with growth in data consumption is the growing need to access data more quickly, i.e. low latency. Autonomous vehicles, remote surgery, and gaming, along with other applications, hinge more on low latency than volume of data. A traffic light doesn't need much data to signal a self-driving car it is changing to red, but it needs to do so quickly. To send data faster, service provider networks and other WANs (healthcare, campus, stadiums and others) must split many of the physical modules

responsible for various routing and transport functions in their networks. For example, a typical baseband unit (BBU) in a cellular network that served multiple data link layer functions is now being split into two newly named devices called a centralized unit (CU) and distribution unit (DU).

The data link responsibilities of these two units that were originally housed in a single “box” are split so their processes can be performed in tandem, which mitigates potential bottlenecks in the network. This splitting combined with the increased number of cell sites, access points, etc. exponentially increases the amount of fiber that needs to be deployed, which begs the question, “Why would you want to deploy stranded fiber cable?”

Benefits of higher-density cable

Cable pulling/jetting and management are two major cost items in network infrastructure installation. Bidders and designers alike seek ways those expenses can be reduced. Ribbon fiber and subsequent equipment advancements in recent years have brought about that solution. The development of “collapsible

ribbon” technology has radically reduced ribbon cable outer diameter (OD) and weight when compared to loose fiber cable constructions.

Mass fusion splice losses

Fiber combination	Average splice loss (dB)	Standard deviation	Maximum splice loss (dB)	Minimum splice loss (dB)
G.657 #1 to G.657 #2	0.03	0.014	0.07	0.00
G.657 #1 to G.652.C	0.02	0.019	0.13	0.00
G.657 #1 to G.652.D	0.02	0.014	0.05	0.00
G.657 #2 to G.652.C	0.03	0.013	0.07	0.00
G.657 #2 to G.652.D	0.03	0.017	0.08	0.00

When considering fiber types in cable, there are three options: loose fiber, flat ribbon, and collapsible ribbon. The chart shows the drastic reduction in size of the new collapsible ribbon technology for outside plant (OSP) cables.

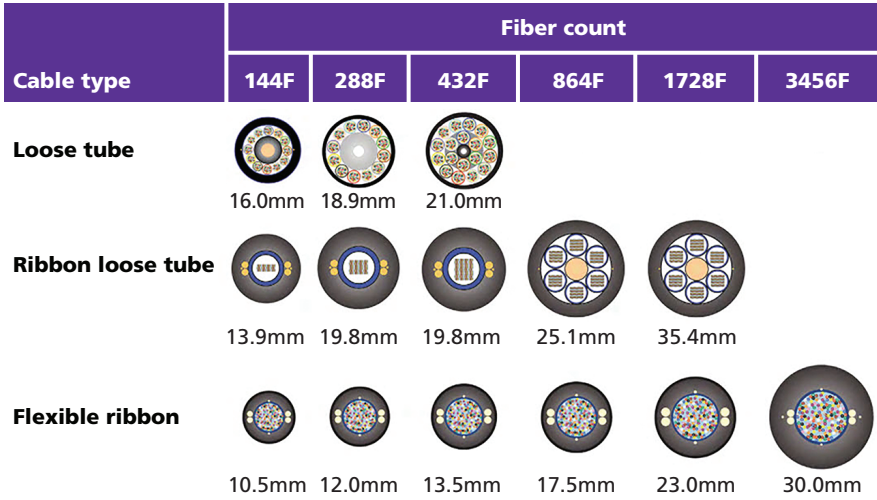
While the chart is an OSP comparison, the same benefits can be realized with inside plant (ISP) and indoor/outdoor cable as well. These size reductions translate to easier pulling (or further jetting) with less pathway real estate at the same or greater fiber counts. Subsequently, handoff and splice points are lessened, and installation time and costs are reduced.

Cable management and connectivity sees the greatest installation benefits from a percentage viewpoint due to simplified cable designs and mass

fusion splicing. There are a multitude of ways to land a cable, but splicing is typically involved. First, the cable must be prepped for routing and subsequent splicing. In OSP and ISP demarcation this also requires prepping the enclosure, which can be time consuming. With many collapsible ribbon cables contained in a central tube design, the strength members are embedded in the jacket, which translates to no buffer tubes and no gel. Therefore, prepping an enclosure for splicing is much faster. No tying off the strength member, no individual buffer tubes to break into, and no gel to clean off. Once the enclosure is prepped and splicing starts, the time reduction is phenomenal.

Various splicing time studies have been conducted over the years from manufacturers and laborers alike. Results from these studies indicate a 60 to 75% splice time reduction for ribbon versus single fiber. These results vary due to improvements in splicing and fiber technologies, as well as the skill of those performing the actual splicing. In a 2018 study conducted by AFL, 144-fiber buffer tube stranded fiber cable was compared to a 144-fiber central tube collapsible ribbon cable. The stranded cable required just under 3.5 hours for cable/closure preparation and splicing—more than one hour

Cable technology comparison



Both inside plant and, as illustrated here, outside plant cable can be pulled more easily thanks to size reduction.

was required for the prep and 2:20 for the splicing. The central tube cable required just over one hour with the time for splicing and preparation at 37 and 34 minutes, respectively. Another way to look at this is for every three of these splice locations, or every 432 fibers spliced, a day's worth of labor is saved. These time improvements can be carried anywhere splicing is involved.

At the connectivity location, splicing is the most common solution for termination. Smaller fiber count backbones will not see as much benefit, but if multiple wall boxes are spliced or a high fiber count closet or two exists, the savings add up quickly. The enabling solutions are LGX-118 or other proprietary form factor ribbon splice cassettes. Traditionally, a fanout kit may be placed over a breakout cable and spliced on 12 individual connectors, or with cassette type locations, a single fiber splicing option is required. The incoming cable largely dictates the choice of cassettes or termination option, but by starting with ribbon, time savings can be realized at all splice points in a network. The material economics are also favorable, as there is no major premium for choosing the ribbon cassette solution. Splice-on connectors are by far the most expensive option, whereas the ribbon cassette may be a little more expensive than the stranded. Typically, more than the difference is made up with the splicing time savings.

A second look at splice loss

Core alignment splicing has long been the workhorse of the splicing world especially in enterprise networks because of the insurance it provides. The fiber core is aligned every time.

Mass fusion has been viewed negatively when compared to core alignment since it is fixed V-groove, and therefore incapable of the same splice quality.

Modern fiber from major manufacturers has changed that consideration. The table on the previous page shows a snapshot from the findings of a 2018 International Wire and Cable Symposium paper re-

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garding mass fusion splice loss of several common fiber types in use today. Note in particular the numbers in the column "Average splice loss (dB)."

While the 0.01 dB average of core alignment may not be seen, 0.03 dB on average is a small price to pay. An occasional outlier of up to 0.10 dB might be seen (that wouldn't be seen with core alignment), but even those outliers are below splice loss specifications of the standards bodies. Mass fusion splicing was not always this seamless and came with a noticeable loss penalty. The change is primarily from glass quality improvements.

Second only to equipment cleanliness, poor core-to-cladding concentricity is the next primary culprit for high optical losses with mass fusion splicing. It was once challenging to manufacture fiber with the core in the center of the cladding, but fiber manufacturers have largely overcome this.

Core-to-cladding concentricity error for optical fiber is specified at $\leq 0.5 \mu\text{m}$. However, when taking the time to measure the values, most are $\leq 0.25 \mu\text{m}$, meaning that the core is $0.25 \mu\text{m}$ or less away from dead center of the cladding.

In general, mass fusion splicers have a much longer arc time than single fiber splicers. They have a longer arc time not because it takes longer to melt the glass. Rather, the arc time has been made intentionally longer to mitigate core and cladding offsets.

The mass fusion splicer takes advantages of the fiber's desire to self-center when in a liquefied state. This "viscous self-centering" in tandem with high quality glass enables low losses with

mass fusion splicing. As a practical matter and specifically concerning splice loss, this means that unless splicing to an old embedded fiber, mass fusion splices will not penalize a network.

Staying connected

The COVID-19 pandemic has highlighted our ability to stay connected while being physically apart. Data demand skyrocketed everywhere during this crisis, and it's reasonable to conclude many online services will continue to be leveraged and improved upon as lessons learned are put into practice.

The services available today and the ones to come offer exciting prospects to benefit lives everywhere. These advancements hinge on the infrastructure required to support them, and traditional methods simply are not suited to keep up with the impending growth. Solutions to improve installation times and cost exist, but "sticking with what works" can sometimes be the enemy. In this fast-paced, data-driven world, continue to look for and learn new ways to improve product and service solutions and connect the world. ♦

Lucas Mays is applications engineer for field fusion splicers and accessories at AFL. He has experience as a fiber-optic installer and splicing technician, and puts that experience to use in his research-and-development projects at AFL. At aflglobal.com, the company offers a technical paper titled "Splicing Efficiency Improvements in Ultra-High Density Fiber Optic Cable."