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Probing Infrastructure Readiness for 5G and Beyond

Three-dimensional, gyroscope-based mapping of telecom ductwork will verify whether it is ready for high-density fiber optic cable and allow assets to be properly charted

As the era of 5G arrives, the field of telecommunications is about to become even more dazzling, dramatically impacting every aspect of people's lives – autonomous cars, smart communities, far-reaching IoT. However, with the rollout currently underway, many contractors and telecom operators are discovering a significant challenge with the existing underground infrastructure, as well as potential obstacles for installing new fiber optic cable - the backbone of 5G and beyond.

As a result, gyroscope-based 3D mapping tools are beginning to play a critical role in telecom infrastructure, enabling operators to digitally track assets as well as ensure that installations are not inadvertently compromised.

Navigating underground maze

The challenge is twofold. First, due to a much greater fiber count, the physical makeup of fiber optic cabling for 5G is not only considerably heftier – having a much larger outside diameter than 4G – but in many cases, it is also less flexible. Second, the duct through which the fiber must run is often installed in highly congested underground areas competing for space in a tangled web of utility infrastructure. This is where telecom, electricity, gas, water, and cable TV grids all compete for space with drainage, mass transit, and other networks.

As a result of these and other natural obstructions, contractors are often forced to maneuver the ductwork to avoid existing barriers. Such maneuvers sometimes result in unexpected turns or bends that compromise min

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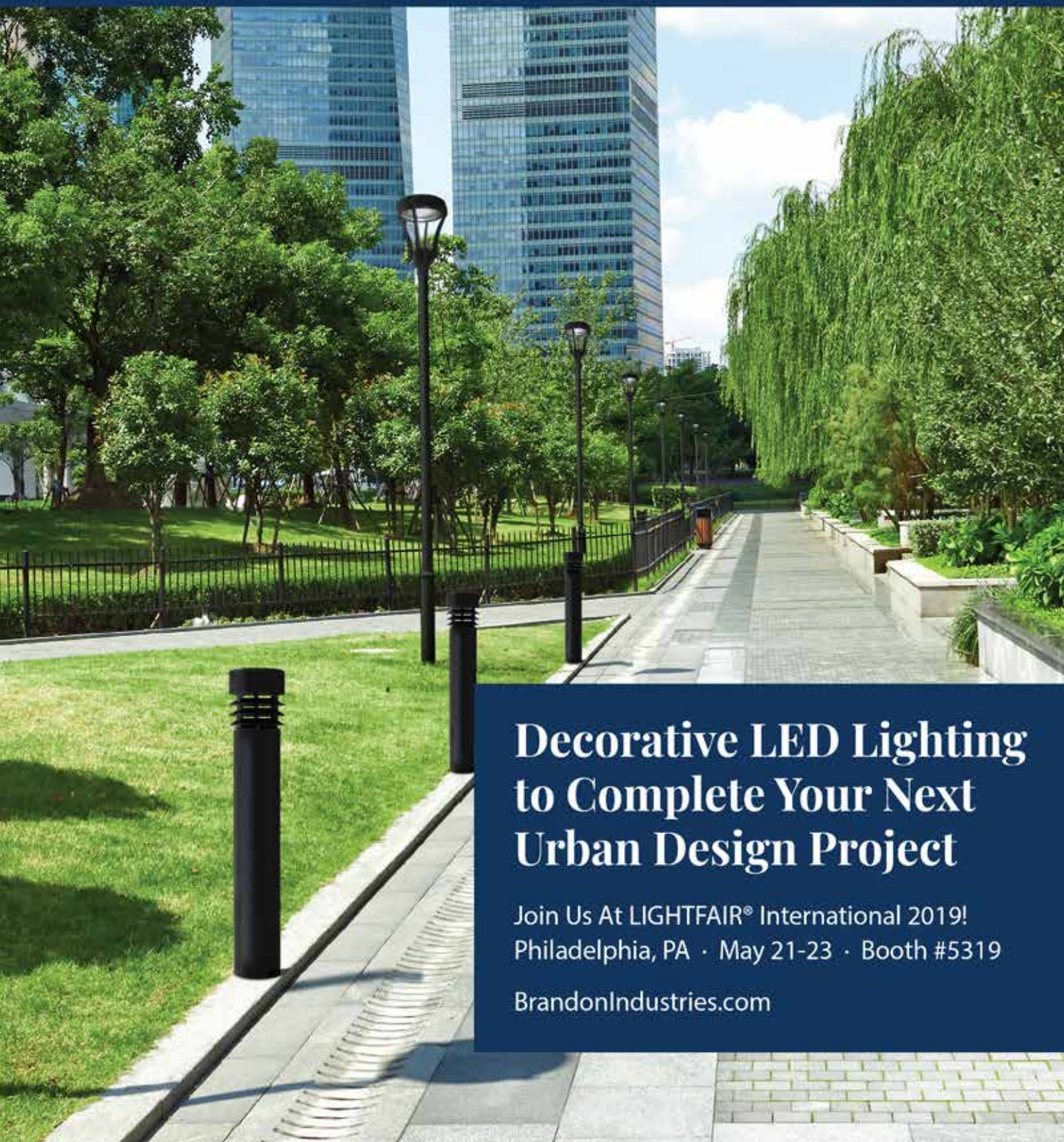

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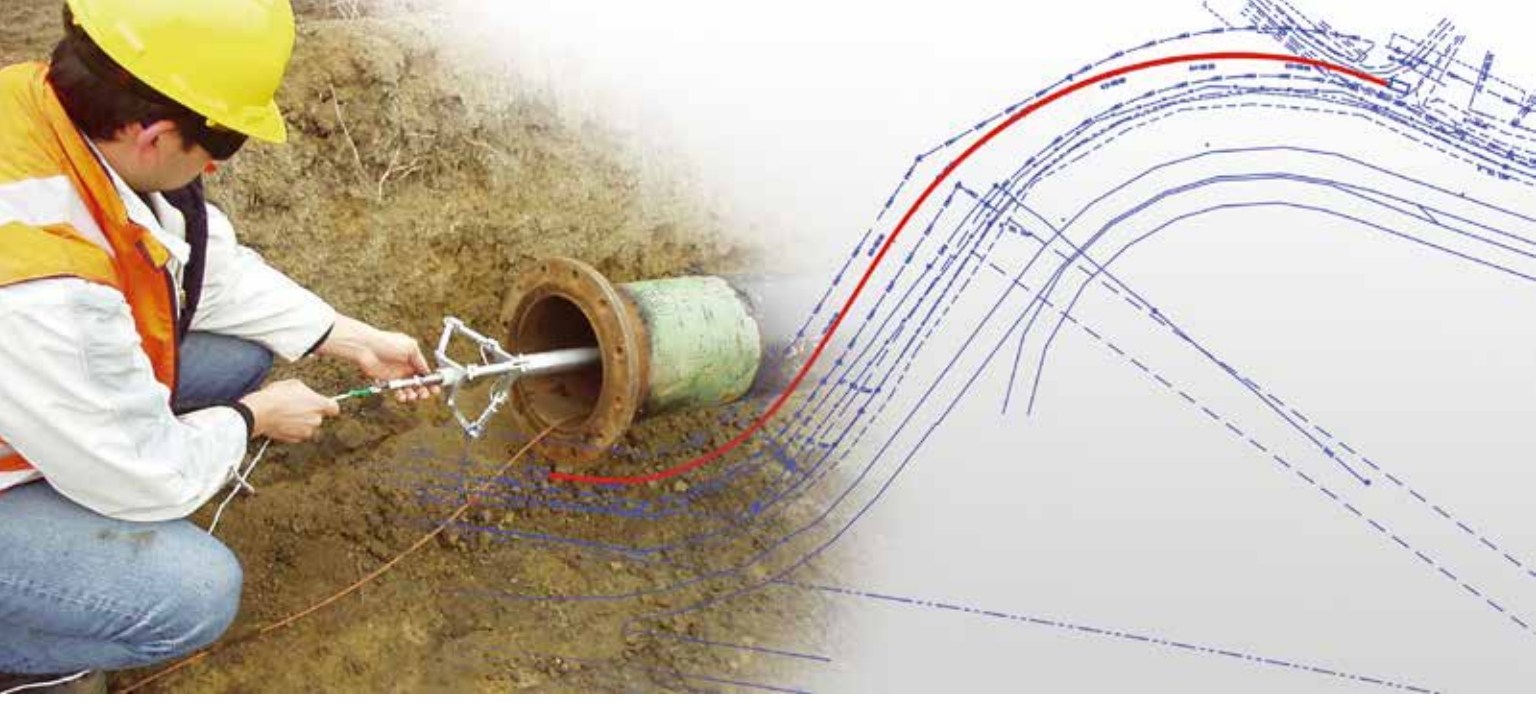

imum "bend radius" specifications mandated by the cable manufacturer which can cause breakage and ultimate failure of large quantities of fiber during installation. Additionally, these manipulations with the path of cable ductwork can leave assets which are not properly mapped, more vulnerable to accidental damage.

It is not only new construction that is at issue. Many plans for installing 5G cable include utilizing what is known as empty or "dark" HDPE ducts that were previously installed with earlier cable installations to allow for future growth. Yet, not many telecom experts were able to foresee the potential shortcomings of these pre-installed ducts. With the smaller 4G and earlier cable generations, the fibers within were able to withstand the tighter bends. Installing 5G cable in many of these same areas has become an unknown risk.

"Looking back on the emergence of 4G, who could have envisioned five years ago that the increase of fiber count for 5G would double or triple – with a range of 1,700 to nearly 7000 fiber strands in a single cable resulting in a fill ratio in excess of eighty percent," says Santosh Saride, Market Analyst, with Condux International (Mankato, MN).

Condux is a major supplier of equipment used to install fiber optic cables, and has found that utilizing advanced duct mapping technology is saving telecoms significant time and money during the ramp-up to 5G.

"Proper mapping of the duct in both new and previously installed ductwork promises to expedite the installation of fiber optic cable for 5G and beyond, as well as reduce future downtime due to improperly mapped ducts," Saride adds.

Evaluating possible solutions

The fact is, many, if not most, telecom operators do not have precise maps of their underground assets. Even for those that have invested in geographic information systems (GIS) to store network-related data, the quality of their three-dimensional (XYZ) data provided from most standard GIS platforms is often inaccurate or inadequate. This is largely due to factors such as: unknown depth; references to aging or no longer existing above ground landmarks; analog data references; and the inability to map infrastructure installed by means of trenchless methods, such as river crossings, underneath buildings, etc.

Alternative techniques such as ground-penetrating radar and beacon-based systems are unreliable or impractical because these systems are difficult to use and don't get the exact measurement of the pipe's centerline. Moreover, beacon-based systems can measure to a limited depth and are highly susceptible to electromagnetic interference, rendering them virtually useless in densely piped areas or near railways and power lines.

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Gyroscopic-based 3D mapping systems, however, are solving the underground duct mapping problem, delivering reliable XYZ data as well as the centerline of the duct or pipe. The technology, which has been proven through years of mapping underground water infrastructure and pipelines, is now being applied to both existing and new ductwork within the telecom market.

Automated gyro-based mapping

Condux International, a U.S. based company that has spent decades providing tooling for blowing and pulling fiber through ductwork, has started providing gyroscopic-based 3D mapping technology that allows customers to ensure successful installations of pipelines and ducts – including those for fiber optic cable.

"The gyro-based tools can precisely map the duct or pipeline through miles of dense infrastructure, accurately locating irregularities in ductwork and providing data on bend radius and other deviations that can interfere with the transmission of fiber optic signals, often robbing a 5G cable of up to 40% or more of its transmission capabilities," says Saride.

Precise mapping of underground cable ducting is now possible through the use of inertial guidance technology that incorporates the exacting 3D instrumentation – gyroscopes, accelerometers, and magnetometers. Incorporated into an innovative tool that travels through the cable ducts, it can precisely map the path from end to end, including bends, undulations and other deviations that may have been required to route the duct through the congested maze of existing underground infrastructure.

Knowing the extent of those deviations, particularly bends, can be critical to understanding the true capacity of the ducts to successfully accommodate the bulkier super-high-bandwidth fiber cable. This is because the radius of every bend in an underground duct can adversely affect the ability of the 5G-or-higher cable to perform according to cable manufacturers' specifications.

Constructed with military grade hardware, the unit features centralizing rings that support a body containing mapping instruments. The 3D gyro-tool is articulated, enabling it to pivot through various bends, bumps and turns that typically occur in telecom ducts. It also features an easily accessible data port for uploading data to a GIS file via laptop or notebook computer.

Some gyro-mapping systems are now available in extremely compact sizes, ranging from the world's smallest gyro-based mapping probe (duct range 40-75mm) to larger models with operational ranges for pipelines 3.5 in. and up.

For information contact: Condux International, 145 Kingswood Drive, Mankato, MN 56002-0247 USA; Phone: (800) 533-2077; FAX: (507) 387-1442; Email: conduxinfo@condux.com; Visit the website ***www.condux.com*** •

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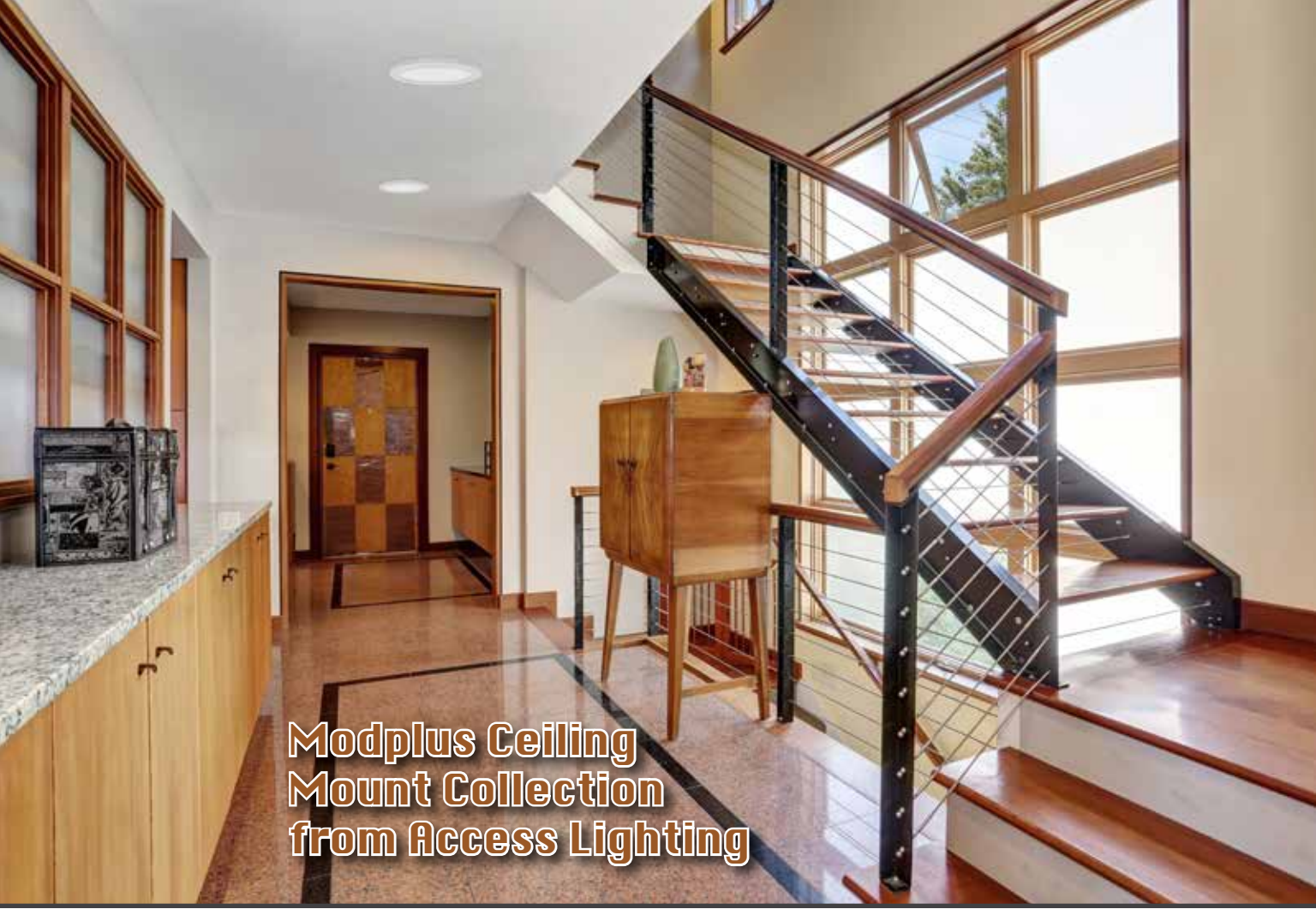

Modplus Ceiling Mount Collection from Access Lighting

ModPLUS is a revolutionary, decidedly contemporary, ultra slim ceiling mount collection from Access Lighting, a leader in contemporary lighting solutions based out of Irvine, CA. Designed with performance, aesthetics and current application trends in mind, ModPLUS nails every attribute to perfection and offers an extensive set of options.

One of the most innovative attributes to the ModPLUS collection lies in the magnetic trim rings that allow for easy conversion of the classic white finish to your color of choice. Standard trim colors include; black, bronze, brushed steel and chrome, but unique colors can be custom ordered. Once ModPLUS is mounted, the accessory trim ring is simply aligned to the fixture body and snaps into place via magnetic force. This provides the distributor with the ability to order and warehouse limited inventory in white, with a host of alternate trim ring finishes ensuring the customer has instant gratification, clearly a key initiative for every savvy business owner in today's retail climate.
The mounting mechanism for the ModPLus ceiling mount, rivals the simplicity and ease of securing the accessory trims. This entails a simple cross bar mount, followed by insertion of the crossbar into the channel provide on the backside of the fixture and finally the snap in of two small clips on either side of the unit to secure the fixture to the crossbar. All of which can be accomplished in a matter of minutes. Almost unheard of in the industry, the ModPlus collection requires that only two screws be used to mount the cross bar only. All final mounting calls for no use of additional tools.

Answering the overwhelming demand for performance, the ModPLUS collection incorporates the latest in today's LED technology. Not only does ModPlus simply meet today's strict energy consumption and flicker

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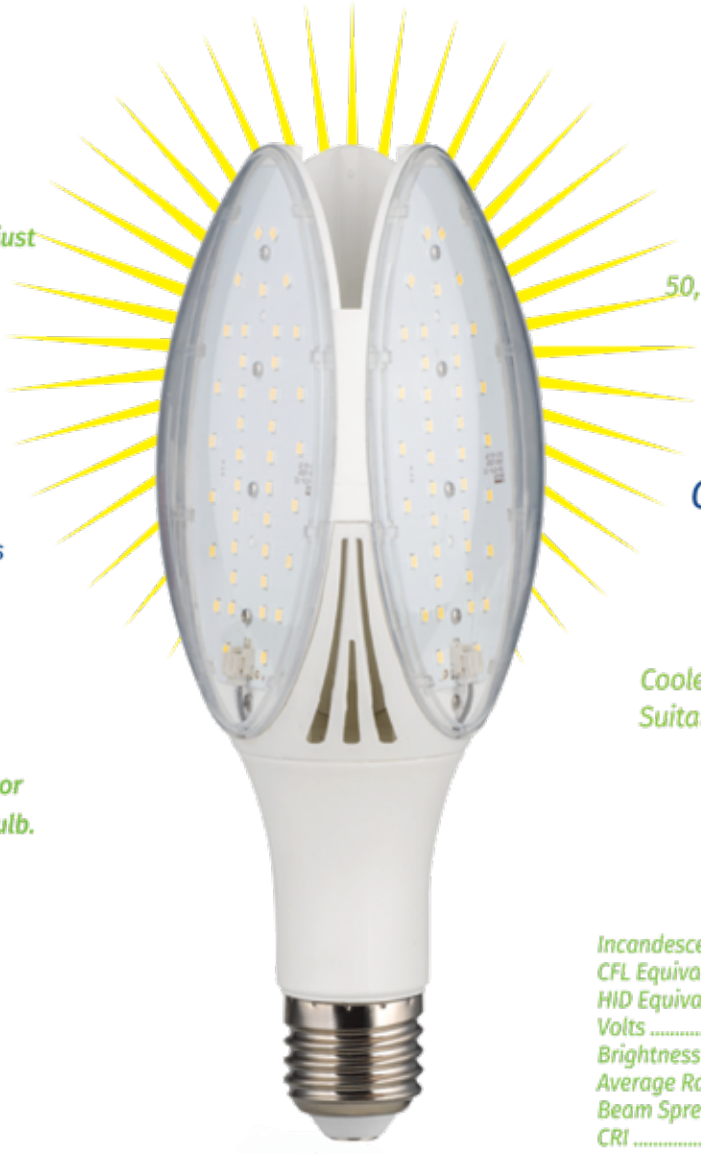

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Average Rated Hours	50,000
Beam Spread	330º
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requirements, but surpasses those requirements entirely. The fully integrated LED modules deliver a range of 793 lumens to a staggering 2843 lumens, model dependent. That translates to an impressive average of 108 nominal lumens/watt. In addition, ModPLUS 120V sports a CRI greater than 90, CCT under 4000K, R9 value greater than 50, flicker rate less than 30% and a rated life > 15000 hours, thus meeting all the California's rigorous JA8/Title 24 requirements with ease. Speaking of certifications ModPLUS is rated for damp locations and both ETL and CETL rated. As LEDs are only now being fully accepted with open arms by consumers and are generally offered in an array of confusing color temperatures, ModPlus's standard offering is in a warm 3000K color temperature and 90CRI, creating a sense of comfort that we are all familiar with and used too. For those light savvy consumers out there, who want options and may be seeking cooler color temperature, a 4000k option can be special ordered.

You want more options, Access has more. The ModpLus collection is offered in both round and square. Its ½" low profile affirms its minimalist air. Access Lighting was truly thinking about the consumer when they developed ModPLus. Often times, the biggest hurdle for Low profile surface mounted luminaires, is being able to be ordered by the consumer or contractor, without questions as to whether it will mount into their application. Not with ModPlus.
The brilliant design of ModPlus 120V 7", 9" and 12" fixtures incorporates everything, including the LED drivers into the luminaire, thus requiring little to no depth for mounting purposes. Yes, this means that ModPlus will mount to any standard 4" junction box, including low profile pancake style junction boxes. An extensive variety of sizes including; 7", 9", 12" and 16" round and either an 8.5" or 11.5" square, allows for a multitude of applications from bathrooms and kitchens to closets, pantries, laundry rooms and corridors. Furthermore, with an acrylic shade as opposed to glass, ModPLUS is easily maintained in those high traffic areas where concerns with cleaning and/or breakage may need to be addressed.

For commercial and industrial use, ModPLUS offers

the 7", 9" and 12" round versions and both the 8.5" and 11.5" in 120-277V. The entire 120-277V offering has 0-10V dimming capabilities. Is emergency battery backup needed? ModPLUS addresses this as well. Its emergency battery backup model is offered in a 9" diameter at 1.75" in height with an impressive 1243 lumens and provides a minimum of 90 minutes of battery life on a 24-hour charge and are equipped with both a test button, a charging indicator, and 2 branch circuit connections to allow for independent connection of the battery backup to a dedicated power supply. Should the consumer need an emergency battery backup luminaire and also want uniformity of the fixtures that are placed in a room or long corridor, a non-emergency battery backup option with the same depth as the emergency battery backup model is available to ensure an even distribution of light and an aesthetically pleasing appearance where both options are required.
The final member of the ModPLUS collection is equipped with a motion sensor for the ultimate in energy efficiency. The 9" round motion sensor armed ceiling mount is sensitive to motion within 15 feet and offers over 1200 delivered lumens. An additional feature is a Day/Night mode switch which allows one to select sensitivity to motion over a 24-hour period or limited to night activation only. ModPLus motion luminaire will remain illuminated for up to 30 seconds without any movement in the immediate space. Oh and did we mention that the ModPLUS motion sensor light does not require a wall switch? Quite ingenious. ModPLUS Motion Sensor- Light it up with a single motion.

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ModPLUS is just one collection in the extensive offerings of contemporary, technically advanced lighting that comprise the Access Lighting assortment.

Founded in 1990, Access Lighting is a small family owned business with big ideas. Access is based in Irvine, California and distributes lighting across the United States, Mexico, Canada, and the Bahamas with independent representatives in each and every state.

The owner, Harry Rosenblatt, was quick to recognize the need for affordable, contemporary lighting, as he embarked on his new career in the lighting industry. Harry immediately set out with a mission to provide, well manufactured, contemporary lighting that was affordable for all who sought out modern lighting designs.

With his roots in the electronic industry, Harry has over the years endeavored to incorporate the latest cutting-edge technology into his lighting. As energy efficiency lighting came into play, Access Lighting was at the forefront, providing thousands of custom-built fluorescent options. With the advent of LEDS being incorporated in luminaires, Access Lighting has been right there providing energy efficient LED options housed in fabulous contemporary designs.

One may be misled into thinking that Access Lighting, much like its competitors, is a "box in, box out" entity with little custom capabilities. However, Access Lighting is a U.L certified conversion center, providing us with the flexibility to custom manufacturer. It is this elasticity that allows for a host of driver options, lumen options, 0-10V dimming capabilities, motion sensor and battery back-up possibilities. Best of all our conversions are completed in house in our warehouse in Southern California, ensuring real time updates of the progress on your order and putting us in the driver seat to manage your job.

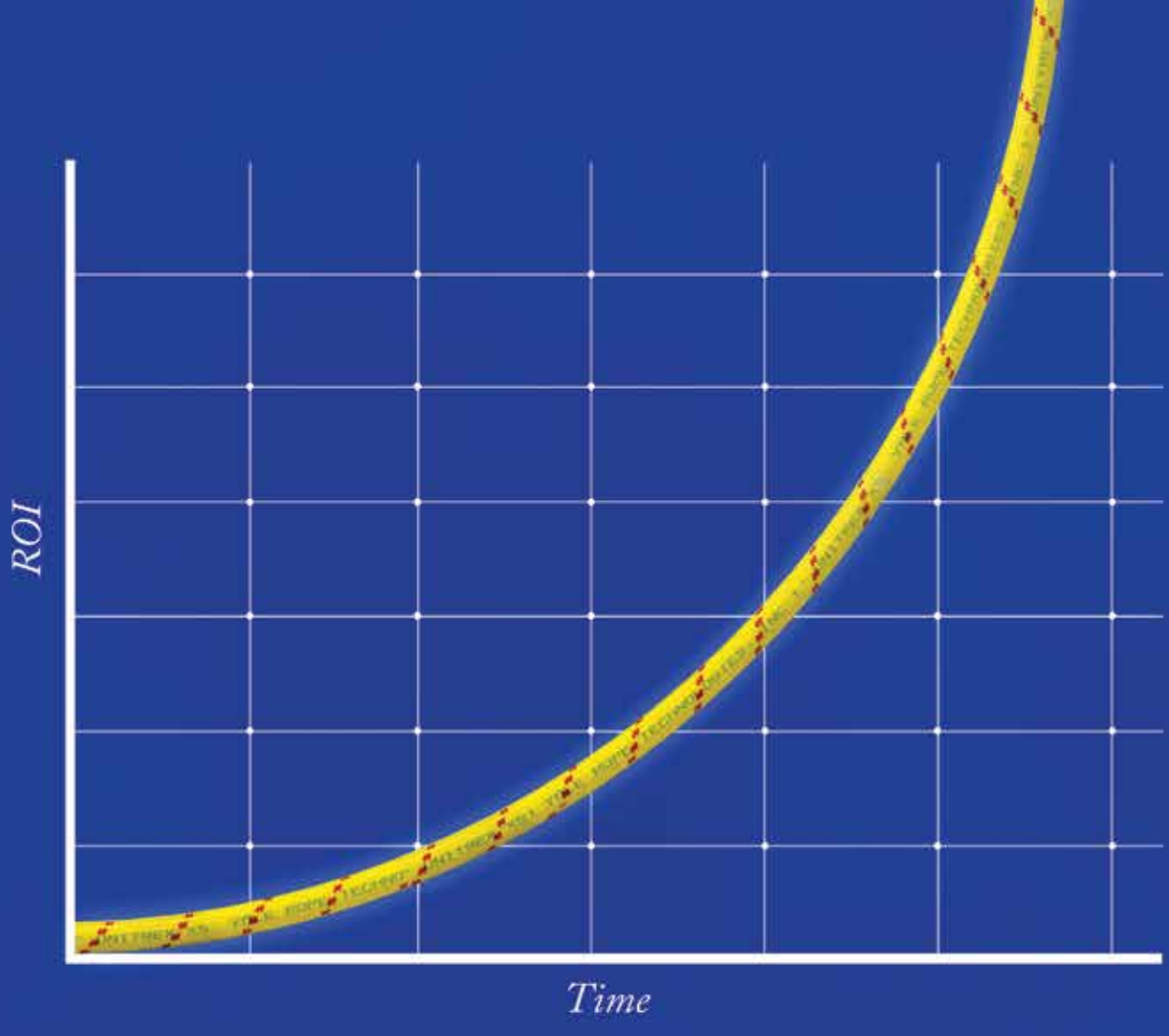
In addition to this Access Lighting is a friend of Hue and has to date over 18 different design options housing fully integrated smart lighting. The full

integration of the Phillips Hue Smart Lighting System allows for the fabulous even distribution of lighting in fixtures that would ordinarily be equipped with smart bulbs. A visual comparison of the two side by side makes it abundantly clear where the superior execution lies.

As a Friend of Hue these smart lighting fixtures can be controlled by the Phillips Hue App bringing routines and human centric lighting to each individual that is in pursuit of their best performance. Preset kelvin temperatures allow one to relax, read, wake up, enhance your energy or improve your concentration in a simple and cost-effective manner. Down to the wireless remote that is available with the Phillips Hue system, ease of use is key.

Phillips Hue is also compatible with Alexa, Google Home, Apple Home and can easily be voice activated. Available in both white and color ambient options, Phillips Hue takes the work out of party and holiday light with the ability to select from over 16 million different colors, bringing the appropriate color to your event within minutes. Have a favorite soccer team, the open source opportunities from Phillips Hue has led to the development of an app that will provide you with the exciting news that your favorite team has just scored with a flash of light. The options are endless with Phillips Hue and as a Friend of Hue, Access Lighting is making those options readily available.

Access Lighting is also known for its commitment



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to staying abreast with the current needs in lighting. As we see the movement across the country to the adoption of Energy Star standards and currently CEC Title 24 and JA8/Title 20, we work diligently to get as many products in our line up certified, ensuring ease of application in the specification channel. Frequently specified products come equipped with detailed Specification data, and IES files, and should you require an IES file that is not readily available we are there to serve you and make one available as soon as possible. All of our product are either U.L. or ETL certified.

On the product front Access Lighting tries to ensure that we meet the needs of the user. Higher lumen outputs and quality LEDS that are high efficacy, consistent in color and stand the test of time are two initiatives that are of the utmost importance to our company. In sync with the quality of the LEDS and just as important are designs that allow for the dissipation of heat from the LEDS and quality drivers to ensure the longevity of the product. We place tremendous emphasis on the construction of our fixtures conducting in-house testing too.

Known for our outstanding selection of outdoor luminaires, we ensure the life span of our outdoor fixtures by largely utilizing Marine Grade paint. Marine grade paint is only effective if the metal to which it is being applied has few impurities and the fixture is well cleaned prior to the application of the paint. Once properly adhered Marine Grade paint will withstand harsh coastal elements well. Access Lighting tests our marine grade fixtures and clearly indicates when a

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fixture is not marine grade by eliminating the letter MG from our model number. We understand that your success is our success, and this is why we strive to provide you with quality fixtures that withstand the harsh elements from the get-go.

Access Lighting is also well known for our ability to design and product fixtures from the ground up. With a tag line like "where exclusivity meets affordability" it makes sense that our goal is to assist you in developing a fixture that is unique, but at an affordable price point. Our dedicated purchasing team will assist you by selecting the appropriate factory with which to partner, the ideal light source for the best performance and life of the fixture, and the most current technology. We will provide you with a sample prior to production and ensure that all of the necessary certifications are obtained to safeguard you and your customer. It must be noted that service does require a minimum threshold quantity.

In closing Access Lighting prides, itself on contemporary designs that incorporate cutting edge technology. We understand that we live and die by our reputation and thus exceptional customer service, quality product, and standing behind our product are the three cornerstones of our company. We strive to separate ourselves from our competitors by conducting ourselves in a moral and ethical manner and delivering product that we are proud to label with our logo. Lastly, we shoot to work with our customers to problem solve when challenges arise, celebrate the wins together and share in the losses. After all, we bring powerful solutions in illumination to all. •

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As data center and enterprise network managers confront the ongoing surge of high-bandwidth, high-speed applications driven by the rapid growth of mobile device use, 4k to 8k video streaming, virtualization, IoT, 5G, and yet-to-be-identified emerging technologies, they are tasked with building a long-life, future-forward network at the lowest cost of ownership. Compounding matters is that network managers also face an unforgiving public that is justifiably intolerant to even a moment of network downtime.

According to a recent report published by Gartner, titled The Cost of Downtime, the average cost of network downtime is approximately $5,600 per minute. This adds even more pressure for data center operators and enterprise managers to keep their networks up and running 24/7/365.

Undoubtedly, fiber optic cables have revolutionized today's enterprise communication and data center networks, as well as the broadcasting industry, due to their extremely high signal bandwidth capacity and long-reaching distance, thereby facilitating the 10G to 100G and beyond network migrations we witness today for OSP backbone, inside plant, and last mile applications.

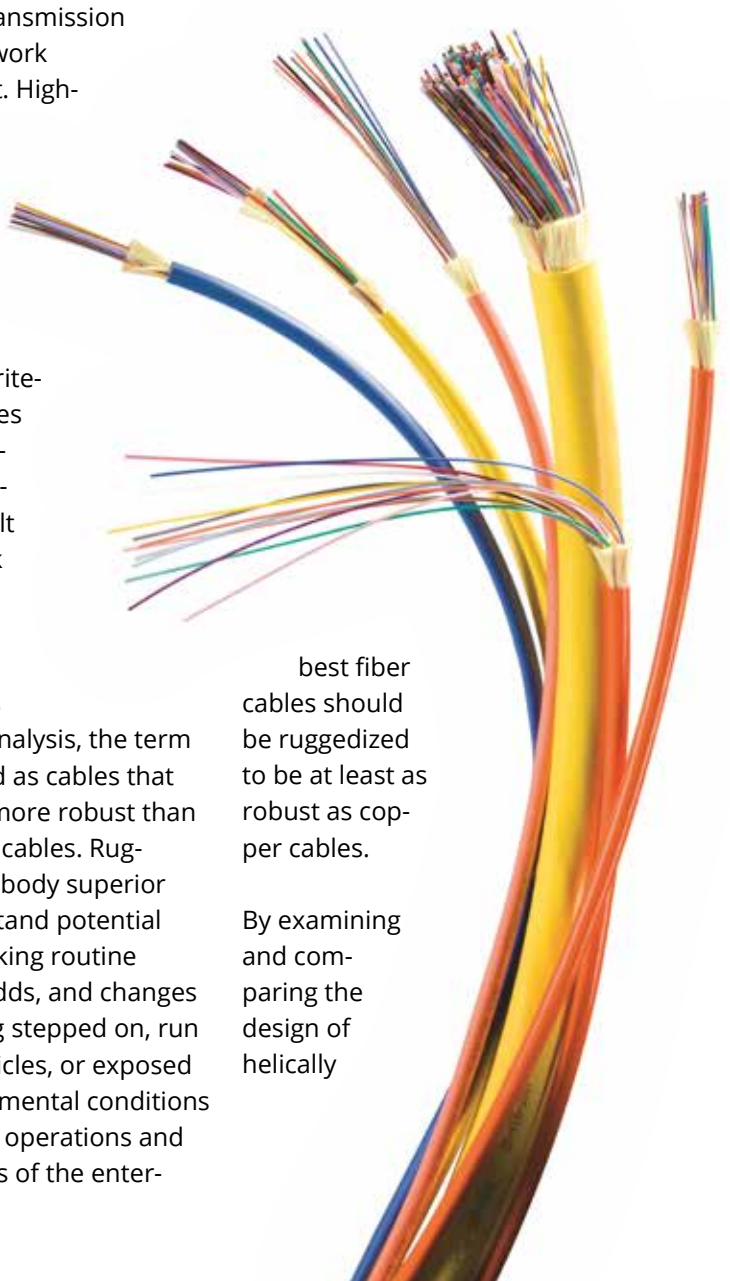
There are two often-neglected optical fiber cable considerations that can impact transmission performance, network longevity, and cost. High-bandwidth-ready fiber optic cable needs to be both macro-bending resilient and rugged. This not only meets the aforementioned criteria, but also reduces downtime, maintenance and trouble-shooting that result is optimal network performance and cost savings.

Ruggedized cables

For comparative analysis, the term "rugged" is defined as cables that are stronger and more robust than industry-standard cables. Ruggedized cables embody superior durability to withstand potential damage when making routine network moves, adds, and changes (MACs) or by being stepped on, run over by heavy vehicles, or exposed to various environmental conditions during the normal operations and typical applications of the enterprise network.

The ability to withstand potential fiber damage and environmental stresses are crucial for the reliability and life cycle of the network. To protect critical communication paths without interruption, the best fiber cables should be ruggedized to be at least as robust as copper cables.

By examining and comparing the design of helically



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stranded tight-buffered, tight-bound high-density cable to ribbon cable and analyzing performance results demonstrated in BER (Bit Error Rate) tests, data center and network managers are in a better position to achieve the most reliable, long-life, and low-cost network.

Macrobending in perspective
Generally speaking, a communication network is composed of two main parts; the passive fiber cable network (also referred to as the Optical Distribution Network [ODN]) and the active electronic transceivers and equipment.

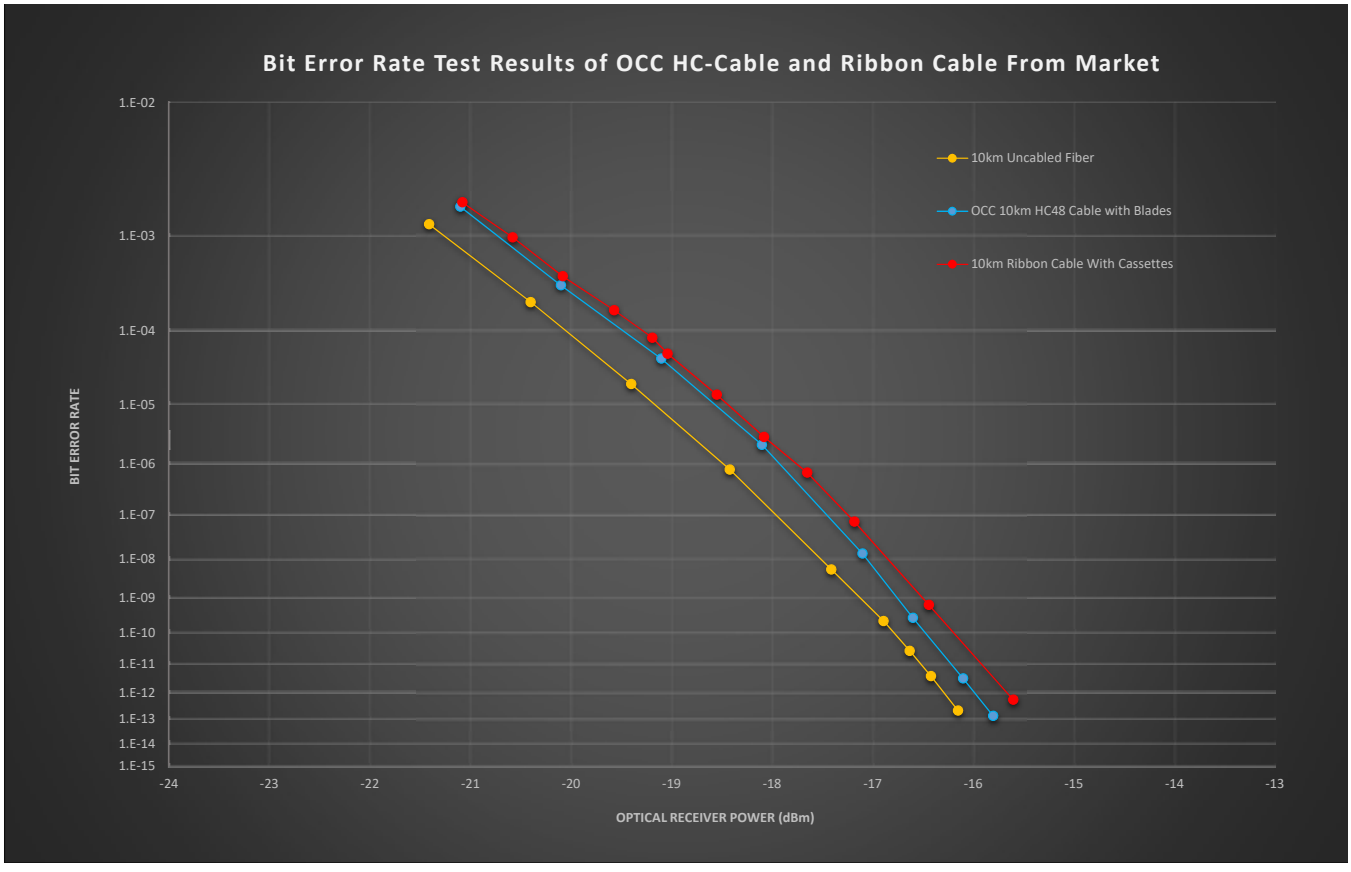
For large optical networks, the ODN typically accounts for more than 70% of the entire network cost. While active equipment can be upgraded with the rapid bandwidth increase of the electronics, the ODN, if designed with scalability, can and should last for 20-plus years.

To protect the network investment, the ODN design must be mechanically robust to survive any MACs, the harsh environment areas of the enterprise, even natural disasters, while also supporting several future generations of high-bandwidth, high-speed emerging technologies and electronic upgrades. These assertions further reinforce the necessity of deploying ruggedized, helically stranded tight-buffered cabling in the network.

To minimize the pitfalls that can lead to network failure and the monumental per-minute costs of downtime, troubleshooting, and network restoration, the cabling infrastructure must also deploy cables that are both ruggedized and simultaneously highly resilient to macro-bending. Macro-bending results in excessive attenuation that seriously degrades system performance and signal transmission and can force the network down. Macro-bending can also cause physical irregularities that can cause micro-bending and severe damage to the fiber.

As any installer can attest, macro-bends can occur during routine network installations, such as routing a jumper in a data center patch panel, routing around sharp corners in an office environment, frequent MACs for dynamic broadcasting applications, or pulling cable around tight bends or within manholes in the OSP backbone.

Chart 1 is a summary from the NTT Advanced Technology study that polled network owners and cable installers on the sources of network failures. Following the more controllable causes of network failure stemming from connector and



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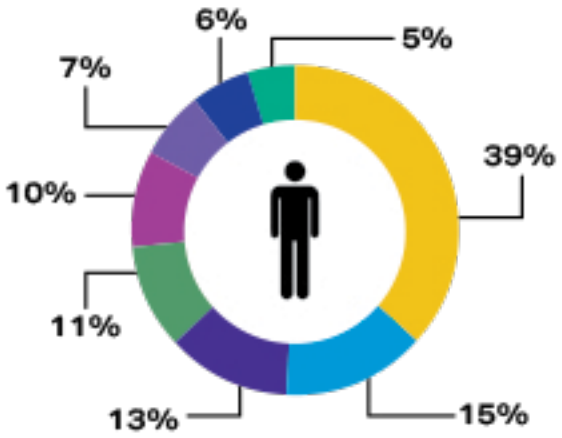

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splicing faults, bending the fiber is the next leading cause of failure—supporting the fact that a more "bendable" and more macro-bending resistant cable, such as helically stranded tight-buffered cables, are necessary to achieve a zero-downtime network.

Helically stranded tight-buffered high-count/high-density indoor-outdoor cable resulted in no change to the BER level when bent, unlike ribbon cable, reinforcing its macro-bending resilience properties.

By deploying cable that is both ruggedized and macro-bending resilient, data center operators and enterprise network managers can achieve time and cost savings with an overall low cost of network ownership through:

- Faster and easier installations, upgrades, and MACs due to easier cable bendability and handling
- Less likelihood of fiber damage and costly replacement
- Reduced network maintenance time and labor for trouble-shooting
- Indoor-outdoor tight-buffered cables that reduce installation and maintenance costs by eliminating traditional connections or splicing for the transition from outdoor to indoor cables, thereby eliminating points of network failure for a continuous fiber run
- Less likelihood of network failure, saving significant per-minute downtime costs
- Increased cable quality for a robust, scalable infrastructure that is installed once, lasting 25 years or longer

The last bullet concerning cable quality raises an important consideration. Cable bendability, macro-bending resistance, and ruggedness are properties inherent in the tight-buffered cable design and manufacturing process. And the quality of the design and development of tight-buffered cables vary by the manufacturer, so it is recommended that data center and network managers choose their tight-buffered cables carefully.

Design Comparison

The helically stranded, tight-buffered, tight-bound technology incorporated by some manufacturers, including OCC, results in fiber cables with much stronger pulling strength and much less bending of the diameter against sharp edges when compared to other straight lay cables, such as loose-tube and ribbon. The bendability is achieved because all the cable elements in the helically stranded cable under pulling stress tend to pull toward the center of the cable.

Unlike some ribbon cables in which elements at one edge could bend at a much sharper diameter than elements at the other edge (causing macro-bending-induced high stress and micro-bending susceptibility), the helically stranded elements are bent equally with the stress averaged across the lay length, thereby eliminating macro-bending and micro-bending within the cable.

Helically stranded tight-buffer technology yields not only a smaller diameter fiber cable—ideal for the higher port densities of data centers and congested conduit capacity of enterprise networks—compared with loose- tube cables and some ribbon cables with the same fiber count, but also provides the highest pulling strength, significantly reducing the likelihood of damage.

The ruggedness of the helically stranded tight-buffered cables can best be exemplified by the cables' crush resistance, the highest in the industry, that exceeds 10 times the 220 N/cm called for by the ICEA S-104-696 standard body.

Additionally, the tight-buffer cables do not rely on extra strengthening elements, thereby making them more flexible than ribbon and loose-tube cables. There are also no messy gels that need to be cleaned before fusion splicing, which improves both installation time and splicing efficiency.

Another important benefit of helically stranded tight- buffered cables is the water-blocked/water-tolerant attributes that provide the very best water protection system available by combining the inherent water-tolerant features of tight-buffered and Core Locked tight-bound cable that features super-absorbent polymer aramid yarn. The design provides superb water resistance while retaining optimal performance and the termination cost advantages associated with totally gel/powder–free tight-buffered cable.

In recent years, gel-free, dry loose-tube and ribbon cables have been introduced to overcome the messy installation and termination headaches associated with the gel. To replace the gel's water-blocking capability, manufacturers added water-swellable powders and tapes in the development of the dry cable.

However, the swellable agents can attribute to further micro-bending in areas where the powder parti-

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cles, for example, can get wedged between the inner surface of the tube and fibers—an occurrence that is detrimental to the cable and, consequently, the data transmission integrity of the network. This is one reason, among others, why dry loose-tube cables have not replaced or made gel-filled loose-tube cables obsolete.

These proprietary helically stranded tight-buffered cable design technologies advancing ruggedness, bendability, installation ease, and friendliness to save time and costs—while demonstrating outstanding transmission integrity—were first developed by OCC in the early 1980s, with ongoing advancements continuing ever since.

Initially, these rugged helically stranded tight-buffered cables were designed for the most reliable military tactical deployments required by the Department of Defense (DOD).

BER Testing High Data Rate Performance

Recently, Bit Error Rate (BER) testing of an OCC HC-Series – High-Density cable and a ribbon cable was performed to compare the system performance of these two different cables.

BER testing is a system-level evaluation of a physical layer optical network to meet the expected requirements for overall signal fidelity. It tests data transport accuracy through actual optical link conditions to ensure the physical layer signal path integrity of the designed optical network. The test results account for effects of all the parameters of the optical link, such as insertion loss, return loss, chromatic dispersion, and differential group delay for MMF. BER testing is critical, especially for high-bandwidth optical networks designed to meet current and future high–data rate operations.

The helically stranded HC-Series – High-Density Tight- buffered Indoor/Outdoor cable with splice-on blades is a popular solution for campus rings and other high-density applications. Another available choice on the market is ribbon cable with MPO-LC cassettes.

The system performances of these two configurations are compared via the BER test. More specifically, the HC-Series – High-Density cable used in the test was a 48-fiber single-mode (SM) cable with bend-insensitive fiber from OCC equipped with OCC's splice-on Procyon Blades on both ends. Comparably, the ribbon cable was also a 48-fiber SM cable with bend-insensitive fiber supplied from a highly reliable, quality manufacturer; the ribbon cable employed MPO-LC cassettes on both ends.

The test results reveal that the design benefits of outstanding ruggedness, bendability, and water resistance of the HC-Series – High-Density helically stranded tight-buffered cable with spliced-on blades did not degrade optical performance at all. Rather, it marginally outperformed the ribbon cable link.

The 10km HC-Series – High-Density cable was error free when further tested under normal operating conditions at the 10Gbps data rate for two weeks and demonstrated the BER of better than 10-15 at a 99% confidence level, further validating that the optical link of the helically stranded HC-Series – High-Density tight-buffered cable was technically error free.

The BER level was monitored for fluctuations while making the same degree of cable bending against sharp edges for the HC-Series – High-Density and ribbon cable. It is noticed that when a ribbon cable was bent sharply, the BER level under impact increased dramatically, indicating the anisotropic Macro-bending induced attenuation and micro-bending susceptibility that compromises signal integrity and transmission reliability.

Conversely, when an OCC HC-Series – High-Density cable is bent in the same angle (or any other helically stranded, tight-buffered OCC cable, since the mechanical design properties are the same), the BER level was not affected at all. This further proves that the helically stranded, tight-buffered cable is more macro-bending and micro-bending resistant.

Additional Considerations

Helically stranded, tight-buffered cable is much more macro-bending resistant than the ribbon cable because the fibers inside the tight-buffered cable are bent uniformly, while the fibers inside a ribbon cable are bending-direction dependent. When the macro-bending occurs along the ribbon surface, fibers at both sides of the ribbon can suffer enormous stress.

Many helically stranded, tight-buffered cables, including the HC-Series – High-Density cable, are also much smaller than the ribbon cable (7mm diameter versus 10mm diameter for a 48-fiber cable). A reel of 1km 48-fiber HC-Series – High-Density cable, for example, is approximately

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two-thirds the size of that with the same fiber count ribbon cable.

The helically stranded, tight-buffered cable is also mechanically stronger (more rugged) than the loose-tube-like ribbon cable. Because the ribbon cable relies on multiple strength elements for mechanical strength, it is not as bendable as the HC-Series – High-Density cable and all OCC helically stranded tight-buffered cables for ease of handling and installation, such as being easily pulled through several right-angled conduits.

However, ribbon cables do have the advantage of massive splicing of up to 12 fibers at a time. Helically stranded, tight-buffered cable can also be easily ribbonized with commercial-available kits before performing mass splicing.

Concluding Summary

The continuously growing demand for increased network bandwidth is one of the most critical issues facing data center operators and enterprise network managers, as more and more are deploying 10-100Gb Ethernet and beyond. Consequently, one of the most important decisions is which optical fiber cable is best to deploy for your OSP and inside plant network applications. This study has built the case that optical fiber cable needs to be both rugged and macro-bending resistant to achieve a long-life (25 years), scalable, future-forward network at a low cost of ownership.

Through BER testing, it is shown that helically stranded tight-buffered cables that feature these two crucial properties, specifically the HC-Series – High- Density compared to ribbon cable, demonstrate the outstanding transmission performance for zero-downtime fiber-optic networks.

The superior ruggedness and macro-bending resilience—along with other cable features—of helically stranded tight-buffered cables are necessary to achieve network longevity, zero downtime, and minimal maintenance and troubleshooting that ultimately results in optimum network performance and cost savings.

For information contact: Optical Cable Corporation, 5290 Concourse Drive, Roanoke, Virginia, 24019; Phone: (800) 622-7711, Canada (800) 443-5262; FAX: 540-265-0724; Email: info@occfiber.com; Visit the website ***www.occfiber.com*** •

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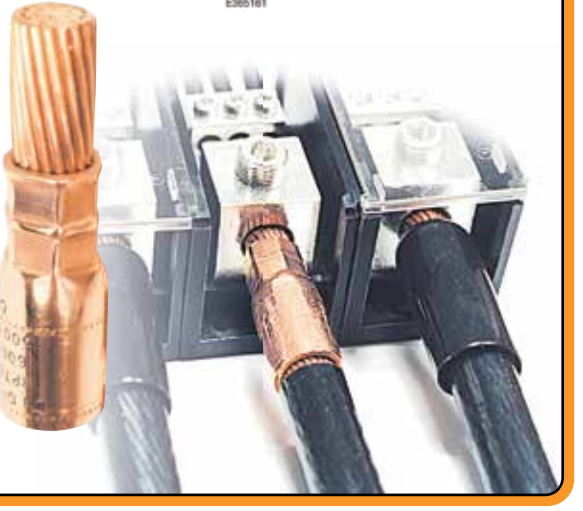

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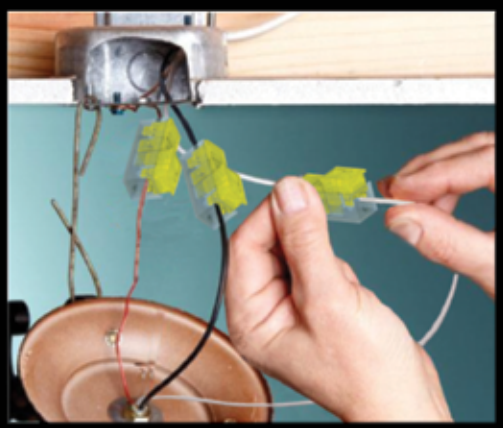

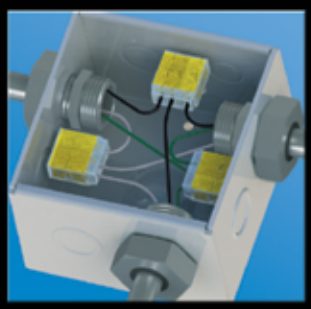

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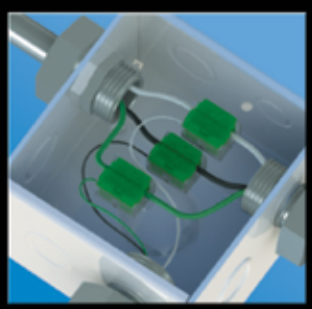

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