ofs
A Furukawa Company

*With Wavelength Allocation in the E-Band,*

# Full Spectrum Fiber Comes of Age

**Mark Boxer**
**Applications Engineering Manager**

Sometimes the future catches up with us before we even know it. Consider the videophone, a technology that never quite caught on. However, relatively quietly over the past few years, enabled by the availability of broadband service, Skype and similar services have made video calls over computers an ordinary part of many people's daily lives.

Another example is occurring in the use of single-mode fiber optic networks. For years, we've been waiting for equipment and applications that enable us to utilize the entire spectrum that fiber offers. Again, somewhat quietly, new wavelengths in the previously unusable "E" band (defined as 1360 - 1460 nm) are being claimed at a speedy pace, fulfilling the promise of full-spectrum optical fiber.

## Wavelengths Across the Spectrum

Original fiber networks installed a couple of decades ago operated only at 1310 nm in the "O" band. The 1550 nm wavelength in the "S" band came along soon after, and both wavelengths formed the basis for the explosion in traffic in the transport portion of the network in the 1980s and 1990s.

Since the initial development of single-mode fiber in the 1980s, the "E" band has not been used for any significant applications. The "E" band includes the "water peak," where absorption of the hydroxyl (OH-) ion historically has caused attenuation of up to and beyond 1 dB/km (see Figure 1).

DWDM applications operating in the "C" and "L" bands came of age in the late 1990s and early part of the following decade. However, these networks were, and still are, mainly devoted to longer-distance, higher data-rate transport applications.

The early part of this decade brought access fiber-based networks and introduced the PON wavelengths, including 1490 nm for downstream data, and 1590/1610 nm for RF return path applications. The trend is continuing as WDM-PON technology and accompanying standards begin to take shape, mainly using the "C" band, and introducing the "S" band.

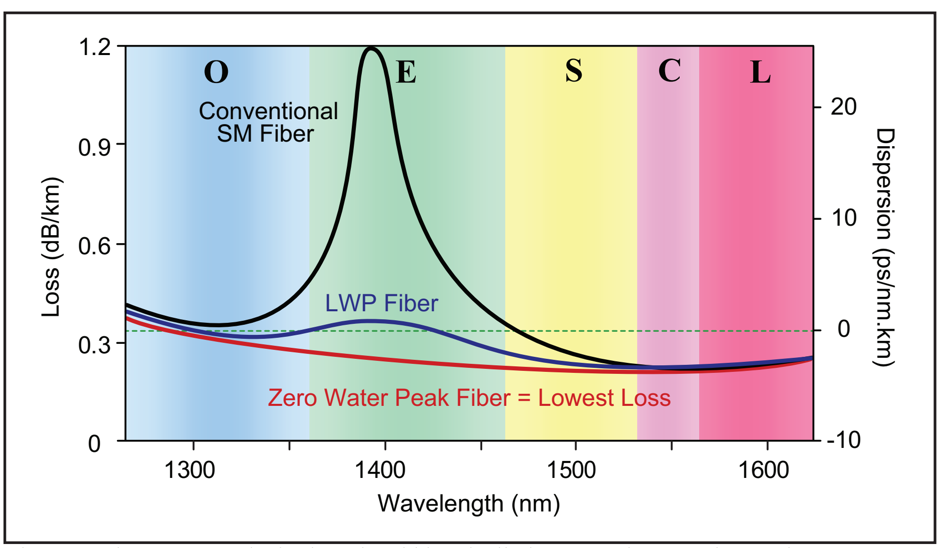


Figure 1: The "water peak" in the E band historically has caused attenuation performance beyond 1 dB/km.

The latest development in spectrum allocation is the emergence of applications and equipment that use the "E" band.

*The availability of CWDM equipment, including the "E" band wavelengths, is giving operators new flexibility in matching wavelengths with appropriate services.*

What's changed? Over the past 10 years, improvements in manufacturing processes have driven much better fiber attenuation performance in the "E" band. Today, the majority of fibers deployed are classified as either low water peak (LWP) and zero water peak (ZWP) - known in the ITU desgination as G.652C/D fibers.

The first full-spectrum fiber was introduced in 1997. OFS' AllWave® single-mode fiber, the world's first Zero Water Peak fiber, was introduced in 2002.

The ITU G.694.2 CWDM grid includes wavelengths spaced 20 nm apart starting at 1271 nm up to 1611 nm. As laser technologies have advanced, the availability of CWDM equipment, including the "E" band wavelengths, is giving operators new flexibility in matching wavelengths with appropriate services. Inexpensive CWDM SFPs, sources and test equipment are now available in such previously unused wavelengths as 1371 and

1391 nm. Given all of the expected demands on the network, it's none too soon.

## Network Design Implications

What does this mean for the network operator? First, when choosing a fiber to deploy in the network, operators need to pay special attention to fiber performance in the "E" band. ZWP fiber performs a minimum of 12 percent better than LWP, and depending on the specification supported by the manufacturer, sometimes as much as 22 percent. Over a wide area network, that performance can make a significant difference in reaching customers - or not.

From a network operation standpoint, the availability of "E" band sources gives the operator unprecedented options for deploying traffic and managing precious fiber resources. A typical network may have a wide variety of equipment deployed over it, including:

- internal traffic for video cameras or internal networks operated over SFP-driven switches
- access PON equipment feeding internal and external customers
- transport equipment operating on DWDM wavelengths.

flicts. A proposed strategy is to move non-revenue-generating applications to the "E" band, including wavelengths such as 1371, 1391, and 1411 nm, while keeping revenue-generating applications on the more traditional wavelengths, such as 1310, 1490, and 1550 nm.

For those networks with no revenue-generating applications, it's still a good idea to operate that equipment in the "E" band, leaving the other wavelengths open for future revenue-producing applications that may be operated on the 1310 and 1550 nm wavelengths.

A sample wavelength allocation map with various applications is shown in Figure 2. Traditionally, much of this traffic would have been solely on the 1310 and 1550 nm wavelengths, or on separate fibers altogether. However, now that "E" band equipment is available, applications such as SCADA, internal communications, and cameras can be placed on the "E" band, leaving the 1310 and 1550 wavelengths open for future, potentially higher value, applications.

While each network is different, these general guidelines show what can be done with a little planning.

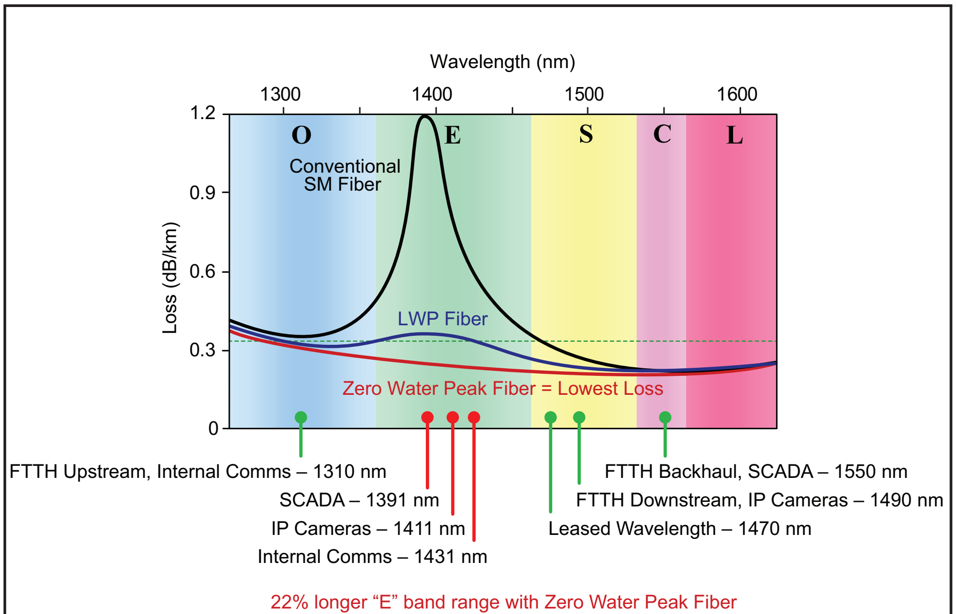


Figure 2: Sample wavelength allocation map

In addition, although the majority of fibers on the market are classified as LWP or ZWP, some fibers that have very poor performance in the "E" band inevitably sneak into the system. Caveat emptor (let the buyer beware)!

Over the lifetime of a network, it's almost inevitable that there will be one or more sections of the network with wavelength conflicts on a particular set of fibers. A wavelength allocation strategy can help to avoid those con-

## Summary

The future is never clear, but there are a few trends that support this approach. Bandwidth demands are only going to increase. This will inevitably lead to the need for new wavelengths. Paying attention to fiber performance in the "E" band and careful wavelength planning now can help save future outages or equipment forklifts in the future.

For additional information, visit our website at www.ofsoptics.com or call 888-fiberhelp or 770-798-5555 (from outside the USA).



A Furukawa Company