AllWave® FIBER BENEFITS
EXECUTIVE SUMMARY

Metropolitan Interoffice Transport Networks

OFS studies and other industry studies show that the most economic means of handling the expected exponential growth in metropolitan interoffice network traffic will be via multiwavelength optical mesh networks. In the near future, bandwidth-efficient SONET networks will become increasingly expensive on a cost per bit basis and will be replaced by networks where dedicated wavelengths connect every office to every other office. In addition to the equipment cost of SONET ring networks at very high network capacities, the increasingly data-driven nature of the emerging networks make SONET multiplexing an unnecessary step and make some of the SONET functions like restoration no longer as important.

Early multiwavelength optical network transmission systems will reuse components from current long haul Dense Wavelength Division Multiplexed (DWDM) systems and will provide flexible add/drop metropolitan systems of 40 or so wavelengths in the 1550 nm wavelength band. However, even with hubbing architectures, 40 wavelength systems will be able to serve networks with 12 or less nodes and more wavelengths will be needed very soon. One source of additional wavelengths is to light more fibers with additional systems in the 1550 nm band. **The introduction of AllWave fiber provides an alternative, and more economic choice: lighting the "1400" nm band (1335 nm to 1450 nm).**

Besides more than 100 nm additional fiber spectrum that can be used for transmission capacity, the "1400" nm band has relatively low dispersion (compared with conventional fiber in the 1550 nm band), providing some significant economic benefits. Specific benefits of AllWave fiber in these networks is as follows:

- Additional capacity allows larger networks to be fully connected and allows multiple connections per node on a single fiber. Use of the 1400 band allows a single wavelength add/drop box (because multiple wavelength bands are used) instead of multiple boxes in 1550 band.
  Benefit: Saves fiber/extends fiber cable life, prevents use of multiple add/drop boxes
- Lower dispersion in 1400 band allows use of less expensive lasers for OC-12 and OC-48 transmission.
  Benefit: Laser savings possible of about $4000 per OC-48 and $2000 - $3000 per OC-12
- Lower dispersion allows long optical distances for OC-192 transmission, prevents need for dispersion compensation in metropolitan networks.
  Benefit: Dispersion compensation costs $2000-$3000 per fiber per node in metro networks
- If a service provider were willing to sacrifice some of the additional bandwidth capability provided by AllWave in return for decreased networking cost, the 1400 band could be used for "coarse" WDM, allowing reduced strictness of tolerances on lasers and other components and reducing equipment costs.
  Benefit: Coarse WDM could provide cost reduction of 10% or more in Optical Networking equipment costs

AllWave Fiber Benefits

Metropolitan Interoffice Transport Application

Summary of AllWave Benefits
Metropolitan Interoffice Transport

Number	Benefit	Rationale	Estimated Savings Per Node Per Unit	96 Fiber/9 node Ring Max Svgs: ($K/Node) 1920 Wavelengths (λ)
M1	100% more capacity per fiber (two DWDM bands instead of one)	• Less fiber (or longer fiber life) • Fewer add/drop boxes by using second wavelength band	• 1/2 as many fibers less AllWave premium • 1/2 fewer add/drop boxes (but they are somewhat more expensive)	AllWave / Conv Fiber 65 / 100 A/D 168 / 240 Total $233K / $340K Δ = $107K $/ λ $121 / $177
M2	Lower cost operation in 1400 band	Lower dispersion allows use of lower tolerance lasers at OC-12 and OC-48	• $4000 per OC-48 • $2K-$3K per OC-12	$72K to $92K (assumes 8 OC-48 per node and 20 OC-12 per node)
M3	Use of 1400 band for OC-192 avoids need for dispersion compensation	Conventional fiber needs compensation if OC-192 exceeds 50 to 100 km.	~$2000 per interoffice fiber per node	$192,000 (assumes all fibers compensated)

Assumption: 15 km between nodes

Total AllWave Savings Per Node (Max) versus Using Conventional USF	$391,000
Total USF Fiber Cost/Node	$100,000
Savings Ratio	4/1
AllWave Premium/Node	$ 15,000
Savings Ratio	26/1

Distribution Networks for MSOs

The capacity demands on distribution systems are driven by the exploding demand for data bandwidth. The fundamental technology driver is the rapidly growing data processing capabilities of the terminals at the ends of the network. Moore's Law remains in effect - processor power continues to double every 18 months.

Recent advances have permitted economic application of photonic technology to the needs of distribution systems. In CATV broadcast systems, fiber has replaced coaxial feeder. With reduction in costs of fiber amplifiers, the fiber reach from the broadcast headend has become longer. Now, targeted distribution services - data, Internet access, telephony, digital video, video conferencing gaming, PCS… - are attracting increasing amounts of attention as revenue generators. **[Cable modem service is about $50/month; DS1 and DS3 private line services are much more expensive and distance-sensitive, in the hundreds and thousands of dollars per month; to these can be added revenues for serving wireless cell sites generate that currently use DS1 transmission rates.]** Wavelength Division Multiplexing (WDM) technology has recently been cited as an economic technology for meeting the distribution challenges for targeted services. **[Projected savings of $10 to $30 per living unit over competing technologies (CED, June 98, "Creating Invisible Hubs", p78ff, table 5).]** First generation systems have reached the market demonstrating these economies. These systems have a limited number of wavelengths and still more economies will be obtainable with more wavelengths as the aggregate access bandwidth grows. AllWave provides the way to the maximum utilization of optical wavelengths.

Besides the economies and revenue generation, there are architectural advantages when using WDM for distribution. These allow flexibility to meet a variety of distribution growth scenarios:

- Interfaces naturally with future optical networks.
- Cross-connects to Metro Optical Networks in both primary and secondary plant for flexibility and reliability.
- Highly scalable to any node segmentation level.
- System can evolve to targeted services at FTTH segmentation level - future proof.
- Supports PCS with remote base stations.
- Enables spectral isolation of AM-VSB broadcast from digital SCM and baseband on same fiber.

We'll now discuss these architectural values in order:

Future optical networks will be DWDM networks that use as great a number of wavelengths as possible to allow a logical-mesh emulated by a physical ring architecture. Compatibility of spectral characteristics between distribution and interoffice networks will simplify cross connection, simplify service delivery, and increase reliability.

Metropolitan networks usually have nearly mesh-like interconnection architectures because of the needs of metropolitan communications. DWDM rings can emulate these meshes logically while providing a reliable and easy-to-administer physical ring. The greater the number of wavelengths, the easier it is to effect the mesh emulation. AllWave fiber, with its maximum number of wavelengths available, is the fiber of choice for Metropolitan Optical Networks. Using AllWave in the MSO's rings allows for dynamic optical add/drop multiplexing and dynamic cross connects with external optical networks. No matter what wavelength the metro network is using, AllWave-equipped distribution networks can support the wavelength and be connected without costly wavelength conversion.

The ultimate segmentation of nodes is FTTH where there is one node per end user. Aggregate demand here will most economically be met with a large number of wavelengths so that end users could share optical fibers and amplifiers. Also, remote control of wavelength routing can configure networks in real time to deliver the services where needed. This targeting of services, even to the FTTH segmentation level, is more easily done the more the number of wavelengths and so AllWave provides a future proofing function by providing the maximum number of wavelengths.

With a great number of wavelengths available, wireless cell sites can be assigned wavelengths to allow remote, centralized placement of controllers, encoders, and decoders for ease of maintenance and sharing of equipment. The savings here will grow as PCS microcell sites proliferate. A wavelength per site may still prove economic for PCS, or several sites may share the wavelength through block conversions onto stacked subcarriers. Cell sites would have low maintenance since only the transmitter/receiver and OE equipment would be necessary at the site.

The large spectral range of AllWave enables greater spectral isolation of fragile AM-VSB broadcast signals from digital SCM and baseband transmissions on the same fiber than if only the 1550nm band is used. The broadcast can be carried at, say, 1560 nm while other payloads can be near 1400 nm. The AM-VSB format would be somewhat protected by this separation, enough to enable single fiber transmission over greater distances. This will enable sharing of fibers over more of the distribution plant and make single-fiber drops more naturally engineered.

These services and architectural capabilities that use DWDM for distribution with a great number of wavelengths are coming. They will create the most economic and flexible distribution systems possible. With the advent of second and later generation equipment, details will change but whatever your choices for distribution systems in the future, AllWave will support them.

AllWave Fiber Benefits Summary
Access Applications

Number	Benefit	Rationale	Estimated Benefit	Benefit/cost (all incremental)
A1	Fiber to the Curb	1400 band enables more revenue options, allows migration to FTTH, and provides compatibility with metro interoffice transport, enables continuity testing	• DS3 private line services (business) • OC3 private line (business) • Additional ethernet service (residence) • Cell site connection	• $25K/per year for $10K cost • $100K/year for $20K cost • $3K/year for $2.5K cost • $6K/year for $2.5K cost
A2	Passive Optical Network (PON) Fiber To The Home	1400 band enables use of single fiber to home from last splitter (versus two fibers), enables end to end testing	• Fiber savings of ½ km per LU • Splitter savings (one port per LU) • Added cost of Coarse WDM	• +$40/LU • +$100/LU • - $30/LU Total Benefit = $110/LU
A3	Fiber to large node (traditional CATV model)	• Use wavelengths to split (scale) nodes • Enables evolution to FTTC and FTTH architectures	• double capacity for same price or fiber savings (2x10 km/node) • Future savings as above	• ~$2000/node