GILDER TECHNOLOGY REPORT

Published jointly by Gilder Publishing and Forbes Magazine www.gildertech.com July 2000/Vol. V No. 7

Circling the Fibersphere

Summer Review: Part 1

Global Crossing has become the paramount planetary utility poised to exploit bandwidth abundance on land and scarcity at sea

Contemplating the mysterious velocity of light, physicist Kenneth Ford declared in 1963: "Even an astronaut falls short of the speed of light by a factor of forty thousand. He needs an hour and a half to get once around the earth, while a photon (*if it could be caused to travel in a curved path*) could complete the trip in a tenth of a second."

Now we know the key to such a global circumnavigation. Do it with mirrors. Indeed, the entire advance of fiber optics springs from the ever more ingenious exploitation of the key feature of mirrors—they bounce back whatever light you send them. They are dumb. They do not have a bit rate or an intelligent protocol or an obvious limit of capacity. They simply reflect whatever hits them in a direction determined by the angle of incidence of the signal. The central breakthrough in the industry was combining a fiber core with a cladding of a lower index of refraction, producing "total internal reflection," i.e. mirror action bouncing the photons down the fiber.

At the time of physicist Ford, however, such curved elongated mirrors were out of the question. To send photons around the globe would have entailed a Rube Goldberg array of reflective glass—whether on land or in orbit—outreaching even the original photophone concept of Alexander Graham Bell. Bell never imagined that, working in gigantic vertical factories built in his name, engineers could someday take a molten ingot of glass and stretch it into a glass tube thousands of miles long, with a reflecting core, a "waveguide" for light, under 10 microns in width. Even Bell's followers at his eponymous laboratories never foresaw the creation of photonic hives arraying thousands of tiny mirrors in all-optical cross-connects capable of exceeding by the billions the bandwidth of the class 5 ESS switches that are still the prize of nearly every telco central office.

Routed by waveguides, light now moves routinely in curved paths through mazes of mirrors and theoretically can circumnavigate the globe in around a hundred milliseconds—one tenth of a second. But only one company has come near to consummating such a planetary waveguide, only one company comes close to deploying the curved path of Ken Ford's fantasy. Early next year, in a large step of semi-circumnavigation, **Global Crossing** (GBLX) will pump bits from Stockholm to Hong Kong without noticeable delay, having traversed earth's two great oceans and North America in between, all on a single arc of mirrored glass.

In This Issue:

Global Crossing has become the paramount planetary utility, poised to exploit at once the emerging bandwidth abundance on land and the continuing bandwidth scarcity at sea. As we predicted almost two years ago, its seamless, single, global network transcends the technical muddle of hybrid networks and the regulatory briarpatch of national telopolies and consortia.

GBLX, refocused

Consider, for example, the transaction costs and complexities comprised in the 13 leased or partnered hand-offs needed by **ATT** (T) to connect, say, Stuttgart and Tokyo. GBLX already seamlessly links London to Los Angeles and Japan to Germany, using a dozen fewer networks than AT&T. After the completion of South American Crossing early next year and the final reaches into the Asian Pacific, the photons will run from Stuttgart to Santiago to Singapore, with no leases, no hand-offs. Just the curved path Ford fantasized, elegant, fast, reliable, and devastatingly cheap.

Guided by Gary Winnick, who with colleague Michael Milken financed MCI's first fiber network, Global Crossing's pioneering entrepreneurs created the network's backbones with a rapidity that made traditional undersea consortia look like the courting sea turtles whose nuptials briefly held up the network's landing in the Caribbean. From the time it turned on its first cable, AC-1, in May 1998, the company outleapt every forecast of capacity sales.

Then, last summer, distraction. The Frontier acquisition gave the company what it soon dubbed its North American Crossing, a 24 fiber, 25 city, transcontinental waveguide. Frontier's web hosting and server hotel business, re-christened Global Center, made GBLX number two in that market behind only Exodus. Yet Frontier's assets brought with them Frontier itself, telco born and bred—the Rochester, New York phone company, basically. When the new telco guy CEO started talking about diversified services to meet the needs of today's customers, even our very own Housatonic Hallelujah Chorus was tempted to sing the blues.

Now, there is nothin' but blue skies and seas. Leo Hindery, Jr., the new, new CEO gets it, big time. Cable guys are just smarter, we guess. So smart we're showing him off at our Telecosm conference, where the IQ admission standards are so high us scriveners have to cop fake IDs to get in.

What Hindery gets is that GBLX is a company with lots of assets, but one angle, and it's a curve, that seamless seductive planetary waveguide. That's the business plan. Everything else is distractive dispersion, a little known non-linear effect induced by a fixation on whether your voice revenues dropped faster last month than AT&T's.

Exemplary customers for GBLX have global reach: financial firms, governments, high-tech and manufacturing multinationals, and infotainment conglomerates. The British government recently attested its appreciation of all GBLX's global curves, in the form of a $250 million, ten year deal to link its 240 worldwide embassies and consulates.

Focused on their particular businesses, such customers need GBLX to weave together their remote offices and outposts into integrated companies, with convenience and reliability and at a price a patchwork network–those thirteen handoffs–could not match. They need a Virtual Private (Planetary) Network, with customized routes and services, using the web while bypassing its delays and uncertainties and avoiding the costs and hassles of leased lines. Fabless semiconductor firms, such as **Broadcom** (BRCM), want to know their designs made it to Taiwan with absolute security. **Dell** (DELL) needs quick and reliable worldwide feedback to keep its famous inventory mechanism online. **FedEx** (FDX) and **UPS** (UPS), who deliver Dell's computers, need an integrated service even more.

Sensing a new inflection point in the industry, Hindery is adding over 1000 "high-level" salesmen under the direction of former **IXnet** chief David Walsh to capitalize on a coming mass exodus from old international telecom contracts and into GBLX's mirrored planet.

With financial firms among the obvious beneficiaries of such connections, on June 15 GBLX completed its acquisition of IXnet, the 60 percent global share leader (70 percent in the U.S.) in the growing business of networking financial services providers to each other and their customers. GBLX will save $1.8 billion by replacing IXnet's ugly network quilt with the new GBLX extranet. Beginning the migration in early June were IXnet's some 750 customers: the **Schwabs** (SCH), **Merrills** (MER), and **Fidelitys**.

Hindery's demand curve

Undersea bandwidth prices have been plummeting (see Chart 5) ever since GBLX entered the market in 1998. Hindery loves it. Elasticity is his friend: "What matters is volume, not price. And volume has always exceeded our expectations and will continue to do so." Or as our friends at **Metromedia Fiber** (MFNX) tell us, "This demand curve is vertical, guys."

On a course to complete its planned 102,000-mile network resoundingly ahead of schedule as usual–by Easter 2001–Global Crossing's execution has been flawless. The next two months will see four major projects go online: the second trans-Atlantic cable (AC-2); Mid-Atlantic Crossing linking New York, Miami, and St. Croix; Mexican Crossing and the Irish Ring. Before year end: lines to Brazil, Argentina, Venezuela and Panama, the southern portion of the trans-Pacific cable and the Japan-Hong Kong cable. Rounding out the 102,000 miles early next year will be the terrestrial Japanese network, GAL, links to South Korea, Taiwan, Chile, Peru, and Colombia, and rings in Spain and Scandinavia.

The fastest growing long-haul network in history, GBLX posted over $1.1 billion in 1Q00 revenue and expects $5.2 billion for the year, data transmission accounting for over 50 percent today and headed fast toward 60 percent. In a business where adjusted EBITDA is the cash flow that counts, it will generate $1.6 billion of such earnings this year on a growth path of some 25 percent per year in revenues and 35 percent in adjusted EBITDA. Lots of cash, some $7 billion of debt to keep a highly invested management focused (the

Milken gambit), and lots of interest payments and depreciation to wipe away taxable paper profits.

Enabling further infrastructure investments is the $3.65 billion sale on July 12 of Frontier's local telephone business. Also targeted for spin-off, as a tracking stock, is GlobalCenter. This fast growing complex of network accelerators is not a bad fit for a network selling seamless speed, but it makes it hard for, say, the Exoduses of this world to know whether they are GBLX's customers or competitors. We vote for partners and liked the now moribund deal turning Global Center over to Exodus in return for a 30 percent share of Exodus. Alas, the market loved it too, Exodus's share price soared, creating for the Exodus board the illusion it was paying $8 billion rather than six and change. In the bickering over volatile paper numbers the companies let an ingenious opportunity slip away.

Metromedia's fibersphere

While Global Crossing rules the waves, Metromedia Fiber (MFN), the world's most insanely great dark fiber company, is dominating the cities.

Launched by Stephen Garofalo, a New York City construction magnate, after reading "Into the Fibersphere" in the first issue of *Forbes ASAP* in 1992, Metromedia Fiber is now a telecosmic monster. To get the flavor, read the Sayings of Chairman Steve:

"Bits per second is history."

"The PSTN is dead."

"Unlimited bandwidth for a fixed price. That's our deal."

"Fifty times the bandwidth for less."

"We are spending more money than anyone else—on thousands of fibers per route mile and eight conduits. We overprovision five times. Our vision of the world: waste bandwidth."

"First we took Manhattan. Now we're in Boston, Washington, Chicago, Dallas, Houston, Philadelphia and SanFrancisco. Fourteen thousand buildings and 67 cities in the US and Europe."

"You can't run storewidth on a DS-1."

"We turned the local loop into a virtual hard drive."

"You can deploy applications that were only a dream and you can't tell whether they are in your hard drive or on our fiber."

"We are the fibersphere."

In mapping its targeted metropolitan areas, Metromedia pinpoints each *Forbes* 1000 company within a 75-100 mile radius. MFN then trenches a path that passes no further than 1,000 feet from each plotted company, laying eight conduits, each able to hold at least twelve 864-fiber cables, spanning the length of the route. Major splice junctures, or "on-off ramps" as Metromedia calls them, are built at 700-1,000 foot intervals all along the network's rings, regardless of whether any customers happen to be there at the time. When customers do show up, MFN loops an entire fiber (or more) out of the 864 to that customer's building.

A major purchaser of AllWave fiber, opening up the entire photonic band from 1280 to 1625 nm, MFN's goal is for its customers to "never think about bandwidth again." MFN has about as high a regard for bandwidth efficiency as it does for copper. MFN often deploys more fiber instead of installing WDM equipment. Thus, when WDM is added later the customer can pump even more hundreds or thousands of lambdas through the enterprise, confirming the **Avanex** (AVNX) vision that the Lambda Network will spread from the enterprise into the core, rather than the reverse.

"Unlimited bandwidth for a fixed price, that's our deal," proclaims Metromedia's Steve Garofalo

The point of spilling all that excess fiber into the streets is to "destroy the bits per second pricing model." For $10,000 a month, companies can procure two of their very own silica strands. Depending on how much they want to spend on terminal equipment and network engineers, they can opt for a few megabits a second all the way up to terabits a second. Over the course of 18 years, the typical life of an MFN lease, 2 fibers will cost about $2 million, $10,000 a month, at least fifty times less than assembling the same capacity from telco leased DS-3s. Chase Manhattan just connected each of its 20 New York City locations, as well as offices in New Jersey, Delaware, and Texas, to each other and to the Net using 4 MFN fibers running into each building. **Storage Networks** (STOR) uses Metromedia to link its Hudson Street, Manhattan facilities with Wall Street and Waltham. Soon there will be Metromedia fiber in a street or building near you.

Clueless Chromatis

Lucent. Lucent. Lucent! (LU) (LU) (LU!). Why is it that whenever we think of this magnificent company, earth mother of the Microcosm and sire, through a thousand start-ups of the Telecosm, we walk around the office like an aging Billy Crystal, head in hands, garments rent, lamenting the follies of this generation? What, in a company with the highest average IQ of any Forbes 500 firm in history, can possibly explain clueless acquisitions like Chromatis? Beloved of analysts focused on yesterday's problems, Chromatis is one of dozens of metro optical network companies–they littered the floor at SuperComm–who have defined their mission in life as:

1. Saving their clients from the burdens of the defining technology of the era, Wavelength Division Multiplexing;
2. Desperately conserving bandwidth in the midst of a terabit tsunami; and
3. Feeding the opto-electronics retiree fund by filling every lambda to the bit gills before using the next one, in a masochistic perpetuation of the SONET hierarchy.

True, bandwidth is currently at a premium in metropolitan networks wedged between the petabit network core and the enterprise edge where petabits are born. If you're looking back at last week's catalog, metro WDM

UNDERSEA OPPORTUNITY

Submarine fiber optic cable deployments surged over the last three years, but there remains a critical shortage of undersea bandwidth.

Not long ago, the substantial majority of intercontinental data was transmitted via satellite, with geosynchronous systems edging undersea cables in total capacity as recently as 1997 (Chart 1). A fresh explosion of undersea bandwidth, however, has relegated GEOS to various niche markets and globalized the Internet. The number of International carriers has increased almost five-fold since 1995, i.e. roughly since the incarnation of the World Wide Web (Chart 2). According to TeleGeography, total trans-Atlantic undersea capacity will have risen "from 23 Gbps in 1997 to nearly 5 Tbps in 2001–a compound annual growth rate of 280 percent" (Chart 3). (The trans-Atlantic route has grown fastest by far, roughly tracking Europe's embrace of the Web. –July 99 GTR) And three new cables–PC-1, China-U.S. and Japan-U.S.–add 180 Gbps in the Pacific this year. The flood of bandwidth is predictably trimming circuit prices (Chart 4).

But hold on. Those 5 trans-Atlantic terabits will be running on fewer than 700 wavelengths. Even after all operating and currently planned transatlantic cables are upgraded to maximum announced capabilities (remember, undersea WDM systems accommodate fewer lambdas), the Atlantic will be bridged by only 980 lambdas, the Pacific by only 420. Yet, one PowerMuxed AllWave fiber could soon carry 3,000 lambdas. A lone Metromedia cable contains 864 fibers. That's two million channels or 6.5 petabits per cable. What happens when our multimillion-channel cables hit the water and slam into a measly 1000 undersea lambdas? The terrestrial rainbow turns into a maritime squall.

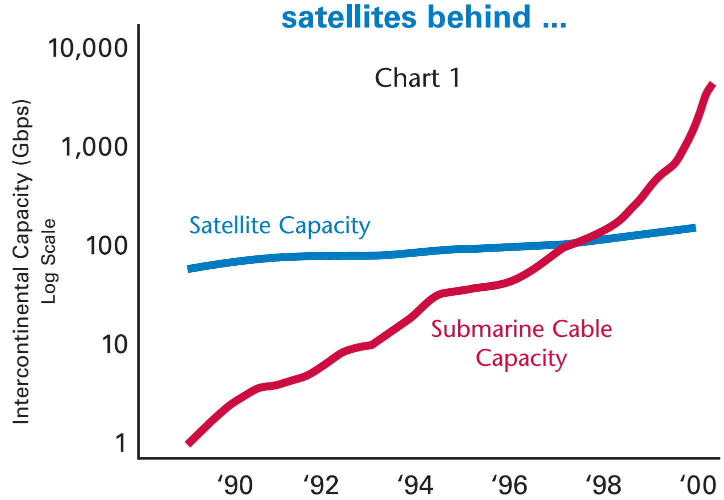
Even allowing for the law of locality's generous grading curve–that network traffic is 80 percent local, 95 percent continental, and 5 percent intercontinental–only 2 percent of cabled fiber installed in 1999 was trans-oceanic (Chart 5). And the total 2001 worldwide undersea capacity of 7 Tbps is just one tenth of one percent of one of our mythical 6.5 petabit cables. Of course raw throughput is no longer the test. Lambdas reign. But they tell the same story: several thousand submarine lambdas cannot pass muster against soon-to-be millions of terrestrial lambdas.

GBLX, Tyco, Alcatel, and KDD better keep their motors warm. These numbers signal rich rewards for further technological and financial risk taking at sea.

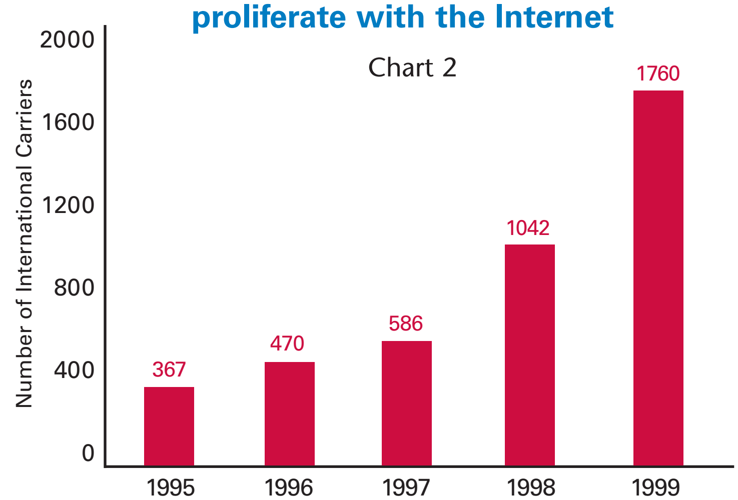
— Bret Swanson

Sources: TeleGeography, Inc., Band-X Ltd., and KMI Corp.
Capacity data after July 2000 includes systems under construction.

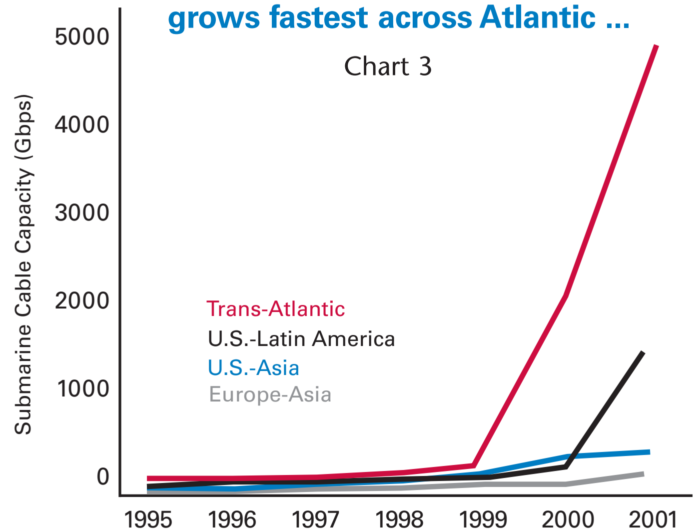
Surging submarine capacity leaves satellites behind ...



... enabling international carriers to proliferate with the Internet

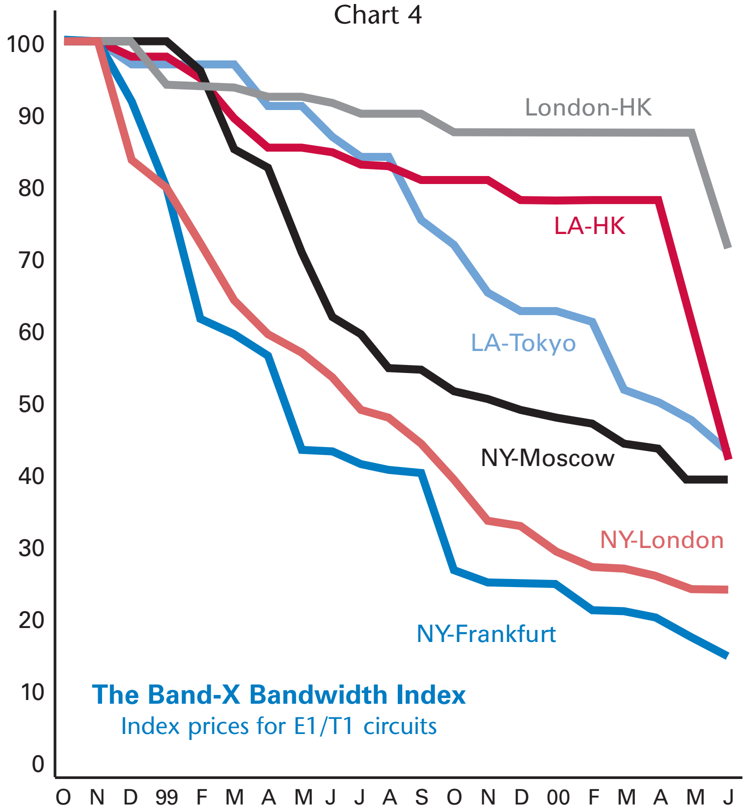


Like Internet traffic, undersea capacity grows fastest across Atlantic ...



... where prices drop fastest as well

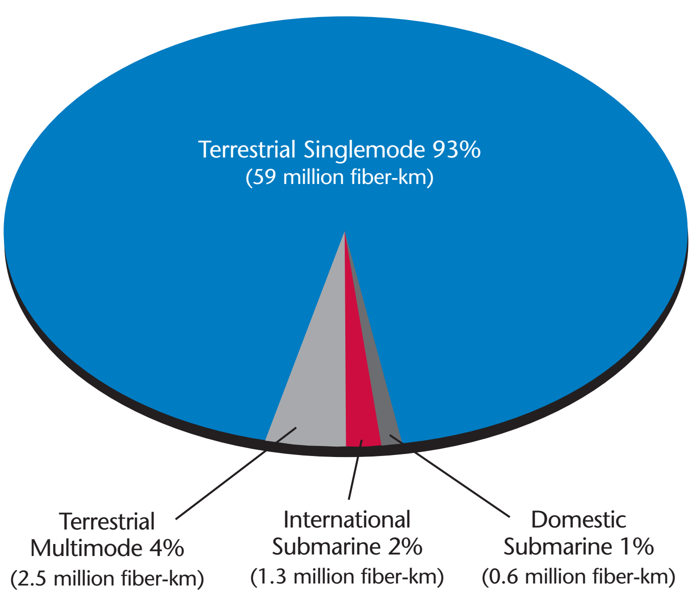
Chart 4



Only 3% of fiber laid goes undersea, setting stage for capacity crunch

Cabled Fiber Installed in 1999

Chart 5



equipment does look pricey. Unfortunately for Chromatis, next week's catalog got revised at Avanex. Replacing its own PowerFilter with a holographic diffraction grating, its Next-Generation PowerMux will chop per-channel WDM costs by a factor of 10 while sporting an 80 percent reduction in footprint. With Metromedia Fiber weaving hundreds of thousands of kilometers of AllWave through 67 downtown dark fiber networks, the bandwidth blowout is coming to Broadway. That makes a grim future for Chromatis and a whole generation of still-born start-ups planning a life as urban bandwidth compactors.

Lucent. Lucent. Lucent. Of course they did invent AllWave, potentially increasing by half the number of lambdas coursing through a single fiber under those city streets. LU marketers mention the miracle fiber so rarely you would think they had forgotten it, but someone cut through the fog long enough to sell $330 million worth (including some TrueWave) to MFN. Perhaps in the same moment of lucidity, Lucent also upgraded its own WaveStar WDM system to 320 channels at a lambda networking friendly 2.5 Gbps.

Lucent's lucid moment

In another giant WDM step, Lucent's LambdaRouter optical cross-connect (OXC), whose once suspect tiny mirrors may turn out to be a significant engineering advantage, will go into beta tests with GBLX at network nodes in Washington DC, New York, New Jersey and London in September. Meanwhile, **Astarte** has gone underground with **Texas Instruments** (TXN) and may be having trouble tilting, aligning, or even lifting its mirrors, 275 times the size of Lucent's. For the moment at least, we replace Astarte with **Calient**, quickly developing its own 256 x 256 OXC, as a company to keep an eye on in the micromirror switching space along with Xros (**Nortel** [NT]).

Toting up moments of Lucent lucidity, its **TeraBeam** collaboration leaps to mind. It showed this supposedly sclerotic scion of the Age of Telopoly agilely dumping its own failing OpticAir project to buy into Greg Amadon's successful version. Plagued since its creation by the spin-out of crucial talent to optical and wireless start-ups, Lucent seems to have caught on to the notion that it is better to do your own spinning.

The recent shedding of its uninteresting Enterprise Network division (call centers, voice messaging, and firewall systems) chiefly serves to increase the company's optical focus. Far more exciting is the plan to spin-off the Microelectronics and Communications Group (MCG), the integrated circuit, opto-electronic and optical component, and fiber division that grew 80 percent last year. An independent MCG could not only help retain talent looking for an IPO payday but also boost sales even further. Current rivals such as Nortel may even come to see the new ex-rival as another welcome merchant competitor to **JDSU** (JDSU) and **Corning** (GLW).

For neither of which, however, shed any tears. Of the four great enabling technologies of the WDM network–the fiber itself; the optical amplifier, which trimmed away more crippling electronics from the network than any other optical innovation; the source lasers and modulators that create the signal; and finally the WDM multiplexers themselves—JDSU and Corning together lead in all four. Moreover, they dominate the production of hundreds of other critical path components strewn throughout the optical network, to split, couple, isolate, filter, attenuate, and otherwise bend or shuffle the light.

In fiber itself, the great innovator for three decades has been Corning, with nearly half the worldwide market, and more than twice as much as second place Lucent. In an industry barely out of the craft-guild stage, Corning stands almost alone among merchant optical component makers not only in making glass but in having nearly a century's experience in mass production, and a research team that rivals for glass what Bell Labs was to, well, almost every other form of silicon.

It is a toss up whether SDL's active components expertise or manufacturing capacity is the biggest prize

Corning is also the world's leading supplier of EDFAs, followed by JDSU and then Lucent, which holds 25 percent of the market. Corning supplies most of the erbium-doped fiber. But the most critical EDFA component, the elite 980 nm pump laser, is a JDSU prize—they lay claim to 60 percent of the world market share. Following JDSU, with 30 percent of the 980 market, is the latest willing JDSU acquisition target, **SDL** (SDLI). The daunting technical challenges of 980 pumps will only get tougher as WDM channel counts increase, making this an even more intimidating market for newcomers. One SDL advantage in the 980 is its skill at packaging its pump into a grating-stabilized module to flatten gain across large channel-count WDM systems, a welcome addition to JDSU's repertoire. Of course the best of the best 980 pumps are those used for undersea, where the combination of breathtaking buildout—thank you GBLX—and premium prices have pumped the market from a mere $1 million in 1998 to $62 million last year, heading for over $160 million in 2000. In this market, JDSU trails only SDL.

Corning ramps Raman

Corning's acquisition last year of Lasertron, through Oak Industries announced its intention to play in the pump laser market. Its first low power entries caused no sleepless nights at JDSU. But acquiring the laser maker did allow Corning to enter the nascent market for Raman amplifiers, hitting commercial production with its PureGain 5000R Raman/EDFA hybrid amplifier this year. The Raman module pumps backward along the fiber, boosting the signal 10 dB before it gets to the EDFA, and because the amplification is distributed it reduces signal nonlinearities and crosstalk between channels. In turn, the signal boost required from the EDFA is reduced to 15 dB, slashing EDFA induced signal noise.

Ultimately Raman's biggest role may not be in ultra-long-haul–Avanex's Power Express all optical long-haul system powers a lightstream cross-continent with nary Raman in sight–but in opening new lambda capillaries in the metro space. This likelihood bodes ill for Corning's fixation on putting 40 gigabit per second OC-768 SONET streams on a single wavelength. However, Corning is also working on a Raman-Thullium hybrid amplifier, to boost brand new lambdas through the erbium hostile S-band (1400 - 1510 nm) opened up by AllWave. (Memo to Lucent: *Corning* thinks AllWave is important. Maybe important enough to release a competing fiber about the same time the Thullium amp goes to commercial release.)

There is no WDM without light. So the source lasers and their attendant, external lithium-niobate modulators, which break the beam into pulses of exquisitely accurate frequencies and shapes, are the third great enabler of WDM. JDSU long ago carved its leadership position in this core technology, though SDL and Lucent command mention. Under chief technologist Fred Leonberger, Uniphase perfected the key process for manufacturing these modulators co-invented by Leonberger at the **United Technologies** (UTX) facility in Granby, Connecticut now owned by JDSU.

Then there are the multiplexers themselves which do the actual work of combining and separating multiple wavelengths of light on a single fiber strand. Today fiber Bragg gratings, arrayed waveguide gratings, and thin-film filters are the crucial components for selecting and filtering wavelengths, and E-Tek gives JDSU prime thin-film filter technology and manufacturing capabilities as well as additional Bragg grating capability. Nevertheless, we look for the Avanex tuneable PowerMux to overwhelm the multiplexer market, rendering the current gratings and arrayed waveguides irrelevant.

JDSU vs. Avanex?

Anxious Gilder Tech Forum (www.gildertech.com) readers have been worrying over this AVNX "threat" to JDSU. But laying thousands of wavelengths down a single fiber, as Avanex will eventually do, is hardly a threat to the world's leading maker of amplifier pumps and transmission lasers.

What Avanex will do, as it pushes the lambda network into the arterial circuits of the long-haul and out to the capillaries of metro and local access, is accelerate the spiral of declining prices, broadening the optical market and requiring even the elite component makers, like JDSU, to focus their attention down market as well as up, perhaps the most difficult challenge in business.

From its creation, JDSU's technical prowess has been rivaled only by its ability to rapidly fuse acquisitions into effective extensions of an optical components lineup unchallenged in depth or breadth. With the E-Tek merger complete, the world's second largest passive components manufacturer helps ease JDSU's capacity crisis.

And in Cronos JDSU found an independent MEMS company that can claim leadership in all three major MEMS manufacturing processes. But the SDL acquisition—assuming someone can convince Janet Reno to send Joel Klein to Antarctica for the duration (just what are those sneaky penguins pulling with the ice market?)—is the best news since the merger with JDS Fitel.

JDSU ♥ SDL

Consistently focused on the most challenging new spaces in the market, it is a toss up whether SDL's active components expertise or manufacturing capacity is the biggest prize. An early leader in Raman—though **IPG Photonics** (watch for that IPO) disputes their claim to the first commercial device—they are planning two new plants to meet the demands of their Raman amplifier product line, and they are moving quickly into lithium niobate modulators. SDL's move into passive components through their acquisition of PIRI (Photonic Integration Research Inc.) may have been prompted by a belief that arrayed waveguides will play a major role in multiplexing. Under the guidance of former Lucent waveguide master Giovanni Barbarossa, Avanex demurs. But silicon optical integration technology has more uses than muxing (witness **Agilent's** (A) use of planar waveguides in Champagne) and it does show SDL's focus on increased channel counts.

With both JDSU and Corning on buying binges, how do customers feel about supplier consolidation?

They love it. The systems integrators want the component makers to get beyond the professor's workshop stage: Procure the quality control and price advantages of grown-up mass production, pump up volumes, move along the learning curve, and do some vertical integration so the Nortels and **Alcatels** (ALA), **Cienas** (CIEN) and Lucents of the world no longer have to assemble their own proprietary subsystems from raw components.

Nortel's mux-up

Nortel's lust for the all-optical network is so intense you can smell the pheromones. They have made some brilliant acquisitions along the way including Xros and, perhaps, Qtera. But the Qtera ultra-long-haul system, powering lambdas coast to coast without an O-E-O conversion, does have a certain jury-rigged quality about it. Requiring forward error correction, soliton transmission, dispersion compensating fiber (DCF), and Raman, it may win more blue ribbons than customers. If solitons turn out to be as cross-talkative as some industry lab rats are now suggesting, limiting channel count, and making the Qtera solution irrelevant to the WDM network, even the blue ribbons may not materialize.

Even without the problem of chatty solitons, Qtera's program is being set by its new parent's addiction to speed. Nortel regards 10 Gbps as a baseline for ultra-long-haul performance and really wants 40 or 80. Can't do that without pumping up the power until it compromises channel count, going backward on WDM. Pumping up the bit rate in the network backbone, just as in the metro with Chromatis, extends the tyranny of SONET. What gets electronically muxed up must get electronically muxed down.

By contrast, Avanex's ultra-long-haul system, PowerExpress, sheds complexity: no specialized fiber, forward error correction (FEC), solitons, or Raman, and it still goes coast to coast all-optically. Unlike Raman and soliton heroics, PowerExpress works well on legacy fiber. Integrating an optimized EDFA with Avanex's proprietary PowerShaper, the Avanex device dynamically compensates for a range of dispersion requirements across the WDM spectrum. As light waves travel down a fiber they become distorted, spread off the center of the wavelength, and eventually mush together, becoming unreadable. This problem obviously becomes even more critical as channel count rises and we cram more and more lambdas closer and closer together on a single fiber. The PowerShaper responds to the problem with an optical leap forward almost as dramatic as the invention of the EDFA ten years ago.

Nortel's jury-rigged ultra-long-haul system may win more blue ribbons than customers

Before the EDFA, electronic regenerators performed as many as three functions, known as the 3Rs. First was repeating or amplifying a signal, which EDFAs replaced with direct amplification of the existing signal. Second was retiming, an inherently electronic function that cannot be performed optically. The third was "reshaping" a dispersed, mushy lambda around the center of the channel, which also had to be done electronically. Thus, even after the invention of the EDFA, two of the three R's still had to be performed electronically. Now the PowerShaper and PowerExpress change the 3R rules. They do without Dispersion Compensating Fiber or the other Qtera (and Corvis) tricks not by extending the distance the unreshaped signal can go but by bringing the reshaping function into the optical domain.

Directly addressing the problem of mushy lambdas by serving up nice, clean, centered versions every few hundred km, PowerExpress will support far larger channel counts than competing long-haul systems. How many? Like the number of lambdas generated by the PowerMux itself, that's a learning curve question with wonderfully dynamic answers. Versions of the PowerMux are generating thousands of lambdas over a single fiber in trials now, but over short distances for enterprise applications. (Yes, we are intrigued by that sentence too, stay tuned.) Since the PowerShaper and the PowerMux work on essentially the same periodic processor principle, (if one lambda is correctly aligned, all are) there is no reason in principle that, with PowerShapers grouped closely enough together, evolutions of the PowerExpress system could not support thousands of lambdas coast to coast.

It's Avanex's network, we just live on it.

George Gilder and Richard Vigilante
July 24, 2000

TELECOSM TECHNOLOGIES

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	REFERENCE DATE	/ PRICE	JUNE '00: MONTH END	52 WEEK RANGE	MARKET CAP
WINGS OF LIGHT						
Wireless, Fiber Optic Telecom Chips, Equipment, Systems	Lucent (LU)	11/7/96	11 25/32	58 5/16	49 13/16 - 84 3/16	189.9B
Wave Division Multiplexing (WDM) Systems, Components	Ciena (CIEN)	10/9/98	8 9/16	166 11/16	29 1/16 - 189	23.5B
Wireless, Fiber Optic, Cable Equipment, Systems	Nortel (NT)	11/3/97	11 1/2	68 7/32	19 7/8 - 72 11/16	188.0B
Optical Fiber, Photonic Components	Corning (GLW)	5/1/98	40 15/16	264	60 5/16 - 277 7/8	75.0B
Wave Division Multiplexing (WDM) Components	JDS Uniphase (JDSU)	6/27/97	3 5/8	119 7/8	19 5/16 - 153 3/8	93.7B
Adaptive Photonic Processors	Avanex (AVNX)	3/31/00	151 3/4	99 1/2	47 3/8 - 273 1/2	6.4B
All-Optical Cross-Connects	Agilent (A)	4/28/00	88 5/8	73 3/4	39 13/16 - 162	33.4B
THE LONGEST MILE						
Cable Modem Chipsets	Broadcom (BRCM)	4/17/98	6*	218 15/16	50 3/4 - 253	47.1B
S-CDMA Cable Modems	Terayon (TERN)	12/3/98	15 13/16	64 7/32	15 5/8 - 142 5/8	4.0B
Linear CDMA Power Amplifiers, Cable Modems	Conexant (CNXT)	3/31/99	13 27/32	48 5/8	27 1/2 - 132 1/2	10.6B
THE TETHERLESS TELECOSM						
Satellite Technology	Loral (LOR)	7/30/99	18 7/8	7	6 1/8 - 25 3/4	2.1B
Low Earth Orbit Satellite (LEOS) Wireless Transmission	Globalstar (GSTRF)	8/29/96	11 7/8	9	5 13/16 - 53 3/4	872.2M
Code Division Multiple Access (CDMA) Chips, Phones	Qualcomm (QCOM)	7/19/96	4 3/4	60	33 15/16 - 200	44.5B
Nationwide CDMA Wireless Network	Sprint (PCS)	12/3/98	7 3/16 *	59 1/2	27 1/8 - 66 15/16	54.5B
CDMA Handsets and Broadband Innovations	Motorola (MOT)	2/29/00	86 †	30 5/16	27 5/16 - 61 1/2	65.2B
THE GLOBAL NETWORK						
Broadband Fiber Network	Level 3 (LVLT)	4/3/98	31 1/4	88	45 1/4 - 132 1/4	32.2B
Broadband Fiber Network	Metromedia (MFNX)	9/30/99	12 1/4	39 11/16	10 9/16 - 51 7/8	21.6B
Submarine Fiber Optic Network	Global Crossing (GBLX)	10/30/98	14 13/16	26 5/16	20 1/4 - 61 13/16	21.5B
Broadband Fiber Network	Northeast Optic (NOPT)	6/30/99	15 1/16	61 5/8	17 3/4 - 159	1.0B
Telecommunications Networks, Internet Access	WorldCom (WCOM)	8/29/97	19 61/64	45 7/8	37 7/8 - 61 5/16	131.3B
CACHE AND CARRY						
Directory, Network Storage	Novell (NOVL)	11/30/99	19 1/2	9 1/4	7 7/8 - 44 9/16	3.0B
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	13 3/4	90 15/16	26 15/16 - 106 3/4	144.2B
Network Storage and Caching Solutions	Mirror Image (XLA)	1/31/00	29	34	197/256 - 112 1/2	3.6B
Disruptive Storewidth Appliances	Procom (PRCM)	5/31/00	25	51 11/16	5 5/8 - 89 3/4	590.1M
Remote Storewidth Services	Storage Networks (STOR)	6/30/00	27*	90 1/4	82 - 114 15/16	8.0B
THE MICROCOSM						
Analog, Digital, and Mixed Signal Processors	Analog Devices (ADI)	7/31/97	11 3/16	76	20 13/16 - 100	27.0B
Silicon Germanium (SiGe) Based Photonic Devices	Applied Micro Circuits (AMCC)	7/31/98	5 43/64	98 3/4	19 1/16 - 158 7/8	12.1B
Programming Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	8 27/32	36 7/8	13 3/4 - 61 3/8	8.2B
Digital Video Codes	C-Cube (CUBE)	4/25/97	23	19 5/8	14 1/4 - 106 1/4	932.4M
Single-Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	15 3/4	54 1/8	21 9/16 - 90 3/8	16.6B
Single-Chip Systems, Silicon Germanium (SiGe) Chips	National Semiconductor (NSM)	7/31/97	31 1/2	56 3/4	22 1/16 - 85 15/16	10.0B
Analog, Digital, and Mixed Signal Processors, Micromirrors	Texas Instruments (TXN)	11/7/96	5 15/16	68 11/16	33 1/2 - 99 3/4	112.4B
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	8 7/32	82 9/16	29 - 98 5/16	26.9B

* INITIAL PUBLIC OFFERING † SPLIT ADJUSTED THIS ISSUE

NOTE: The Telecosm Table is not a model portfolio. It is a list of technologies in the Gilder Paradigm and of companies that lead in their application. Companies appear on this list only for their technology leadership, without consideration of their current share price or the appropriate timing of an investment decision. The presence of a company on the list is not a recommendation to buy shares at the current price. Reference Price is the company's closing share price on the Reference Date, the day the company was added to the table, typically the last trading day of the month prior to publication. Mr. Gilder and other GTR staff may hold positions in some or all of the stocks listed.

Gilder Technology Report ***Published by Gilder Publishing and Forbes Inc.***

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