GILDER TECHNOLOGY REPORT

Published jointly by Gilder Publishing, LLC and Forbes Magazine www.gildertech.com August 2001/Vol. VI No.8

Photonic Trampolines

Leading the next generation of the Telecosm, Terry Turpin of Essex has revealed to us the secret of his Hyperfine wavelength multiplexer

As I was finishing this issue our optics sage, Charlie Burger, rushed into my office with another shocking tale from the topsy-turvy world of Telecosm 2001, where paradigms wither, fiber gluts, and tech shorts become the shamans of the season, strutting their stuff down the beaches of the Hamptons and on the casting couches of the money shows. In these apparent "end times," telcos teeter like dot-coms, with stock prices lower than Japanese interest rates, and fiber is the Heart of Darkness, with United Artists reissuing *Apocalypse Now* for the Telecosm era, with lugubrious lambdas and glum playmates added. Real-time worldwide deflation so addles Christopher Byron of MSNBC and the *New York Observer* that he can only compete by caching and mirroring his old **Xcelera** (XLA) shock-horror fictions on the alleged greed and scandal of Alexander Vik. Alan Abelson is also on the brink of running out of technology scams to expose, and Paul Krugman is gloating again about having warned us last year, and the year before, and the year before that, about the contractionary perils of electing George Bush. Ravi Suria is dirging and devaluing the entire electromagnetic spectrum, and the ITU is said to be meeting in Geneva to downgrade the speed of light.

Amid all this portentous noise, Charlie would not consign his once-in-a-lifetime scoop to so shaky a channel as a high frequency carrier wave. Who could tell what would befall the bits as they were levered through some Ponzi scheme of **JDS Uniphase** (JDSU) lasers, **Merrill Lynch** (MER) junk bonds, and **Nortel** (NT) add/drop multiplexers, before flying down a lightwave flicker on a glass thread from **Metromedia Fiber Network** (MFNX) only to overrun the buffers on a line of credit and die a miserable death in the dark at a sepulchral **Exodus** (EXDS) dot-com debtor-center.

So Charlie chugged into my office in person to disclose in unmodulated phonons the latest shocking news from the front: *The Internet lives. It is alive and thriving.* Bret Swanson has all the lascivious details. Larry Roberts of **Caspian**, one of its prime inventors, has polled all the leading carriers in the industry and has ascertained that the growth of Internet bits continues to accelerate. According to Roberts, traffic has been increasing *faster than ever*, an unprecedented fourfold annual pace. If it keeps up—with a new Napster factor a quarter needed—that means a thousandfold in five years. **Qwest** (Q), **Global**

In This Issue:

Crossing (GX), and Google, in their different markets, confirm the numbers. Meanwhile, gobbling up marketshare in the metro is **ONI** (ONIS), with revenues doubling in six months, and its stock down 10 percent in a day. Are we having fun yet? Faster Internet growth could mean that MFNX (stock price 66 cents) and Exodus ($1.54) will make it through to the dawn.

Most important of all, Charlie reports, the world of optics is bursting forth with inventions so radical and paradigmatic that they leap to the front of the Telecosm even before they are introduced as marketable products. **Avanex** (AVNX) defined the photonic processor, launched the product, and leads the field. Now a new generation is ratifying the vision.

Turpin Greens

Transforming the possibilities of the entire industry, new companies are drastically simplifying and enhancing the designs of the two pivots of the wavelength division multiplexed (WDM) network—the erbium-doped fiber amplifier (EDFA) and the multiplexer-demultiplexer (mux-demux). Amplifiers boost the signal down the line; without them it dwindles and has to be recovered by electronics. Muxes take several colors of light, each bearing a separate bitstream, and fuse them on a single fiber. Demuxes separate them again at the other end to be sent to their destinations. The two inventions promise to make these processes so cheap and simple that they can be applied to thousands of wavelengths.

Leading this next generation of the Telecosm is Terry Turpin of **Essex** (ESEX) in Columbia, Maryland, near **Ciena** (CIEN) and **Corvis** (CORV). Remember the lean and hungry optical genius who demolished Nortel's fat-wave strategy in last month's GTR. A former NSA optical processing guru and girls' trampoline teacher ("Try it. You'll enjoy the optics."), he explained the secret of his Hyperfine wavelength multiplier and unveiled his Laffer curve of technology design.

Wavelengths bounce across Terry's crystal trampoline and come out the other side in perfect order, just 6.25 gigahertz, or less, apart

"By throwing away most of the parts used in other muxes—all the array waveguide filters and cascaded interleavers and attached thermal compensation modules—and by forgoing different models for the C-band and the L-band, I found everything got better. I got 30 dB [1000X] more dynamic range and doubled the speed." The result is a simple pair of crystal lenses which uses the natural aliasing of harmonic frequencies to create a nearly unlimited span of carrier channels. Behind this feat is Turpin's law: "When I am on the best path, things get simpler. When I throw away components and things improve, I know I am doing right."

During a ruminative moment beside the trampoline—watching the high school girls bounce up and down—Turpin reached the conclusion that "the only reason energy states are quantized is standing waves. Without boundary conditions to support standing waves, you don't get quantization." You bounce off the trampoline and dwindle away into the unresilient gym. Turpin believes that Heisenberg uncertainty in position and velocity and other polar phenomena are all merely expressions of certain reciprocal relationships summed up in Fourier transform mathematics. Fourier showed that any oscillatory pattern repeating in time translates into a sum of sine waves (such as pure colors or musical tones). A complex broadband signal spread out in time (such as an OC-768 40 gigabit per second TDM bitstream) converts to a series of docile narrowband signals running at lower power. Watch the wavelengths bounce across Terry's crystal trampoline and come out the other side in perfect order, just 6.25 gigahertz (50 picometers)—or less—apart.

Before you rush out to buy the stock, however, you may want to adjust for certain nonlinearities in Ohio-born Turpin's own personal history. Hey, you may have qualms about his Harley, his leather jacket, his black eye-patch, his academic rank of 31st out of 200 in his 1961 high school class. But against that you can set his more recent first place finish in Laurel, Maryland, in a dancing contest against several hundred rivals at Randy's California Inn, where Turpin and his wife of 32 years blew away the competition in the Country and Western Swing category. Then again you may simply want to take the word of WDM inventor and patriarch Paul Green, who spends more time with Essex than with any of his other consulting clients, that Terry Turpin is a "flat out genius."

Turpin grasps the new optical paradigm because it happens to be his old paradigm of analog optics that he began pursuing as a small boy building telescopes to watch the heavens over Akron (where he enjoyed the Hercules cluster, Jupiter's moons, and Saturn's rings, but found Venus "uninteresting, just bright.") From telescopes, Turpin went on to a two-decade span solving problems for the National Security Agency where he served as chief of the Advanced Processing Technology Division. There he used optical analog processors for broadband DSP (digital signal processing) for such crucial applications as the Strategic Defense Initiative, which is probably not feasible in its currently favored digital form. Now Turpin's crystals can achieve a bandwidth of 500 gigahertz with a resolution of 50 megahertz. In radar signal processing, it permits reading not only the terrestrial topography from a satellite but also the subsurface location of mines, pipes, bombs, concealed laboratories, and other underground points of interest. In WDM the 500 gigahertz span with 50 megahertz resolution means some 10 thousand channels in a spectrum space that could hold just five Nortel OC-768 40 gigabit per second streams.

If Turpin's Hyperfine WDM multiplier achieves its goals, virtually no one will ever purchase an OC-768, since under Green's guidance Essex is engineering a single card version of Hyperfine that can fit within the 100 gigahertz slot for OC-768 and supply the same bandwidth at lower power and exponentially less dispersion of the signal. For a small fraction of the cost and complexity of a real OC-768, the device is a virtual OC-768 comprising 16 OC-48s at 2.5 gigabits a second each (or 40 one gigabit Ethernet streams) that can be added or dropped or combined as desired by passive optics rather than by opto-electronic supercomputing.

Phantom of the OPERA

Next in the pipeline at Essex is a further Turpin invention called OPERA. This is a new analog optical processor for CDMA wireless applications that not only identifies the code of one user in a cell but also reads the signals of all the other transmitters in real time and nulls out all the multi-user noise. Every CDMA user gets treated like the only person in the cell. Being scrutinized by the obvious players in CDMA, OPERA will be explored in a future GTR.

Hyperfine and OPERA make Turpin perhaps the leading pioneer of the new optical paradigm, covering both wireline and wireless communications. Basic to the Telecosm is the intrinsic unity of wireline and wireless, with wireless conceived as simply an electromagnetic channel insulated by air, while fiber optics is insulated by glass. Extending this paradigm in our new book of the month, *Mind at Lightspeed,* is physicist David Nolte of Purdue. The inventor of several ingenious hologram technologies, Nolte shows the potential of light as a total communications medium, whether across continents or in neighborhoods or between computer backplanes. Although never optimal for general purpose computers, ultimately light will be the key information bearer even in the links between microchips.

This vision sets forth an agenda for the industry. As Paul Green puts it, "There are terahertz of potential bandwidth at the core of the network and many gigahertz of potential bandwidth in the internal links of computers. But between them is a bottleneck, where even cable and DSL (digital subscriber line) operate at speeds thousands of times slower. If this bottleneck can be broken, the entire industry will be awash in demand." That is the targeted role of Terry Turpin, Hyperfine, and whatever companies finally adopt his inventions or outdo them.

Taking a still more Olympian view in *Mind at Light Speed*, Nolte proceeds on to a final bandwidth bottleneck. Visual reality seems to be coded as oscillations and waves of neural excitation that wash back and forth across the brain and enable identification of edges and contrasts in an image. The 6 million cones and 120 million rods in the human retina initiate this process, enabling the eyes to accept a fabulous 15 orders of magnitude (a factor of a thousand trillion) of dynamic range or brightness levels. But with 500 micron spacing between the cones and 30 millisecond latency in the rhodopsin molecules that detect and convert light, human eyes can receive no more than one gigabit a second of information. Moreover, the 126 million rods and cones link to the optic nerve through the only one million ganglion cells—a compression ratio of 126 to 1—that reduces the flow to just seven megabits a second. But it gets worse. Sight itself—the actual ability of the brain to absorb and interpret words or images—remains intractably at around 25 bits a second.

None of Turpin's innovations is likely to have the immediate impact of the radical breakthrough in nonlinear amplification from NP Photonics

Therefore, Nolte believes that the real bottleneck is the brain stem and the key to breaking it is the development of computer architectures that exploit what he portentously calls the Parallel Advantage of Light and Image. At the heart of such architectures will be images that can serve as programs to process other images. Since images are inherently analog, the ultimate light computer will be an analog machine, working with interference, refraction, and defraction among intersecting colors of light with different phases and amplitudes. Digital is great if you don't know what you are doing and need to program it later. But if you know what you are doing—identifying a preset pattern, face in the crowd, code in a congested cell, missile in a crowded sky, or WDM array of closely packed channels—analog optics is far faster and more capacious. If you can use the image as a program to process other images, you can do massively parallel processing in real time. By overlaying one image on another, you can cancel all the redundant information and leave only the desired deltas or deviations.

In such linear processing, you get out exactly what you put in, plus or minus any transitory interference effects. Nonlinear optics enables reshaping the signal or enhancing it or creating feedback and learning effects. Dependent on the properties of the materials,

INNOVATE OR DISINTEGRATE

As deflationary recession slithers through the U.S. economy, the aggregate revenue of the six publicly-traded page-8 companies most heavily invested in fiber-optic technologies (JDS Uniphase, Corning, New Focus, Avanex, Corvis, and ONI Systems) has begun to decline after peaking during the final calendar quarter of 2000 (Chart 1). Analysis by company shows revenue maximums occurring during fourth-quarter 2000 or first-quarter 2001 for both of the larger firms (Chart 2) and all of the smaller firms (Chart 3), with the exception of surging metro WDM-systems provider ONI, so-far immune to the slump (Chart 3).

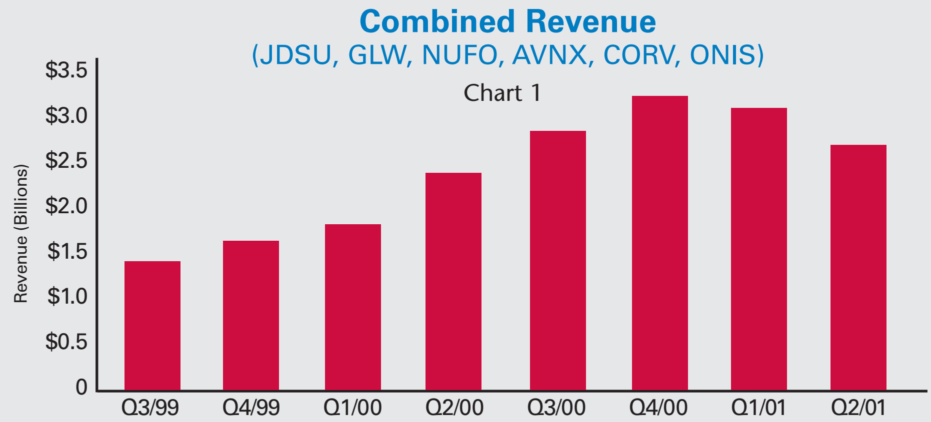
How well will these six "established" innovators, some only a few years old and all facing steadily-sagging prices spurred by a strong dollar and technological advance, fare against telecosmic tremors triggered by stealth gurus such as NP Photonics?

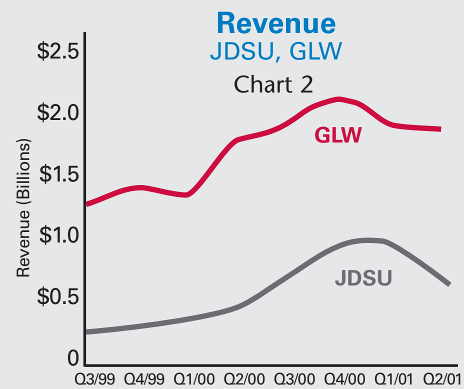
JDSU appears most vulnerable to NP Photonics' drive toward drastically simplified EDFAs and away from high-power, grating-stabilized pump lasers; we estimate that JDSU's 980 nm pumps comprise a shade under 10 percent of their total sales (Chart 4) while Corning weighs in at less than a percent.

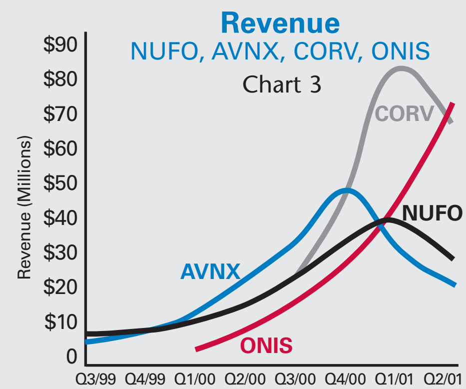
Though EDFA revenues are harder to quantify, we note that "amplification and transmission" active components make up 41 percent of JDSU income, while all of Corning's "photonic technologies," both active and passive but excluding fiber, comprise just 11 percent of revenues (Chart 4).

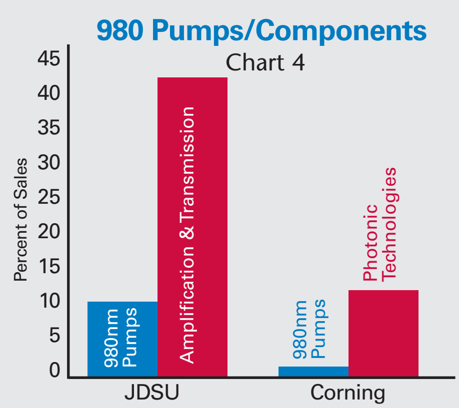
Defending their turf, our fiber-optic companies continue to increase R&D spending in absolute dollars as well as percentage of sales (Chart 5); strong surges by Corning, JDSU, and Corvis are followed with solid showings by New Focus and ONI (Charts 6 & 7). The slight decrease in Avanex's R&D spending still represents an increase as percentage of sales from 36 percent in Q1 to 43 percent in Q2.

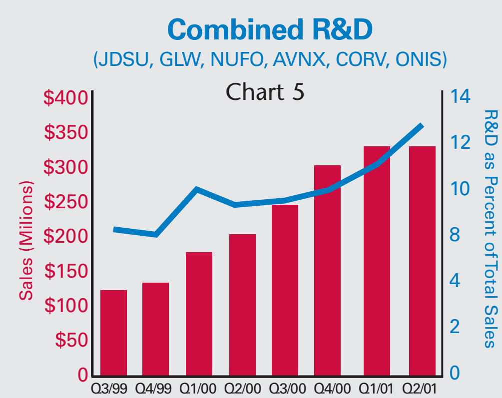
- Charles Burger

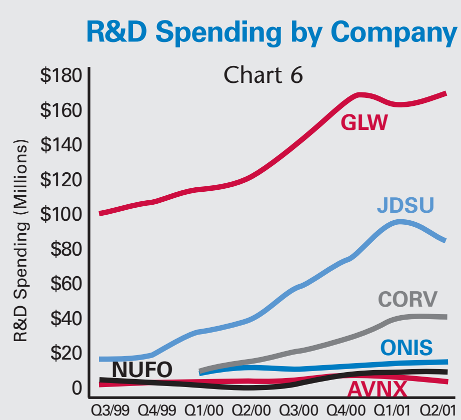


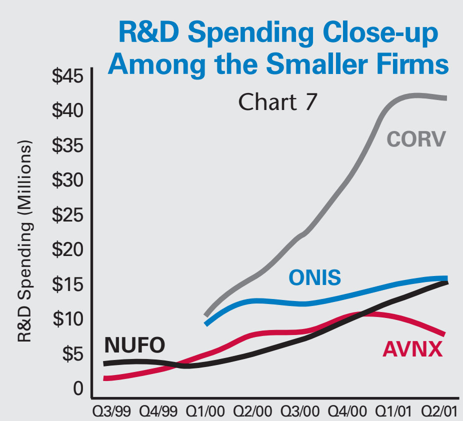












nonlinearities derive from the impact of the electromagnetic energy of light on charged electrons linked to protons in the atoms of the medium itself: in fiber optics silica glass or crystalline lenses. Distending the shape of the fiber's atoms, the light's electrical charge causes material polarization. As a wavefront of light interacts with the bound electrons polarized in the medium, it causes them to oscillate, creating phonons or sound waves that either directly or indirectly unleash new lightwaves down the fiber. Distinctive for every material medium and frequency of light, this polarization defines the "refractive index" of the material, which determines the speed of light in it, its dispersion characteristics, and its angles or modes of propagation. These electrical forces in the fiber give the optical engineer like Turpin a rich palette of nonlinear effects. But none of his innovations is likely to have the immediate impact of a radical breakthrough in nonlinear amplification from Tucson, Arizona.

The new age of EDFAs

In 1990, I began to ruminate on the implications of Will Hicks's prophecies of an ascent of optics hugely faster than the previous rise of electronics and on Paul Green's assertion that optics would outperform copper wires by a factor of ten billion both in capacity and in bit error rate. Essential to fulfilling these prophecies is efficient forms of amplification, chiefly erbium-doped fiber amplifiers introduced by David Payne and Simon Poole, then of Southampton University in the UK. By infusing a three-to-five meter stretch of fiber with rare earth ions and pumping it with an attached laser on the side, the doped glass can amplify all the signals commonly transmitted in fiber. An Atlantic to Pacific all-photonic run requires some 60 such amplifier segments.

Current-day EDFAs, however, are too large, cumbersome, and pricey for use in advanced networks with the thousands of lambdas envisaged by Simon Cao of Avanex and Turpin of Essex. But Turpin's law of simplification is about to strike the world of EDFAs. Throwing away most of the current EDFA components, drastically reducing the present three to five meter span of doped fiber, and making the system far simpler and more effective, is an upstart group of glass gurus under the leadership of Nasser Peyghambarian, chairman of the optical science department at the University of Arizona, Tucson, and chairman of **NP Photonics**. Enlarging the erbium core 31 times from a diameter of 9 microns (millionths of meters) to 50 microns, Peyghambarian customizes the fiber so that it can hold dense concentrations of erbium. But he still manages to confine the telecom signals to a much narrower single-mode region. Conceived seven years ago and made manufacturable over the past few years, the new technology achieves full EDFA gain in some three or five *centimeters* of doped fiber.

Vanishing along with the long spans of doped fiber are erbium-fiber noise, distortion, and loss. Yielding still greater efficiencies is the novel fiber geometry which permits pumping free-space through a prism into the cladding. Vastly broadening today's unforgiving 100 nanometer fiber-alignment tolerances, NPP's spacious device reduces EDFA manufacturing and cooling costs. Tolerating wavelength drift, it also obviates fiber Bragg gratings and polarization-maintaining fiber. Usable as a result are low-cost uncooled multimode pumps that drain less power and are more reliable lasers since heat degrades performance over time. NP Photonics thus not only revolutionizes amplification, it also transforms the pump laser business.

NP Photonics not only revolutionizes amplification, it also transforms the pump laser business

NPP's amplifiers are individually tunable. Gone are the attenuators needed to balance the power from the EDFA when signals are added or dropped. NPP integrates several tiny tunable EDFA "amplets" in a single module. Tunability allows the system to boost weaker wavelengths rather than attenuating the stronger ones. In a world of linear, noiseless, inexpensive, tunable gain, with multiple devices in each package, amplification becomes ubiquitous, integrated into components and sprinkled throughout the network as needed or desired.

Genoa disrupts

Offering a similar vision for smaller networks is **Genoa**. This Fremont, California, company projects that its tiny semiconductor amplifier chips, barely visible to the naked eye, will fill every nook and cranny of metro networks. Though far lower-powered than EDFAs, semiconductor amplifiers can amplify broadband over the entire AllWave transmission window (from 1280 nm to 1625 nm). Eliminating crosstalk, Genoa pumps the semiconductor optically with a VCSEL (vertical cavity surface emitting laser) built into the chip, manufactured simultaneously as one monolithic structure in indium phosphide. Multiple wavelengths pass horizontally across Genoa's chip directly through the beam of the vertically emitting laser which amplifies light using the same quantum mechanical principles that make the laser work. With a 45,000 square foot manufacturing plant recently completed and ongoing customer testing with such pleased customers as **Intel**'s (INTC) LightLogic, Genoa remains firmly on our list. But with a maximum 13 dB of gain compared to 30 dB typical in EDFAs, Genoa's amps are destined to disrupt from below.

A new game of EDFAs will begin shortly. After seven years of experimentation to make the manufacturing process robust and repeatable, Peyghambarian and crew from NP Photonics will begin customer testing over the next few weeks and full commercial production before next summer, making the fiber in their own drawing towers. With virtually no competition, the company currently targets a 75 percent power-for-power price cut on EDFAs of vastly increased functionality and adaptability. But as JDSU's Fred Leonberger recently reminded us, cost effectiveness alone cannot prevail in optics without a fully tested and reliable understanding of failure physics. For mass adoption, new technologies need proven in-network track records. Both Essex and NP Photonics may run into more resistance than they expect before they usurp the far inferior technologies now in place.

JDSU jives to Turpin

JDSU maintains a large lead in range of offerings. A sprawling empire of some two dozen acquisitions, JDSU now boasts tunable filters, fiber Bragg gratings, transponders, modulators, multiplexers, source lasers, tunable dispersion compensators, planar lightwave and thin-film technology, diffraction gratings, tunable optical add/drops, MEMS technology, interleavers, tunable lasers, optical switches—almost any component other than fiber, most of which can thrive in Turpin's and Peyghambarian's lambda-rich arena.

Long-haul leader Corvis can only benefit as it adapts the most appropriate amplifiers to its backbone systems

On the leading edge, JDSU stars in Raman technology, both in the powerful 14xx pumps which drive the amplifiers and in the amplifiers themselves, generally Raman/EDFA hybrids. Rather than amplifying the transmission signal in a discrete device like an EDFA, Raman lasers pump backward down the fiber and pervasively amplify the signal from the other end, tens of kilometers before it reaches the EDFA. This lowers the gain demanded of the discrete EDFA and thus lowers the accumulated noise.

Although cheap, low-power, broadband NPP may render the noise abatement of expensive, high-power, broadband Raman unnecessary and undesirable, Raman's distributed amplification performs a feat discrete EDFAs can't duplicate. Ramans effectively decrease network hut spacings so signals can be launched at less-distortive lower powers. For networks to achieve the same benefits from NPP erbium, they would need to redesign their long-haul links, perhaps adding scores of huts.

How well Raman will be able to play on NPP's turf will not likely be known for several years. Whatever the outcome, long-haul leader Corvis can only benefit as it adapts the most appropriate amplifiers to its backbone systems.

Corning perennially processes

Watching the match closely will be **Corning** (GLW), already crowned EDFA champ, arguably the Raman/EDFA leader, and like JDSU a 14xx pump powerhouse through its Lasertron division. But with a list of components and technologies extending far beyond amplifiers and practically duplicating JDSU's list though on a slightly smaller scale, Corning too should thrive with due vigilance. Unlike its younger Telecosm siblings, Corning enjoys the added advantage of a perennial process innovator, with patents split evenly between materials and process technology. For example, a recent joint venture with **Samsung** (SSNHY) to automate the manufacture of thin-film filters for coarse WDM has already improved production yields some 25 percent and reduced cycle times from two weeks to two days.

In NPP's new world, the fate of **New Focus** (NUFO) appears more tenuous, since its industry leading optical circulator is used heavily to route lambdas in the most complex, high channel-count EDFAs and its polarization beam combiner is used for boosting pump power in EDFAs and Raman amplifiers. We await the outcome of trials of New Focus's tunable transmission laser (New Focus is already a pacesetter in tunable lasers for fiberoptic test and measurement) and interleaver.

Following Turpin's law—cutting back on components and complexities—NPP has transformed the world of amplification. With time, competitors will follow, adapting lasers and glass mixtures and manufacturing processes—pumping prices ever downward. As companies jump on and off the all-optical trampoline, the paradigm marches on, at an ever faster pace, toward millions of lambdas, in a network potentially as abundant in pervasive connectivity as it is today in backbone bandwidth.

ONI at the edge

Building a captive customer-base (now an impressive 24, up from 7 a year ago) primed for future upgrades, ONI's relentless CTO Rohit Sharma continues to succeed against competitors Nortel and Ciena in the rapidly growing metro arena. Sharma takes network intelligence out of big **Cisco** (CSCO) core routers and switches and places it in servers on the edge where, as he explains, most of the network intelligence already resides. As a result, grooming—the capability to dynamically mix, match, and stack lower bitrate data on WDM channels, inherently a bandwidth-conserving activity—

also recedes from the core where bandwidth is abundant (and where Ciena's CoreDirector switch and Nortel's SONET now perform the function) toward the network edge where it is needed.

ONI technology makes lambdas at the edge more flexible, easier to deploy, and cheaper. Its 160-channel WDM system replete with dynamic add/drop and real-time lambda management now includes, with Corning's help, EDFA gain that is tunable within milliseconds, adapting to channel fluctuations on the fly.

Avanex flexes

In contrast to Turpin's experimental Hyperfine which is limited to discrete multiplexing without grouping of wavelengths, Avanex's PowerMux flexibly uses cascades of interleavers as well as multiplexing discretely. In addition, the PowerShaper, which resembles the Turpin technology, can dynamically compensate for all forms of chromatic dispersion by reshaping optical pulses.

An interleaver segregates WDM channels into odd and even sets. For example, a group of channels spaced 25 GHz apart can be separated into two sets spaced 50 GHz. By grouping wavelengths, interleavers simplify network growth by allowing seamless expansion to denser channel spacings. Alternatively, discrete multiplexers may require forklift upgrades.

Avanex's product line is also relevant to the NP Photonics EDFA breakthrough. By integrating its components into subsystems, Avanex promotes network simplicity and efficiency. The PowerExpress, for example, marries Simon's PowerShaper dispersion compensator with an EDFA and thus extends its transmission distance by as much as 25 percent. All Avanex products would be enhanced by cheaper and more functional EDFAs from NPP.

Avanex's VIPA (virtually imaged phased array) is a close kin to the Turpin Hyperfine device. Using VIPA, Avanex can perform the same experiment as Turpin, demuxing 100 GHz spaced channels into 16 channels spaced 6.25 GHz—or 32 GigE channels spaced 3.125 GHz or hundreds of MHz-spaced channels—and do it in a much smaller footprint with almost any channel shape you desire, from "square" to Gaussian. It remains to be seen if Turpin can duplicate the performance (channel shape and separation) and simplicity of Simon's elegant etalon within the time frame that both the market and Avanex's further advances will demand.

Bottom lines

If we applied Turpin's "less-is-more" philosophy to our list, we might be tempted to drop some companies. **Procom** (PRCM), which began as a disrupter, now is lusting to compete at the top of the market with **EMC** (EMC), before selling anything much at the bottom. Not a good sign, and it leaves the list. Many subscribers are inquiring about Mirror Image after the latest screed by the inimitable Christopher Byron. It was entertaining as usual. True, originating in tax-heavy Sweden, the company has its headquarters in the Cayman Islands and is sparse with its financial reports. But Byron got almost nothing else right. Alexander Vik has not sold any personal shares, and the Vik Brothers Incorporated (VBI) reduced its holdings from 77.6 percent of the company in 1999 to 73.3 percent in 2000. The Viks and their partners hold a net of about 70 percent of the shares today (Exodus has 15 percent and the public the rest). Although auditors require "going concern" warnings to be applied to companies that lack the cash to support their burn rate, Mirror Image's corporate shell is Xcelera, which has $250 million in cash and marketable securities. Vik assures us that he is fully committed to Mirror Image, which now has 150 customers and is expanding its clientele at a rate of 15 a month (and revenues and share apace) in a down market.

It remains to be seen if Turpin can duplicate the performance and simplicity of Simon's elegant etalon

Added to the list is Essex, with no debt, no factories, and a steady flow of contracts for unique optical computing services. More important, Turpin and his team of optical processing experts have been working together for over a decade and are ahead of the innovation curve. With no marketing or manufacturing and with the product still in prototype, however, Essex is for sale. Is Avanex listening? Its rivals are streaming through the Essex headquarters.

New inventions vindicate the paradigm and expand the potential of the Telecosm. New inventions drastically enhance the cost effectiveness of the technology and ensure its more rapid deployment. Prices plummet and vendors of high priced spreads howl in pain. But carriers see cheaper systems and customers see cheaper connectivity and investors see new opportunities, as more compact and capacious multiplexers and amplifiers enable more pervasive deployment of the technology and more profitable applications to pay for it. It is tricky on the optical trampoline these days, but the view is worth it. "Leap before you look" is a law of enterprise, which cannot burst ahead through incremental look-before-you-leap maneuvers. You cannot see anything truly new from an old place.

George Gilder
August 17, 2001

TELECOSM TECHNOLOGIES

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	REFERENCE DATE	/ PRICE	JUL '01: MONTH END	52 WEEK RANGE	MARKET CAP
FIBER OPTICS						
Optical Fiber, Photonic Components	Corning (GLW)	5/1/98	13.64	15.66	12.60 - 113.33	14.6B
Wave Division Multiplexing (WDM) Components	JDS Uniphase (JDSU)	6/27/97	3.63	9.24	7.90 - 128.00	12.2B
Adaptive Photonic Processors	Avanex (AVNX)	3/31/00	151.75	6.96	6.82 - 161.38	452.7M
All-Optical Cross-Connects, Test Equipment	Agilent (A)	4/28/00	88.63	28.61	25.00 - 68.00	13.1B
Tunable Sources and WDM Components	New Focus (NUFO)	11/30/00	20.31	5.00	4.95 - 142.50	379.4M
Crystal-Based WDM and Optical Switching	Chorum (private)	12/29/00	–	–	–	–
WDM Metro Systems	ONI (ONIS)	12/29/00	39.56	23.15	15.75 - 114.75	3.2B
WDM Systems, Raman	Corvis (CORV)	3/30/01	7.03	3.90	3.00 - 114.75	1.4B
Metro Semiconductor Optical Amplifiers	Genoa (private)	3/30/01	–	–	–	–
Optical Processors	Essex (ESEX.OB)	7/31/01	5.90	5.90	1.38 - 6.70	24.2M
LAST MILE						
Cable Modem Chipsets, Broadband ICs	Broadcom (BRCM)	4/17/98	6.00*	43.63	20.88 - 274.75	11.4B
S-CDMA Cable Modems	Terayon (TERN)	12/3/98	15.81	6.52	2.36 - 61.38	441.7M
Linear Power Amplifiers, Broadband Modems	Conexant (CNXT)	3/31/99	13.84	9.51	6.90 - 54.94	2.4B
Broadband Wireless Access, Network Software	Soma Networks (private)	2/28/01	–	–	–	–
WIRELESS						
Satellite Technology	Loral (LOR)	7/30/99	18.88	2.14	1.03 - 8.50	710.2M
Low Earth Orbit Satellite (LEOS) Wireless Transmission	Globalstar (GSTRF)	8/29/96	11.88	0.39	0.25 - 14.19	42.7M
Code Division Multiple Access (CDMA) Chips, Phones	Qualcomm (QCOM)	7/19/96	4.75	63.23	42.75 - 107.81	48.1B
Nationwide CDMA Wireless Network	Sprint (PCS)	12/3/98	7.19 *	25.92	15.72 - 56.06	24.3B
CDMA Handsets and Broadband Innovation	Motorola (MOT)	2/29/00	56.83	18.69	10.50 - 37.25	41.2B
Wireless System Construction and Management	Wireless Facilities (WFII)	7/31/00	63.63	8.06	3.31 - 82.69	361.0M
Internet Backbone and Broadband Wireless Access	WorldCom (WCOM)	8/29/97	19.95	14.00	12.50 - 38.38	41.3B
GLOBAL NETWORK						
Metropolitan Fiber Optic Networks	Metromedia (MFNX)	9/30/99	12.25	0.87	0.49 - 40.19	528.9M
Global Submarine Fiber Optic Network	Global Crossing (GX)	10/30/98	14.81	6.55	5.00 - 37.75	5.8B
Regional Broadband Fiber Optic Network	NEON (NOPT)	6/30/99	15.06	4.75	3.40 - 50.13	101.4M
National Lambda Circuit Sales	Broadwing (BRW)	6/29/01	24.45	24.31	15.40 - 30.00	5.3B
STOREWIDTH						
Directory, Network Storage	Novell (NOVL)	11/30/99	19.50	4.99	3.44 - 12.75	1.8B
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	6.88	16.29	12.85 - 64.69	53.1B
Network Storage and Caching Solutions	Mirror Image (XLA)	1/31/00	29 .00	2.75	2.49 - 29.00	291.8M
Remote Storewidth Services	StorageNetworks (STOR)	5/31/00	27.00*	6.25	4.25 - 141.00	601.9M
Complex Hosting and Storewidth Solutions	Exodus (EXDS)	9/29/00	49.38	1.17	0.99 - 69.00	648.2M
Hardware-centric Networked Storage	BlueArc (private)	1/31/01	–	–	–	–
Virtual Private Networks, Encrypted Internet File Sharing	Mangosoft (MNGX.OB)	1/31/01	1.00	1.07	0.53 - 12.75	28.9M
MICROCOSM						
Analog, Digital, and Mixed Signal Processors	Analog Devices (ADI)	7/31/97	11.19	46.00	30.50 - 103.00	16.6B
Silicon Germanium (SiGe) Based Photonic Devices	Applied Micro Circuits (AMCC)	7/31/98	5.67	17.14	11.25 - 109.75	5.2B
Programming Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	4.42	10.01	7.63 - 21.94	4.6B
Single-Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	15.75	21.78	13.65 - 40.75	7.9B
Single-Chip Systems, Silicon Germanium (SiGe) Chips	National Semiconductor (NSM)	7/31/97	31.50	32.05	17.13 - 47.94	5.6B
Analog, Digital, and Mixed Signal Processors, Micromirrors	Texas Instruments (TXN)	11/7/96	5.94	34.50	26.26 - 71.00	59.8B
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	8.22	40.00	29.79 - 92.50	13.3B
Seven Layer Network Processors	EZchip (LNOP)	8/31/00	16.75	6.35	3.69 - 38.44	40.9M
Network Chips and Lightwave MEMS	Cypress Semiconductor (CY)	9/29/00	41.56	27.28	13.72 - 49.94	3.4B
Field Programmable Gate Arrays (FPGAs)	Altera (ALTR)	1/31/01	30.25	30.06	18.81 - 67.13	11.6B

ADDED TO LIST: ESSEX DELETED FROM LIST: PROCOM

* INITIAL PUBLIC OFFERING

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, LLC and Forbes Inc.***

291A Main Street • Great Barrington, MA 01230
Tel: (800)292-4380 • Fax: (413)644-2123 • Email: info@gildertech.com

EDITOR: George Gilder
PUBLISHER: Richard Vigilante
ANALYSTS: Charles Burger, Mary Collins, Bret Swanson
RESEARCH ASSISTANT: John Hammill
MANAGING EDITOR: Debi Kennedy
DESIGNER: Julie Ward

SUBSCRIPTION DIRECTOR: Rosaline Fernandes
GENERAL MANAGER, GILDERTECH.COM: David S. Dortman
PRESIDENT: Mark T. Ziebarth