GILDER TECHNOLOGY REPORT
Published jointly by Gilder Publishing, LLC and Forbes Magazine www.gildertech.com November 2000/Vol. V No. 11

Connectivity is King

Global Crossing and 360networks will battle for worldwide supremacy, but a trillion dollar market ensures neither will lose.

I am in an American Eagle prop jet flying coach into Miami with Shlomo Rakib, brother of Zaki, and co-founder of **Terayon** (TERN). As the plane bumps and grinds through the clouded skies, I find myself reflecting on this miraculous vessel so taken for granted that millions of customers actually complain about it—the occasional delays, the crowded airports, the lack of airborne haute cuisine, the onset of untoward weather. Yet, surely a device of unimaginable systemic complexity that can allow me to speak in three remote corners of the country over three days and put me in bed with my wife before midnight on the third, is some kind of providential marvel.

At the same time, the airplane serves as a seductive analogy—for our technologies, our companies, our markets, even entire economies. Periodically, throughout the history of investment, the market has lost its bearings in bad weather and fallen prey to gusts of panic and ignorance. The airports throng with confused and exhausted travelers. In the stock market, such times represent supreme moments of opportunity for the building of wealth. In the GTR, I try to give my readers enough confidence, based on real knowledge and understanding, to buy tickets to the Telecosm in turbulent times.

The disdain of press and Wall Street wiseguys is a crucial enabler of the opportunity. It is what gives you the chance to buy a stake in the stratospheric future of communications at the price of a pedestrian blue chip. To buy shares, for example, in a potential global franchise in telecom, whether low earth orbit satellites or undersea fiber, for the price of an Appalachian REIT. Yes, I mean **Global Crossing** (GX) and **Globalstar** (GSTRF).

At some point the market will come to appreciate the significance of the unique reach and undersea capacity of the Global Crossing network at a time when Internet traffic continues to surge faster around the world than in the U.S. As Global Crossing quickly rolls past $5 billion in annual revenue, deftly partnering with **Exodus** (EXDS) and maintaining its impeccable reputation for prompt construction, the market says GX is no more valuable than it was in January 1999. Other carriers say they won't go near the volatile and pricey subsea cable business. But there is emerging one company smarter perhaps than the other carriers, and it is paying GX the ultimate compliment.

In This Issue:

Led by former **Microsoft** (MFST) CFO Greg Maffei—who negotiated Microsoft's purchase of some 15 percent of **Asia Global Crossing** (AGCX)—**360networks** (TSIX) has stolen Gary Winnick's playbook: network map, financing, blazing build-out and all. But Maffei is a different coach, and he has expelled a few players from the team. After agreeing to buy ATM equipment and actually accepting delivery of $8 million worth, 360 cancelled the unfilled orders, sold off the few ATM boxes it had, and bet on IP. The new **Sycamore** (SCMR) 16000 switch will administer the Internet's open shortest path first (OSPF) routing and manage the tricky multiprotocol label switching (MPLS). Still embroiled in standards debates, MPLS seeks to capture the connection-oriented benefits of ATM for the ordinarily connectionless packets of IP. In the form of multiprotocol lambda switching (MPλS), it may even provide the key to adapting the packet-oriented Internet to the lightwave circuits of the fibersphere.

360 "Plows" ahead

360networks has lit 10,000 of its 20,000 route miles in North America with 160 **Nortel** (NT)/**Avanex** (AVNX) waves at 10 Gbps. The South American cable extending to Brazil is half lit, with the other half coming online mid next year. 360atlantic is being dropped into the water right now for completion in March 2001, while the Asian and trans-Pacific cables will be ready for service by March 2002. The first three cables range between 1 and 2 terabits per second in total capacity, but 360pacific will hold 4.8 terabits.

Terrestrially, 360's deployment gained speed from its patented Rail Plow which obviates the need to retreat to an often distant side spur every time a train comes by. Using hydraulics, Rail Plow lifts the spooler off the track temporarily while the train passes. Such innovations enabled 360 to begin constructing its North American net eighteen months after **Level 3** (LVLT) and finish first.

Globalstar's problems could be solved overnight through its adoption by Wingcast

What about Level 3's vaunted "continuously upgradeable" network with 12 to 20 conduits everywhere? It turns out that the real physical layer is not the fiber but the light. Together with a surprise invention, the Cao's Law ascent of optics now calls into question Level 3's multiple conduit strategy. 360 has announced a new system from NKF Kabel that uses compressed air to insert "mini-ducts" in already filled fiber conduits. Boding well for scarce conduit networks like **Williams** (WCG), an empty conduit could hold up to 600 fibers in 10 mini-ducts, each deployable as new generations of fiber come online.

Maffei says he's trying to scare other marine players away with rock solid funding and a quick buildout. Financing in the subsea arena is hard to find, and he thinks many cables already announced by other companies will never be built. The company has $3 billion in available cash and a $1.2 billion backlog, 55 percent for dark fiber, 45 percent for lit services. Targeting the very same market as Global Crossing, 360 is wholesaling to global carriers and setting up virtual networks for multinational "datacoms," as Maffei calls them.

In a sense, this is a double or nothing endorsement of GX, which remains at least two years ahead of 360. Today, there is no economy but the global economy, no Internet but the global Internet, and no network but the global network. GX and TSIX will battle for worldwide supremacy, but in a trillion dollar market, there will be no loser.

Despite the foibles of its management and its revolving CEOs, Global Crossing remains simply the world's best situated telecom company, achieving its complex and ambitious buildout faster than any previous venture. With its network mostly complete and with cash on hand, it now stands ready to harvest richly from the daring vision of its proponents and investors.

Wingcast solution for GSTRF

As for Globalstar, it also offers far more potential upside than is imagined by purblind commentators, such as Merrill Lynch's Mark Nabi who has declared that "the equity value of Globalstar shares is zero." Soon enough the market will even realize that Irwin Jacobs and Bernard Schwartz are not so obtuse or vain that they will allow this immense global asset to wither away merely because two old men cannot get their act together. They could solve the Globalstar problem overnight merely by announcing the adoption of the system by Wingcast, the **Qualcomm** (QCOM)-**Ford** (F) partnership to supply wireless services to cars. At present, other methods—such as OnStar used by twenty-nine **General Motors** (GM) models for global positioning and remote control services in case of accident, theft, lockout, or illness—do not work when you move beyond cellular coverage. OnStar excels only in populated areas where communications are available, chiefly when you don't acutely need it. It lacks the global star.

Similarly, Wingcast will be a failure unless it offers the universal two way coverage that only Globalstar can enable at a reasonable price. By dedicating just 20 percent of its capacity and employing car antennas with double the gain of its handsets, Globalstar could even offer 3G vehicular services at some 153 kilobits per second to millions of automobiles. Indeed, the same megabit-plus services to be made available in airplanes, as the Qualcomm-Globalstar InFlight system adopts HDR, are technically feasible for buses, trains, boats, cruises, or automobiles.

As North American carriers debate whether to flee to GSM or CDMA from TDMA and EDGE, the CDMA movement needs Globalstar to maintain a competitive global footprint.

Jacobs' assurance that the Globalstar "system" will last "indefinitely into the future" will not help Qualcomm if he and Bernie stiff the existing Globalstar shareholders and plunge the company into a briarpatch of bankruptcy litigation and scandal. With the junk bonds recently sell-

ing as low as a dime on the dollar, the company remains financially vulnerable even as its technology becomes ever more valuable. This paradox cannot last forever.

WCOM's long-distance challenge

Such financial perils, however, in no way impair the immense potential of Telecosm technologies. The Telecosm is not even remotely near stalling or stagnating; it is still on the runway, gaining momentum. Wireless access remains mostly unavailable and most Internet wireline links still function at 56 Kbps or slower, entailing a prolonged boot and dialup. Download delays still average more than 130 milliseconds in the U.S. and at least double that overseas for a single object in web pages that routinely hold twenty objects or more. The Net is still a jungle of "hot potato" routing and conflicted peering, with packet loss at 5 percent or higher. Yet Internet traffic continues to boom. Despite crippling anti-trust handcuffs on **WorldCom**'s (WCOM) Internet strategy, John Sidgmore declares that IP traffic on UUNET continues to soar at close to tenfold every year or so, which means some one thousand fold in half a decade. On a single fiber cable, the fibersphere promises bandwidth in petabytes per second comparable to total current Internet traffic in petabytes per month.

This surge is rippling through the industry. In just the last two weeks, AT&T, **British Telecom** (BTY), and WorldCom itself have announced tracking stocks or spinoffs of their withering long-distance businesses. AT&T and BT will also cleave their wireless units, hoping to dissociate ascendant mobile from grounded fixed line voice. The vertically integrated towers of telecom are swaying under the weight of the Telecosm.

The trillion dollar challenge that can truly unleash the Telecosm, however, is not bandwidth but access. Resorting to another aeronautic analogy, Simon Cao of Avanex speaks of long-haul fiber optic backbones, moving traffic over thousands of kilometers, as "airplane technology" and stresses the need for photonic "cars" that can move readily on and off of a highway. Thus, he makes the vital point that the value of networks in a time of bandwidth abundance comes not merely from capacity but from connectivity. The skies have nearly unlimited bandwidth or capacity. But no one buys airline stocks on the basis of the volume of air; airline income depends on command of runways and airport slots. The key to the supreme prospects of optical technology is not the bandwidth of fiber, but the connectivity of light.

Terayon expands focus

I break from my optical daydreams and resolve to interview Shlomo, a king of connectivity. He is a man in a plane, and in a company like in a plane still in hurtling ascent, yet, assumed by the market to be stalling and ready to tumble from the skies. You remember Terayon, don't you? Breaking through last year in Asia with code division multiple access (CDMA) cable modems and set to become the "next Qualcomm." Then strangely purchasing RADWIZ for $50 million to enter the digital subscriber line (DSL) market. And Imedia for $100 million to acquire video routing capabilities and MPEG digital video for the cable TV headend. And Combox for wireless and satellite terminal gear and Telegate for voice over IP. If you have the best cable technology, why diversify into the brambles of DSL and Voice over IP? Why flee upward into headend systems or satellites? I wanted to know.

Shlomo replied that it was his decision and he would be vindicated by the convergence of all these technologies in single boxes, driven often by single chip systems. Without command of these access protocols, Terayon would risk usurpation by **Broadcom** (BRCM) and other companies supplying complete integrated silicon solutions. He implied that Terayon itself would soon sell such integrated systems on a chip along the Broadcom or Qualcomm "Spinco" model. He predicted the emergence of a more powerful Terayon that supplies boxes for residential access covering all three connection methods—cable, wireless, and twisted pair. Among the benefits of Shlomo's four purchases, totalling over $300 million—compared to Broadcom's $50 billion acquisition array—is the enlistment of scores of superb Israeli engineers who could constitute a potent force in fabless broadband semiconductors. Although I still have qualms about a possible loss of focus, I was persuaded that Shlomo commands an aggressive and ambitious model for his company based on a fully deliberated strategy.

Watch for a more powerful Terayon that supplies boxes for residential access covering cable, wireless and twisted pair

Yet, Shlomo has just undergone the weird experience of telling an analyst conference of his soaring revenues (up 35 percent quarter to quarter), earnings (up 70 percent), and market share (number one everywhere in the world outside the U.S. and gaining on **Motorola** (MOT) here), only to crash his stock by acknowledging the obvious residual effect of the force of gravity. In essence, he said that as his company accelerates its growth and increases its mass, its rate of ascent is likely to slow. According to Einstein, updated for the Telecosm, this phenomenon affects all objects as they near the speed of light, unless they are engaged in quantum tunneling or are navigated by Henry Nicholas.

News would arrive from Nortel in due course, proving that Einstein's strictures also apply to optical companies. The $30 billion Canadian colossus had increased its optical revenues by a mere 90 percent year over year rather than the expected double—and as in previous years had suffered a quarter-to-quarter slowdown. Blazing on a giant CNN ticker over the building across Broadway in the midst of Times Square, this Nortel news came just in time momentarily to dim the lights at the New Economy Conference at New York's Millennnium Hotel.

VOICE WANTS TO BE FREE . . .

Loaded with CDMA up spectrum capacity, Sprint's all PCS network continues to recruit new customers faster than any major U.S. wireless carrier, steadily gaining market share against third place AT&T (Chart 1).

Soaring sales of handheld wireless devices vindicates our prediction that the most common computer of this decade will be the mobile "teleputer." The sale of Palmtops has more than doubled to nearly 8 million units, far outpacing the sale of sub notebook PCs (Chart 2).

Monthly wireless plans have plunged below 10 cents a minute. Monthly wireless bills average less than half the levels of a decade ago (Chart 3). The recent uptick in monthly bills may represent U.S. users joining the trend toward replacing wireline with wireless. What do *you* do when it's two days to the end of the month and you have 100 "free" minutes left?

Expect that trend toward "wireless only" to accelerate in the U.S., as we add new wireless subscribers more rapidly than the European and Asia countries with traditionally higher wireless penetration rates (Chart 4).

Though wireless bandwidth remains costly compared to wireline, for some business applications the difference is trivial compared to the gap between online and off. The average wireline Internet banking transaction is priced at 13 cents. The same transaction via mobile Internet costs 16 cents. Getting the same work done by phone, chit-chat included, costs more than half a buck.

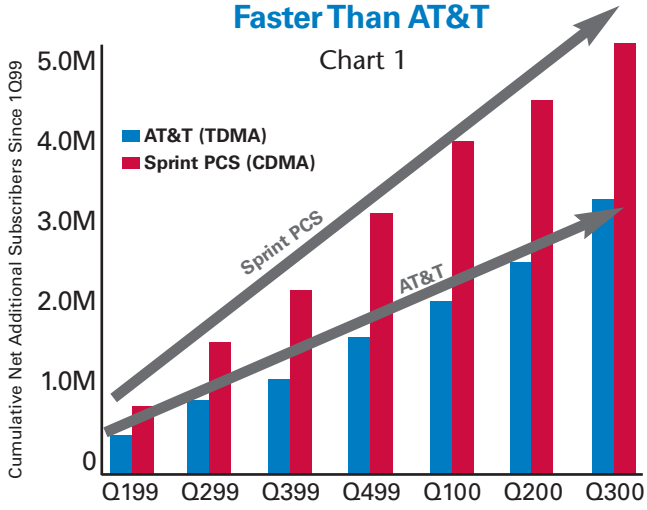
Though undersea remains a relatively bandwidth constrained environment, even here fiber's bandwidth will trivialize the cost and value of voice traffic (Chart 5).

Wireless and wireline costs are both plunging, but the two businesses are headed for very different fates (Chart 6). The cost of shipping one miniscule data stream— a voice call—across a fiber net is so small it is hardly worth billing for. But wireless's almost-universal connectivity to that fiber net represents an irreducible value and an enduring business.

So what is Globalstar's truly universal connectivity worth?

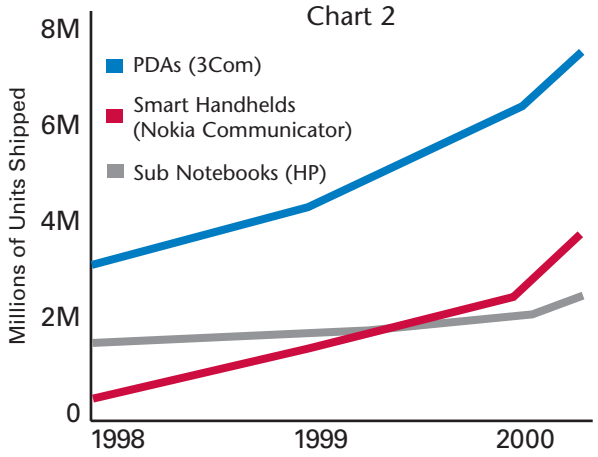
– Mary Collins

Sprint Adds New Customers Faster Than AT&T



The Teleputer Takes Off

Global Shipments of Handheld Wireless Devices



Beginning an interview of Larry Ellison of Oracle (ORCL), I recalled the day in early 1991 when he glowered from the cover of *Upside*, clinging to his silver cylinder in Redwood Shores as his stock plummeted some 80 percent following a sales falsification scandal. Now there are ten silver cylinders on the same campus and investors reminisce about this golden opportunity to buy Oracle at 13 cents a share (adjusted for splits). Ellison said he had saved his company a billion dollars in costs in fiscal year 2000 ending in May by putting the entire Oracle business system on the Web. With revenues rising 15 percent and earnings rising 80 percent, the stock soared fourfold. If costs had risen apace with revenue, they would have been $948 million higher (hence the $1 billion claim). Ellison says he can do it again next year.

However, an Internet company maintaining snailware growth of 15 percent a year—while increasing margins by garroting costs—may well be losing ground fast. Compare Oracle with Terayon, which is growing over 35 percent a quarter and which actually commands a unique technology in the critical path of Internet expansion.

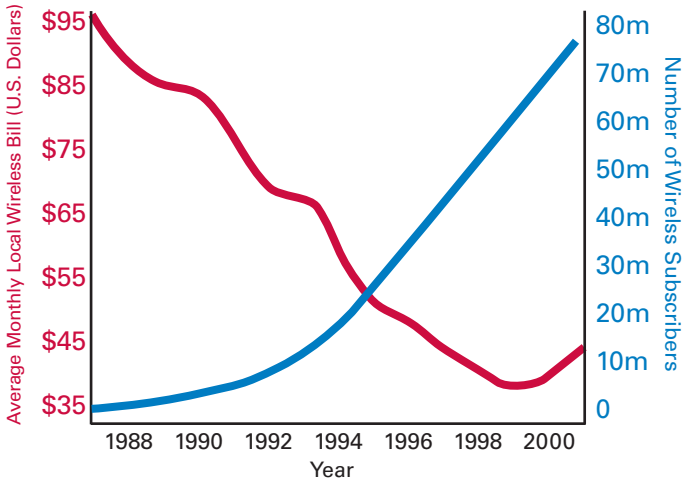
The real stars of the Net are not Ellison and Steve Case of **America On Line** (AOL) but Roth of Nortel, which continues to dominate the world's most important systems business—fiber optics—Josef Straus of **JDS Uniphase** (JDSU), which still prevails in optical components, and Cao of Avanex with his new optical law.

Cao's Law tells us that the communications spectrum is virtually infinite and that wavelength division multiplexing (WDM) will follow a sort of turbo version of Moore's Law. WDM will spread across an optical fiber more and more and finer and finer channels of light each using less and less power. It will multiply these lambdas two to three times as fast as Moore multiplied transistors. Channels on a fiber will recapitulate the saga of transistors on a chip and exhibit many

. . . OR AT LEAST UNTETHERED

As Cost Drops Voice Goes Wireless

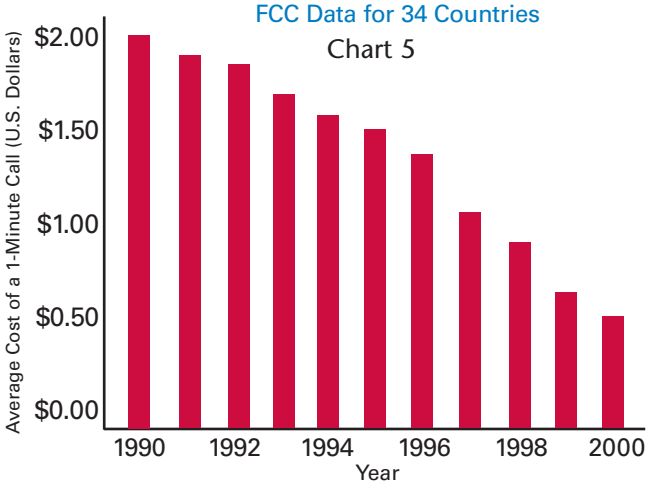
Chart 3



Even Undersea, Voice Costs are Collapsing

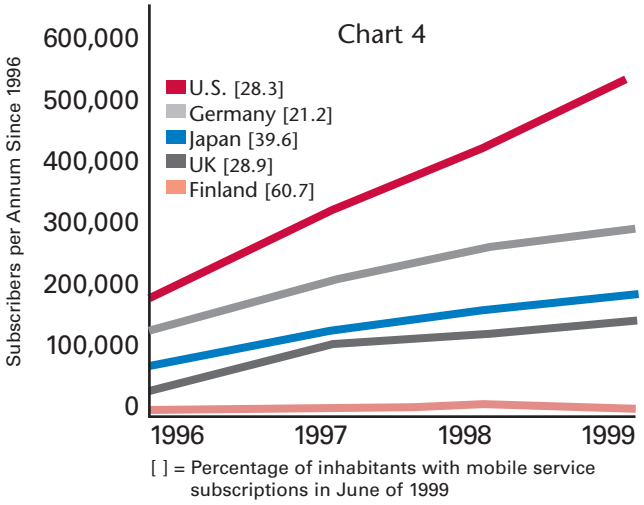
Cost of Wireline International Calls to the U.S. Based on FCC Data for 34 Countries

Chart 5



U.S. Adds More Wireless Users

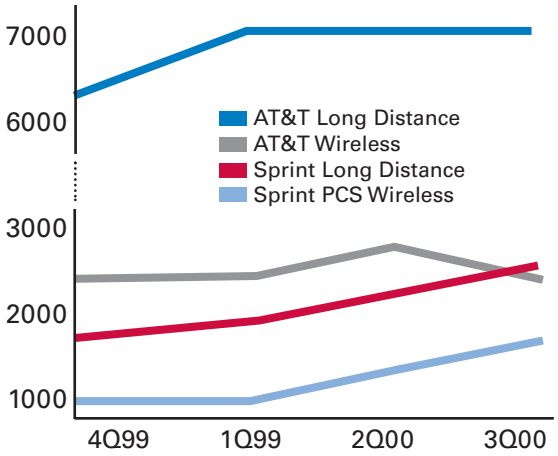
Chart 4



[ ] = Percentage of inhabitants with mobile service subscriptions in June of 1999

Why AT&T Split Up

Chart 6



Sources: CTIA, ING Barings, ITU, Merrill Lynch, OECD, WRHambrecht+Co

of the same trade-offs between power and connectivity.

On optical fiber, the trade-off is between bitrate and channel count. So far, we can pump a high bitrate on each channel, or we can transmit lots of channels. But we can't do both on the same fiber. The dispersive effects of 10 and 40 Gbps systems, in which the modulated signals tend to "mush" together, can disable high channel count WDM. At the other extreme, each of Avanex's 100,000 channels–if they ever escape from the lab–will probably bear multi-megabit not multi-gigabit signals. Nevertheless, there is today among telecom carriers a real world pattern emerging that manifests Simon Cao's law in action.

Corvis complements Williams

Williams Communications is now deploying **Corvis**'s (CORV) ultra-long-haul system on a pair of fibers crisscrossing 24,000 miles around the U.S. Though built by a Cao competitor, David Huber, Corvis follows the wide and weak WDM paradigm. The Corvis system incorporates backward pumping Raman amplification, erbium doped fiber amplifiers (EDFAs), and forward error correction (FEC) to transmit signals up to 4,000 km without electronic regeneration compared to a maximum 600 km for existing systems.

Often including electronic add-drop multiplexers (ADMs), regenerators can cost $300,000 a piece, per wavelength, and entail provisioning times measured in months or years. The Corvis system obviates much human tinkering: pop in the line cards at each terminal, and the lambdas appear. It initially pumps 160 wavelengths at 2.5 Gbps and is upgradeable to 320 2.5-gig channels in 2001. It's very wide—only Fujitsu with help from Avanex has a wider system at 176 channels—and reasonably weak—no one is introducing a new core WDM system with a lower bitrate. Complementing Williams' already telecosmic architecture which employs a restorable mesh instead of Sonet rings, the Corvis system can optically add and drop lambdas at

every node with help from a point-and-click graphical operating system. The mysterious Corvis optical switch can steer up to 160 waves on each of six fibers, says Williams.

Chomping at the bitrate

Most of the optical industry continues to struggle toward 40 and 80 gigs. The reason for this high-powered, big bitrate regime may center on the very device that first ignited the all-optical dream: the mighty EDFA, and its modest home, the EDFA hut.

Most of the networks of the 1990s have been built in essentially similar fashion. Polyvinyl chloride conduit is laid along a railroad or utility right-of-way or inside a decommissioned pipeline. Inside the conduit is a cable containing a hundred or so fiber strands. Every 60 to 100 km, a hut is built to house an optical amplifier—the EDFA. This distance is called the link length. Then every 400 to 600 km lies a larger station full of electronics for regenerating, routing, and adding and dropping signals. Until now, most WDM systems, with tweaks here and there, seemed to work equally well on any network within these broad parameters. Williams, however, observes that its decision to build EDFA stations every 65 km, instead of every 100 km like Level 3 and **Qwest** (Q), critical to making the Corvis system work, will give it a huge financial and technical edge. In agreement are **Broadwing** (BRW) (also deploying Corvis with EDFA spacings between 60 and 80 km) and 360networks.

Williams's 65-km EDFA spacing offers substantial technological and economic advantages

EDFA pump lasers amplify both the signal and the noise of an optical transmission. Sixty-five-kilometer spacing means more EDFAs and, one might think, more noise, right? Not with Corvis, because it uses Raman, which adds a "pull" effect to the EDFA push.

A backward pumping Raman amp will reach back about 30 km to re-energize a nearly exhausted light signal. Thus, with amplifier huts placed only 65 km apart, the EDFA pump needs only power the signal about 35 km. Assume that a light signal loses half its power every 12 km. The EDFA pump in a Corvis-type system could operate at an order of magnitude less power with 65 km spacing than with 100 km spacing.

Noise increases by the square of the pump power, so the problem–and the Corvis/Williams advantage–is not additive but exponential. In a triumph of the wide and weak paradigm, Corvis pushes Williams's signals coast to coast by *lowering* the power. But lower power is also crucial to restricting dispersion and thus increasing channel count *and* lambda connectivity. It really is a beautiful world.

In fact, it is a BIG beautiful world, because wide and weak not only empowers long distance, and consummates connectivity, it also boosts bandwidth. With Corvis, and presumably Nortel's Qtera which also uses Raman and FEC, the 100-km network has only one choice. It must limit the channel count to 40 and increase the bitrate to 10 Gbps. Larger spaces between lambdas make them easier to read, and the higher bitrate is needed to compensate for the lower channel count. The result for the 100-km network is half the total bandwidth (400 Gbps versus 800 Gbps) and eightfold fewer lambdas per fiber (Qwest's 40 versus Williams' 320).

Avanex saves the day

Low and slow, wide and weak systems will be the foundation of the all-optical network. More important than bitrate is connectivity. Witness WorldCom's UUNET. It has the most extensive and robust Internet backbone on the planet. Yet UUNET growth slowed last quarter. Bernie Ebbers struggles to leverage this dominant asset not because it transports too few bits, not because it has too little bandwidth, but because like even the best networks today, it has too few broadband connections. It's the lack of connectivity in the metro and last mile. Simon Cao, meet Bob Metcalfe. Networks, Metcalfe showed, increase in power by the square of connected nodes. Similarly, eight times the number of lambdas means not just eight times the flexibility but some multiple of eight.

Every time you deploy a channel with a higher bitrate than is useful to a customer, you must engage in further electronic processing to separate out one user's signal from another user's signal riding on the same lightwave. By requiring more electronic muxing and demuxing, high bitrates retard the outward reach of the optical edge and thus increase cost and complexity. True, many 2.5-gig bitstreams will also be packed with multiple signals. And when high and hard systems "progress" to 40 and 80 gigs, wide and weak ultra-long-haul systems may be doing 10 gigs per lambda. But at the margin, lower bitrate channels, which conform more closely to the needs of individual users, will always require less logical processing. Wasting bandwidth so as to multiply connectivity, we rightly choose high channel counts over high bitrates. The bandwidth we cast upon the waters is returned, perhaps in some ultimate consummation of Cao, a thousand fold.

Does the superior efficiency of the Williams configuration dash the all-optical hopes and 80-gig dreams of the networks with 100-km spacing between huts? Not quite. Once again, Avanex saves the day. First, anyone who wants to do 40- or 80-gig channels—ultra-long-haul notwithstanding—will most likely need the Avanex dispersion compensator, called the PowerShaper. As lasers pulse on and off faster to create the more highly modulated signals, the pulses are so close together that they tend to become unreadable over even moderate distances. As its name suggests, PowerShaper reshapes the signal—that is, it "squares" and redefines the pulses—optically rather than electronically. So far, it's the only way to produce a readable signal at super-high bitrates.

The more important application of the PowerShaper,

however, is in the PowerExpress ultra-long-haul system. It combines the dispersion compensator with an optimized EDFA. Where Corvis or Qtera use Raman and FEC to *eliminate* the reshaping function previously performed every 400 to 600 km by electronic regenerators, the PowerShaper system obviates the Raman and the FEC and, for the first time, brings reshaping into the optical domain. And it works with 100-km spaced line amps. In fact, at 2.5 Gbps per wavelength, PowerShapers are required only every 300 km. Next year, when the 3,200 km system becomes available, in conjunction with the next generation 800 lambda PowerMux, a network could achieve 2 Tbps of ultra-long-haul light per fiber, with more than double the connectivity of any other system.

Might the "sub-optimal" 100-km spacing of other networks, in a weird twist, lead them away from Corvis and into the hands of Avanex? Might Williams' "advantage" thus quickly be turned on its head? It depends on whether Level 3 and the others resist the temptation of speed and turn away from 40- and 80-gig systems—that is, if they open their eyes to the wider spectrum of light.

Will Level 3 see the light?

So far, Level 3 says it may think about doing ultra-long-haul on "certain express routes," meaning high-traffic, east-west links. WorldCom is also contemplating it for express routes. But for the most part Level 3 continues to promote the fiber itself, and the conduits containing it, as the key factors in the unit cost competition. Content for now to leave optoelectronic regenerators in place on most light paths, more than any other carrier Level 3 looks to improvements in the fiber itself for optical fulfillment. Level 3 built twelve conduits nationwide to accommodate new generations of fiber and doesn't see how any network with fewer than six conduits can be successful. (Can you say "mini-ducts"?) The company is also excited about its plan, early next year, of pulling through its second conduit a new, more perfectly symmetrical generation of Corning LEAF that helps reduce polarization mode dispersion and goes some way toward enabling 40 gigabit per channel transmissions.

One hundred one million of Level 3's $255 million in third quarter communications revenue was dark fiber sales, leaving $154 million in resale and lit services and co-location. Williams, by comparison, sold $178 million in network services last quarter and may have $100 million in dark fiber sales for the entire year. 360's Greg Maffei, moreover, readily admits that Level 3 is far ahead of other next generation networks in co-location construction.

Level 3 likes to say that for every one dollar spent on fiber, a network must spend nineteen dollars on optics and electronics. Under the pressure of Cao's Law, however, that ratio is collapsing. As the PowerMux product family wildly proliferates wavelengths and extends their reach, it will accelerate the exit of expensive electronics from the system. The absolute cost of lighting a fiber will continue to drop. And the cost per lambda will drop even faster.

The unit cost of the bit, say the carriers, is the only thing that matters. They are wrong. Connectivity is king. The plummeting price of lambda connectivity will become the supreme force fueling the opportunities of the Net. Bits per second will take care of themselves. Level 3 understood that pricey optical fiber is cheaper than inexpensive copper. But so far, it has failed to grasp the new paradigm. That light is cheaper than fiber.

Cao's Law is collapsing the fiber/optronics price ratio. In the new paradigm, light is cheaper than fiber.

Perhaps Jim Crowe's ultimate role will be as a wholesale supplier of dark fiber, conduit, and colocation. Perhaps Level 3 is just a construction company—no more, no less—after all. Long haul network construction and colo real estate leases may be profitable businesses, but they fall short of the Telecosm, and thus we remove them from the list.

In Michael Mandel's new book, entitled *The Coming Internet Depression (and how to prosper afterwards)*, he presents the entire economy as a vessel like an airplane that has to maintain its momentum of growth to stay aloft. If it stalls, it crashes. Essentially it rides on air, and as Michael insists, it is sure to stall, is stalling now. This is nonsense. The Internet is lifted not by stock market froth but by the immense value released by the combination of Moore's Law silicon advances, annual doublings of storage capacity, and some fivefold annual increases in bandwidth.

Mandel foresees a collapse of innovation and growth when the venture capital outlays slow in a bear market. The effects of venture capital, however, play out not over months but over decades. The growth of the nineties was largely an effect of the venture innovations of the 1980s. The huge surge of venture investments of the late 1990s and early 2000s—with outlays doubling in the second half of this year compared to last—will yield a steady flow of innovations reaching the market over the rest of the decade. These innovations in turn will manifest themselves not chiefly in new flows of spending but in new wireless and broadband Internet access, petabits per second of backbone bandwidth, millions of lambdas of new cheap connectivity, exabyte tides of new web traffic. Demand is relevant to economic growth only as a symbol of real productive contributions. The rise in stock values and venture capital are significant not because of their impact on consumer or business outlays but because they manifest the ascendant momentum of the new economy.

George Gilder with Bret Swanson
November 9, 2000

TELECOSM TECHNOLOGIES

ASCENDANT TECHNOLOGY **WINGS OF LIGHT**	COMPANY (SYMBOL)	REFERENCE DATE / PRICE	OCT '00: MONTH END	52 WEEK RANGE	MARKET CAP
Wireless, Fiber Optic Telecom Chips, Equipment, Systems	Lucent (LU)	11/7/96	11 25/32	23 5/16	20 - 84 3/16	77.9B
Wave Division Multiplexing (WDM) Systems, Components	Ciena (CIEN)	10/9/98	4 9/32	105 1/8	16 3/4 - 151	29.9B
Wireless, Fiber Optic, Cable Equipment, Systems	Nortel (NT)	11/3/97	11 1/2	45 1/2	30 1/8 - 89	139.0B
Optical Fiber, Photonic Components	Corning (GLW)	5/1/98	13 41/64†	76 1/2	25 1/2 - 113 5/16	67.6B
Wave Division Multiplexing (WDM) Components	JDS Uniphase (JDSU)	6/27/97	3 5/8	81 7/16	41 5/16 - 153 3/8	78.0B
Adaptive Photonic Processors	Avanex (AVNX)	3/31/00	151 3/4	101 9/16	47 3/8 - 273 1/2	6.5B
All-Optical Cross-Connects, Test Equipment	Agilent (A)	4/28/00	88 5/8	46 5/16	38 3/16 - 162	21.0B
THE LONGEST MILE						
Cable Modem Chipsets, Broadband ICs	Broadcom (BRCM)	4/17/98	6*	222 3/8	63 1/2 - 274 3/4	49.4B
S-CDMA Cable Modems	Terayon (TERN)	12/3/98	15 13/16	22 3/8	17 3/8 - 142 5/8	1.4B
Linear Power Amplifiers, Broadband Modems	Conexant (CNXT)	3/31/99	13 27/32	26 5/16	20 7/16 - 132 1/2	6.0B
THE TETHERLESS TELECOSM						
Satellite Technology	Loral (LOR)	7/30/99	18 7/8	5 11/16	3 3/4 - 25 3/4	1.7B
Low Earth Orbit Satellite (LEOS) Wireless Transmission	Globalstar (GSTRF)	8/29/96	11 7/8	2 29/32	2 - 53 3/4	296.9M
Code Division Multiple Access (CDMA) Chips, Phones	Qualcomm (QCOM)	7/19/96	4 3/4	65 7/64	51 1/2 - 200	48.5B
Nationwide CDMA Wireless Network	Sprint (PCS)	12/3/98	7 3/16 *	38 1/8	27 13/16 - 66 15/16	35.4B
CDMA Handsets and Broadband Innovation	Motorola (MOT)	2/29/00	56 53/64	24 15/16	20 - 61 1/2	54.4B
Wireless System Construction and Management	Wireless Facilities (WFII)	7/31/00	63 5/8	50	30 5/8 - 163 1/2	2.1B
THE GLOBAL NETWORK						
Metropolitan Fiber Optic Networks	Metromedia (MFNX)	9/30/99	12 1/4	19	15 1/16 - 51 7/8	10.4B
Global Submarine Fiber Optic Network	Global Crossing (GX)	10/30/98	14 13/16	23 5/8	20 1/8 - 61 13/16	20.8B
Regional Broadband Fiber Optic Network	NEON (NOPT)	6/30/99	15 1/16	12 1/16	10 1/2 - 159	200.9M
Telecommunications Networks, Internet Backbone	WorldCom (WCOM)	8/29/97	19 61/64	23 3/4	20 3/16 - 61 5/16	68.2B
Global Submarine Fiber Optic Network	360networks (TSIX)	10/31/00	18 1/8	18 1/8	13 3/4 - 24 3/16	14.8B
CACHE AND CARRY						
Directory, Network Storage	Novell (NOVL)	11/30/99	19 1/2	9	7 1/2 - 44 9/16	178.4B
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	13 3/4	110 7/8	51 5/16 - 129 5/16	178.4B
Network Storage and Caching Solutions	Mirror Image (XLA)	1/31/00	29	12	4 7/16 - 112 1/2	1.3B
Disruptive Storewidth Appliances	Procom (PRCM)	5/31/00	25	22 11/16	8 5/8 - 89 3/4	259.0M
Remote Storewidth Services	Storage Networks (STOR)	5/31/00	27*	63 7/16	50 9/16 - 154 1/4	5.8B
Complex Hosting and Storewidth Solutions	Exodus (EXDS)	9/29/00	49 3/8	33 9/16	19 7/8 - 89 13/16	14.0B
THE MICROCOSM						
Analog, Digital, and Mixed Signal Processors	Analog Devices (ADI)	7/31/97	11 3/16	65	27 - 103	11.1B
Silicon Germanium (SiGe) Based Photonic Devices	Applied Micro Circuits (AMCC)	7/31/98	5 43/64	76 7/16	19 - 109 3/4	26.0B
Programming Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	4 27/64	14 15/16	9 9/16 - 30 11/16	6.9B
Digital Video Codes	C-Cube (CUBE)	4/25/97	23	19 1/2	14 1/4 - 106 1/4	959.0M
Single-Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	15 3/4	32 5/8	22 5/8 - 90 3/8	10.1B
Single-Chip Systems, Silicon Germanium (SiGe) Chips	National Semiconductor (NSM)	7/31/97	31 1/2	26	21 15/16 - 85 15/16	4.6B
Analog, Digital, and Mixed Signal Processors, Micromirrors	Texas Instruments (TXN)	11/7/96	5 15/16	49 1/16	35 - 99 3/4	84.9B
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	8 7/32	72 7/16	38 - 98 5/16	23.8B
Seven Layer Network Processors	EZchip (LNOP)	8/31/00	16 3/4	23 5/8	3 7/8 - 43 3/4	152.4M
Network Chips and Lightwave MEMS	Cypress Semiconductor (CY)	9/29/00	41 9/16	37 7/16	25 1/16 - 58	4.7B

ADDED TO THE TABLE: 360networks
DELETED FROM THE TABLE: LEVEL 3

† SPLIT ADJUSTED THIS ISSUE * 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 and Forbes Inc.***
Monument Mills • PO Box 660 • Housatonic, MA 01236
Tel: (800)292-4380 • Fax: (413)274-3030 • Email: info@gildertech.com

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

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