GILDER TECHNOLOGY REPORT

July 1998 www.gildertech.com Volume III Number 7

Published Jointly by GILDER TECHNOLOGY GROUP and FORBES MAGAZINE

THE UP SPECTRUM PARADIGM

Broadband wireless offers a wide path around and through the copper cages of the incumbent local phone companies.

Awash in the floods of facts and fancies concerning information technologies, from the superchip to the superconductor, we can cling to one great unifying structure of science. The heart of the Telecosm is a spread of frequencies–an infinite rainbow of colors visible and invisible–used for communications. It is Maxwell's rainbow, for it was James Clerk Maxwell, a polymathic Scot with a gigantic dark beard, diverging from his chin in a huge fractal tangle of twists and curls, who in 1865 invented this span of cornucopian carrier waves. On it can be mapped the central frequency of every computer and communications system, from your 330 megahertz Pentium personal computer to your 2 gigahertz personal communications system (PCS) phone and from your one megahertz AM radio signal to your 500 megahertz cable channel to your 200 terahertz fiber optic long distance connection, from your kilohertz cortical neurons to your 400 to 700 terahertz eyes, from your 60 hertz power line link to your petahertz (10 to the 15th) dental X-rays.

Many observers associate spectrum strictly with wireless. But spectrum is often most efficient and interference free when it is confined in insulating wires. When **AT&T** (T) moved to purchase **TCI** (TCOMA) late last month, what it got was a gigahertz (a billion cycles a second) of broadband coaxial cable spectrum already deployed in one third of the nation. That's 40 times more than all its cellular wireless spectrum purchased through the buyout of McCaw.

At some $43 billion, excluding content properties, this huge cable asset cost slightly more than twice as much as the McCaw holdings. But TCI is free of much of the regulatory pettifoggery applying to wireless and commands a state of the art broadband technology model (rather than an obsolescent one like McCaw's last ditch Time Division Multiple Access or the Digital Subscriber Line [xDSL] of the telcos).

At the heart of the move to cable for access to offices and residences is a move up spectrum. To date, most access to the phone network used the 4 kilohertz twisted-pair telephone lines that operate in baseband (baseband carriers bear their signals on the lowest frequencies compatible with the sounds or other content they represent, as you can hear when the computer modem dials in to your Internet Service Provider). Cable carrier frequencies operate as much as a billion cycles per second (gigahertz) higher than unconditioned phone lines and command a

The high frequency empires of air command some *50,000 times* more bandwidth than all the lower frequencies we now use put together.

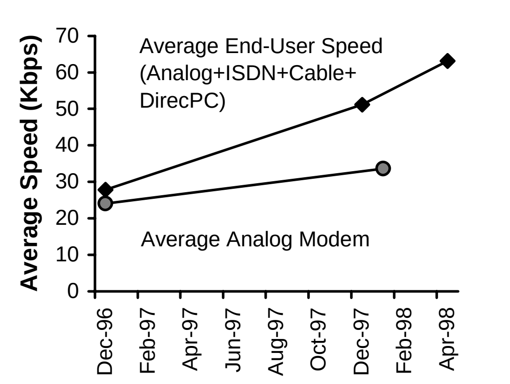
potential capacity 250 thousand times larger.

DSL technology on reconditioned wires only appears to close the gap. One point to point application with DSL electronics at each end can carry as much as six megabits per second downstream for as far as 18 thousand feet. But unlike TCI's shared cable, DSL links are not available for broadcast applications or multiplexed signals from many sources. When you are not using your link, it is unavailable to anyone else. Offering better spectrum than twisted-pair wires, cable's bus topology requires less intelligence on the ends. In one of the canon rules of the Telecosm, it uses bandwidth as a substitute for processing.

Similarly trading in smart electronics for dumb bandwidth is **AOL** (AOL). AOL is tearing out its ATM (asynchronous transfer mode) switches in favor of paring its network down to the backbone and running Internet Protocol (IP) directly on SONET (the telcos' optical signaling standard). By contrast, **Sprint**'s (FON) heralded new Integrated On-demand Network seems to be going in the opposite direction, promising per bit pricing of html on http on IP on ATM on SONET on glass. Ultimately the most efficient system with the lowest latency will use bandwidth as a substitute for all this complexity, putting IP on lamda, the optical carrier wavelength in WDM (wavelength division multiplexing). First reports suggest that instead Sprint plans to put a telco Rube Goldberg protocol tower on lamda.

Chart 1

Internet End-User Bandwidth



Just as the Microcosm defied the expectations of nearly all analysts by becoming exponentially more powerful as it was compressed into smaller spaces with ever more minuscule circuits, so the Telecosm is flouting all conventional wisdom about the diminishing returns of shorter waves and higher frequencies. Moving up spectrum in defiance of the crowds in the licensed bands below recapitulates moving down silicon in defiance of the fabled "laws of physics" that supposedly barred the way to submicron devices. Both contrarian moves yield exponential fruits, feeding on Maxwell's grasp of the unexpected and baffling fact that at the foundation of all phenomena, from images and energies to lights and temperatures, were *oscillations.* Almost all information technology can be described as modulating various frequencies of oscillation.

Most physicists and historians of science, of course, would say that Maxwell did not invent the spectrum at all, he *discovered* it. They believe that it is a natural entity like electricity or the South Pole or Laetitia Casta or viruses. Below 300 gigahertz microwaves, however, human ingenuity is the source of nearly all terrestrial wave action, from police radar and microwave ovens to infrared remotes and AM radios. Beginning with Heinrich Hertz's laboratory radio waves, emitted by a spark gap device and received by a crude antenna across the room, men have used rotary oscillators, vacuum tubes, electron guns, traveling wave tubes, masers, lasers, klystrons, gyrotrons, cyclotrons, magnetrons, gallium arsenide semiconductors, indium phosphide semiconductors, varactor, tunnel, IMPATT, avalanche, and Gunn diodes, among other ingenious devices, to contrive an endless span of oscillating electromagnetic fields and colors. Maxwell, though, used a more subtle and flexible apparatus of photosynthesis: his mind.

Excogitating four elegant equations of vector calculus, he defined these waves as a spectrum of interwoven electrical and magnetic fields. In Maxwell's mathematical scheme a changing electrical field generates a changing magnetic field which in turn induces a new electrical field in an endless spiral of concentric circles spreading through space or focused down a wave guide or wire.

Crucial to processing these waves is the phenomenon of resonance. Through resonance, inductor-capacitor circuits allow isolation of particular frequencies. The capacitive and inductive reactances (or impedances) neutralize each other, leaving the desired frequency to surge forth. That's how radios are tuned and how radio waves are broadcast.

In these circuits, the inductance and capacitance are normally separate–lumpy–and embodied in discrete devices. The capacitors are created by separating two conductive plates by an insulator; the inductors are coils that bend radiation and thus accelerate it, creating magnetism. But inductance and capacitance can also pervade a medium. At the heart of Maxwell's invention was the realization that the electrical and magnetic permittivities of free space, per meter, were constants measuring the inductance and capacitance of space: its openness to an accelerating electric field and thus to its conversion into a magnetic field, and vice versa, as a wave travels through the air. To capture this complementary effect, corresponding to the inductance and capacitance of a circuit, Maxwell fatefully included the product of these free space permittivity constants in his theory.

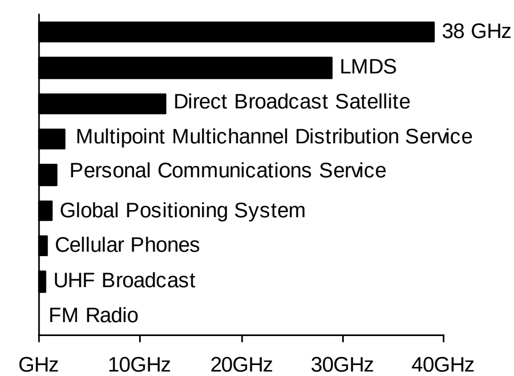
This product is 9 times 10 to the 16^{th}, which is a velocity squared. Taking its square root yields 3 times 10 to the 8^{th} or 300 million meters (186 thousand miles) per second. This we now know as the speed of light. The speed of light is essentially the resonance of free space.

Maxwell found "*c*" speed everywhere–in the capacitive charges in a Leyden Jar (the first effective battery), in Sir William Thomson's ohmic wires, in a resistive coil connected by two parallel disks, in a "Wheatstone Bridge" resistometer. Most important, he showed that "the dielectric capacity of a transparent medium should be equal to the square of its index of refraction." In other words, refraction (an optical property) and dielectricity (a property of electromagnetism) converged. Light transpired as a form of electromagnetism.

Maxwell predicted the potential existence of an entire spectrum of frequencies observing the electromagnetic rules. Ten years later, Hertz produced wavelengths from 10 meters to 30 centimeters, comprising radio waves of frequencies running between 100 megahertz, now used for FM radio, to around 12 gigahertz, now used for Ku-band satellite transmissions, such as DirecTV. Such frequencies had never been seen before in nature. Ten years later, Roentgen generated the first X-rays, also following Maxwell's laws. These demonstrations of wildly diverse forms of electromagnetic radiation all moving at lightspeed confirmed Maxwell's math and inspiration. Soon Guglielmo Marconi and others sent radio waves across oceans and rushed off to launch the Telecosm.

In the product of frequency and wavelength, the frequency is dominant. When electromagnetic radiation moves from a vacuum to a medium with a higher index of refraction (lower permittivity), its frequency does not change. Its wavelength compresses. Thus when infrared waves, moving at 300 million meters a second enter a fiber optic line and slow to a velocity of 210 million meters a second their frequency remains the same. The wavelength compresses. If the light were in the visible range, its color would persist. This characteristic is crucial to the new fiber optic technologies of the Telecosm.

Chart 2
Licensed Radio Frequencies



In a further effect, the refraction index of the medium–such as a fiber core–actually varies slightly with the frequency, causing dispersion of signals of infinitesimally different colors. This chromatic dispersion is exacerbated with higher power signals entailed by higher bitrates on a single lamda. Thus Maxwell's findings paved the way to the "wide and weak" paradigm, sending many lower powered colors down a fiber line in the wavelength division multiplexed (WDM) systems now revolutionizing telecom.

Like a magician, Maxwell stands before us and shuffles the cosmic cards in a shimmering cascade of vector calculus, and from every crease and nook of every equation, from under his asymptotic hat, from up his inductive sleeve, within the capacitive pockets of his coat of many colors, and seemingly out of the thin air of his displacement current, pops out and shines forth his ace of lights–the inevitable *C*–until you think that it is all he has in the deck. But through his *C* squared factor, equally widespread, he also exfoliates energy and anticipates Einstein.

Maxwell imposes no limit on the possible range of frequencies and wavelengths. Above 14 gigahertz today are few widespread human applications in the air. But these high gigahertz and terahertz frequencies, with wavelengths running from the centimeters or millimeters of microwaves, to the microns of infrared and nanometers of visible light, provide much of the new action in the Telecosm–all the new up spectrum wireless and fiber optic systems. Even excluding the widely useful ultraviolet bands, these empires of air command some *fifty thousand times* more bandwidth or communications potential than all the lower frequencies we now use put together.

To put this band in perspective, the difference between the wavelengths of the longest and shortest forms of electromagnetic radiation is a factor of some 10 to the 25^{th}. In his new book, *Nature's Destiny*, molecular biologist Michael Denton calculates, "If we were to build a pile of 10 to the 25^{th} playing cards, we would end up with a stack stretching halfway across the observable universe." Seventy percent of the sun's light and heat occupies a span between the near ultraviolet and the near infrared, from 300 to 1500 nanometers, or just the width of the edge of one playing card in the cosmic Maxwell stack. This is the span that sustains all life and enterprise and it perfectly fits both with the transparency of water and the atmosphere and with the span of resonant quantum energies in the carbon atoms of the living world. Maxwell, however, opened the way to using much of the rest of the deck for human communications.

Broadband wireless, for example, offers a wide path around and through the copper cages of the incumbent local phone companies. These wireless systems typically operate in the 18 – 38 GHz range of the microwave spectrum, much higher than cellular at 800 and 900 MHz, and PCS near 2GHz. Many observers imagine that these high frequencies create special problems that render them less useful than lower frequency radio waves. This is true if your goal is to transmit as far as possible, penetrating all obstacles in a single bound with high powered signals. Engineers with radio and TV broadcasting backgrounds or even with analog cellular experience assume this high power, low frequency ideal.

Followers of the low power broadband paradigm will not be surprised to discover that if your goal is to interfere as little as possible with other transmitters

The new rule is the higher the frequency the smaller the antenna, the wider the bandwidth, and the lower the power.

Chart 3

WDM Capacity Accelerates Climb

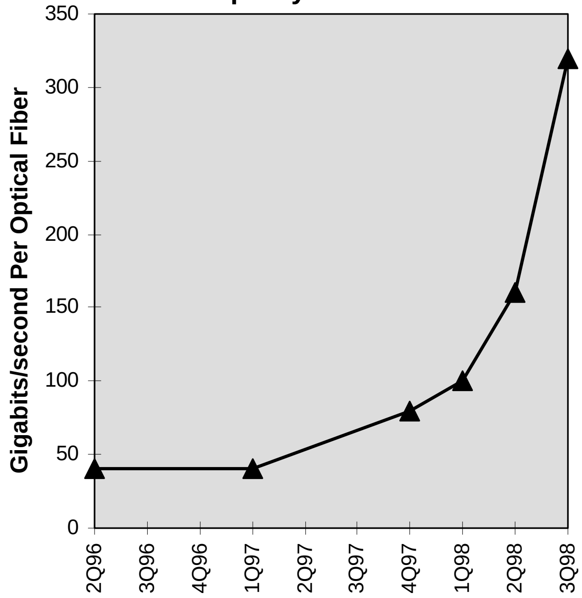
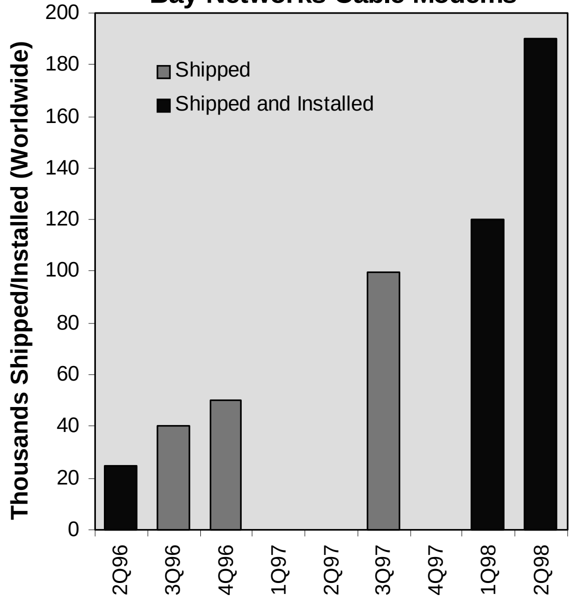


Chart 4

Bay Networks Cable Modems



Source: Company Announcements

Transmission capacity *of commercially available Wavelength Division Multiplexing (WDM) systems continues to climb (***Chart 3***). Following on Ciena's shipments of their 100 Gbps (gigabit per second) system during 1Q98, Nortel offered a 160 Gbps system. On June 9, 1998 at Supercomm, Fujitsu launched a completely operational 320 Gbps system ahead of both Nortel's 320 Gbps upgrade and Lucent's announced 400 Gbps system each expected in 4Q98.*

Nortel's acquisition of Bay Networks *for an estimated $9.1 billion, solidifies their position in the Telecosm of combined data and telecom networks. A GTG favorite among Bay Networks' technologies has been their cable modem division (formerly LANcity) which has held a leading share of worldwide cable modem shipments. Bay Networks has shipped and installed over 190,000 cable modems and deployed headend equipment capable of providing cable modem service to over 4 million homes (***Chart 4***). The June 23, 1998 announcement of @Home's testing and integration of Bay Networks' standards-based headend equipment was overshadowed by the following day's news of the AT&T merger with @Home's biggest stakeholder, TCI. Also obscured, was the June 30 @Home announcement of ten new distribution agreements covering some 10 million homes, potentially gaining @Home access to over half of North American homes. Cable modem chip maker Broadcom's stock soared with @Home. Additional good news for Broadcom came with the June 15 announcement of Microsoft and Compaq's combined $425 million investment in Road Runner, the cable modem venture of Time Warner and MediaOne. Each company will receive a 10% stake in the venture and Compaq will produce and ship cable-ready PCs. Speaking at PC Expo, Compaq President and CEO Eckhard Pfeiffer said Compaq will begin shipping cable modems in some PC models this year and all new PCs by next year.*

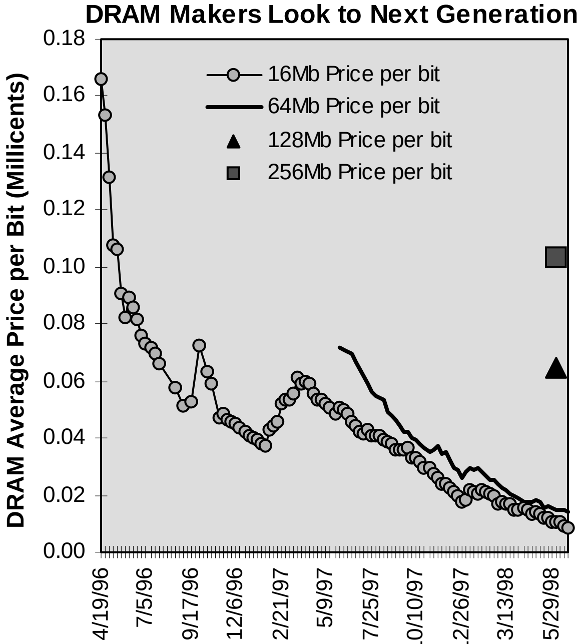
Texas Instruments' *focus on the key Telecosm Technology of digital signal processors (DSPs) was solidified with the $800 million sale of TI's memory business to Micron Technology, announced June 18. Micron will become the world's largest DRAM manufacturer as prices continue steady declines (***Chart 5***). With Mitsubishi, Hitachi, NEC, Toshiba, Samsung, LG Semicon, Hyundai each announcing plans for next generation 128 Mb and 256 Mb DRAMs, Micron's challenge is to continue its leadership in low cost DRAM production which has allowed it to profitably gain market share even as pricing fell.*

Semiconductor capital spending *estimates for 1998, announced in June by IC Insights, show Taiwan bucking the trend set by other Asian manufacturers (***Chart 6***). Benefiting from demand from fabless semiconductor companies, whose growth has increased faster than the general semiconductor market, Taiwan's largest chip companies, TSMC (Taiwan Semiconductor Manufacturing Co.) and UMC (United Microelectronics Corp.) are reportedly profitably expanding production. And Nikkei BP reports, Tawain's 1Q98 production of desktop PCs rose 64% over 1Q97.*

-KE

Chart 5

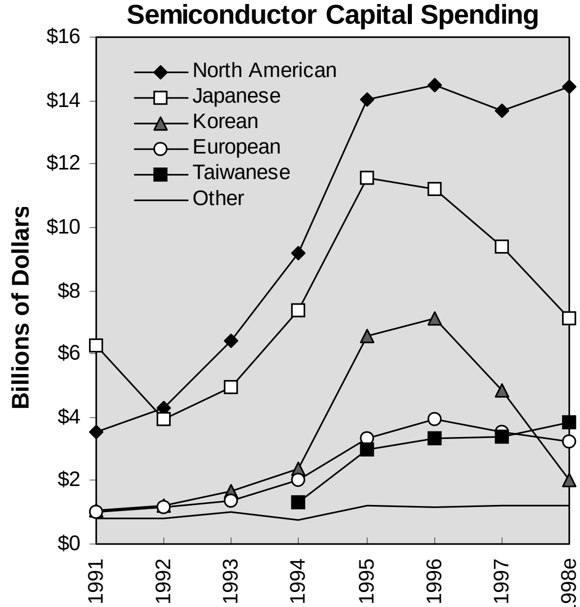
DRAM Makers Look to Next Generation



Source: Mission Electronics, GTG

Chart 6

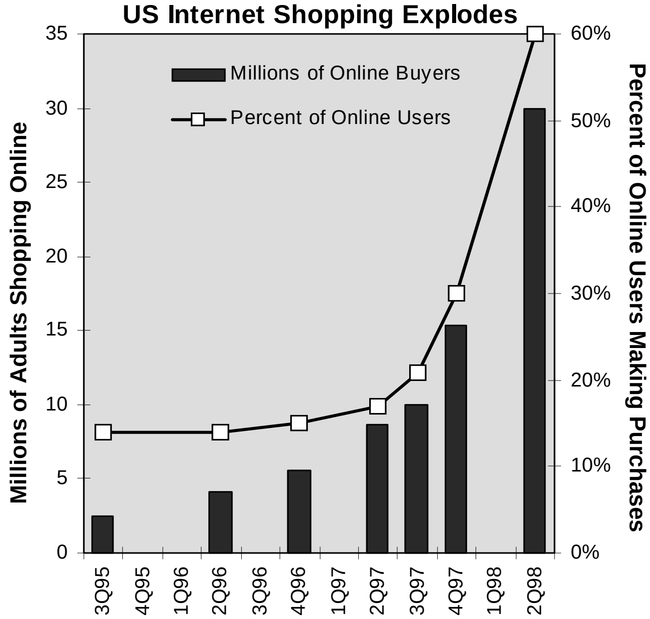
Semiconductor Capital Spending



Source: ICE, IC Insights

Chart 7

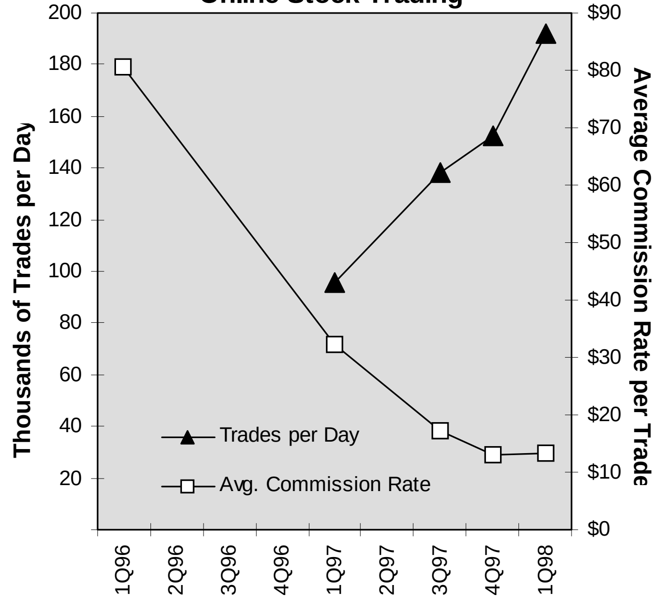
US Internet Shopping Explodes



Sources: Nielsen, AmEx, Ernst & Young, Wirthlin, PSI Global

Chart 8

Online Stock Trading



Source: Piper Jaffray

Fifteen percent of US adults, *or some 30 million people, have made an online purchase according to a recent poll conducted by Wirthlin Worldwide for the Information Technology Association of America (***Chart 7***). The jump in e-commerce was independently confirmed by a PSI Global study of online households showing 60% of respondents now buy products online. Two-thirds of buyers found it easier to shop online and 30% cited lower prices, according to PSI Global. The explosion of online commerce comes as consumers gain confidence in the Internet. Of those not buying online, according to Wirthlin, more than twice as many (15%) expressed a lack of trust in electronic merchants and how they would use personal information than expressed a fear of computer hackers and the theft of their credit card numbers (7%). Inability rather than fear was cited for not using credit cards online: "five times more respondents cited credit cards than computers as the missing ingredient to shopping online."*

Online stock trading *increased 26% from the 4Q97 to 1Q98, doubling over 1Q97, despite the bottoming out of commission rates (***Chart 8***). Piper Jaffray reports, Charles Schwab led brokers with a 32% share of online trades, more than double 2nd place E-trade's 12% share, followed by Waterhouse, 9%; Fidelity, 8%; Datek, 7%; Ameritrade, 6%; DLJ Direct, 4%; Quick & Reilly, 4%; Discover, 4%; and all others with 14%. Schwab reports that during 1Q98 retail investors bought and sold securities valued at approximately $26 billion through their web site. Over 6 months, Schwab's active online accounts have increased 47% to 1.74 million in May, with assets managed online rising 55% to $120 billion. During 1997, online trading accounted for 17% of all retail trades. By January 1998, Roper Starch Worldwide found 14% of online users were buying or selling stocks online. Look for growth with broker service offerings from Wells Fargo, Bank of America and other large banks and the rapid expansion of overseas and foreign language trading sites.*

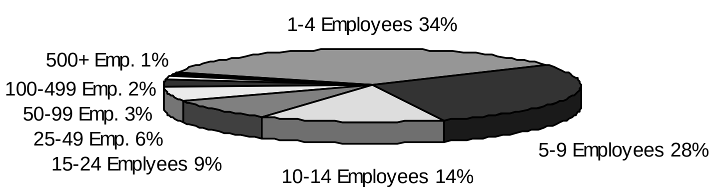
Internet service providers *(ISPs) with fewer than 10 employees represent some 62% of the market (***Chart 9***). But despite small size, with nearly 5,000 ISPs the numbers add up. Local ISPs consistently beat the large online services and national ISPs to capture some 60% of the commercial Internet access market, according to ZD Market Intelligence. And among residential subscribers nearly half use a local ISP (***Chart 10***).*

Sprint PCS *dominated 1Q98 PCS market share (***Chart 11***). PCS C-block reorganization in June reduced competition by 26 companies as licenses for 167 markets covering 53 million pops (potential subscribers) were returned to the FCC. Another 36 licensees returned half their spectrum in some 130 markets with 45 million pops. Only 99 markets covering 38 million pops were retained in full. NextWave, with 63 licenses covering 104 million pops, failed to elect an option having instead filed suit against the FCC and for bankruptcy protection. The number of markets with an active PCS carrier rose from 105 in 1997 to 143 this year, with 47 markets having more than one, up from 27 (***Chart 12***). The chief competition has been between incumbent cellular and new PCS providers. Paul Kagan Associates reports average PCS pricing ranges from 20% to 41% lower than cellular rates. Average wireless prices for the highest use subscribers fell as much as 20% from September 1997 to March 1998.*

-KE

Chart 9

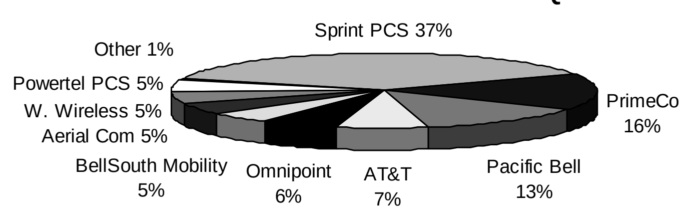
Internet Service Providers Size



Source: ZD Market Intelligence

Chart 11

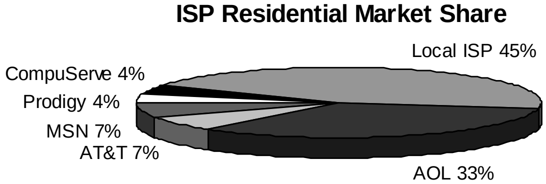
PCS Subscriber Market Share 1Q98



Source: Strategis Group

Chart 10

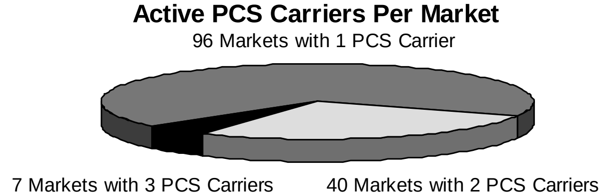
ISP Residential Market Share



Source: ZD Market Intelligence

Chart 12

Active PCS Carriers Per Market



Source: Strategis Group

Richly funded and sharply targeted, Teligent is a perfectly situated paradigm company.

and to deploy lots of small low power antennas, high frequencies are actually superior. The inverse square and inverse fourth laws that govern the attenuation of terrestrial signals are a huge burden when you are designing broadcast towers to cover counties in Colorado. But these power laws work in your favor when you are shrinking cells from 30 mile spans to one mile microcells and want to maximize frequency reuse. In most applications, the new rule is the higher the frequency the smaller the antenna, the wider the bandwidth, the lower the power, the denser the channel reuse, and the higher the market potential.

This is the up-spectrum paradigm at work. In an eye-popping article in the June 1 issue of *Telephony,* consultants Bart Stuck and Michael Weingarten pointed out that the two leading companies in broadband wireless, **Teligent** (TGNT) and **Winstar** (WCII), now command market caps totaling nearly $3 billion despite a minuscule number of customers. As an explanation, they compare the cost structure of these companies with the cost structure of **Teleport**'s (TCGI) metropolitan fiber links, which can serve as a proxy for other access fiber services, such as **WorldCom**'s (WCOM) MFS and Brooks Fiber. Weingarten and Stuck find that despite Teleport's some $1.5 billion invested in outside plant, in the average served Metropolitan Statistical Area (MSA), containing some 14 thousand buildings, Teleport is connected to only 77. The reason is that it costs Teleport $112 thousand in capital to pass a single building and $303 thousand to link to it. This compares to under $10 thousand to connect a building with broadband wireless radios.

Fiber is tremendous paradigm technology. All these broadband wireless companies will use it for their backbones. Allowing cheap add-drop muxes, WDM will bring fiber deep into the local loop. But unless you want at least a 155 megabit per second connection, it simply doesn't pay as an access tool for the vast majority of the some four million commercial buildings in America.

Most prominent among the new broadband wireless players is Teligent, headquartered in Vienna, Virginia, and led by Alex Mandl, a former president of AT&T. Its digital wireless networks ultimately will reach more than 700 cities and towns using spectrum licenses in the 24 GHz band. Teligent's original licenses were in the 18 GHz band, but **Teledesic**, the Gates-McCaw low earth orbit satellite venture, flagged down Mandl for interference, called the FCC, and pushed him out, kicking and screaming theatrically, into the 24 GHz briarpatch, which Teligent shares with police radar. To offset the risk of speeding tickets, Teligent obtained some 300 megahertz more spectrum.

With a recent $100 million equity investment by **Nippon Telegraph and Telephone Corp**. (NTT), a senior discount note transaction of $250 million, and other agreements, Teligent has raised or secured commitments for $1.6 billion, which makes it the richest of the new microwave players (with the possible exception of Teleport's BizTel, which is now owned by AT&T). Owning relatively little spectrum, BizTel may have felt like an orphan after AT&T CEO Michael Armstrong's assertion that broadband wireless is years away.

Rolling out its wireless network the second half of this year, Teligent has rights to offer competitive local telephone service in 42 markets. Interconnection agreements have been signed with **Ameritech** (AIT), **Bell Atlantic** (BEL), **BellSouth** (BLS), Pacific Bell, **SBC** (SBC), and **GTE** (GTE). The company will use **Nortel** (NT) Reunion wireless equipment, including switches, base stations, and receivers, and will work with Nortel's Broadband Networks, Inc. (acquired in January) on the design, manufacture, and installation of the network.

Richly funded and sharply targeted, Teligent is a perfectly situated paradigm company. But early signs suggest a certain touch of telephonitis. Like hundreds of companies with lucrative business plans, it apparently hopes to be shielded from reality a few more years by the T-1 tariff price umbrella. This allows the telcos to charge as much as $2000 per month for 1.544 megabit a second services that entail virtually zero incremental cost on fiber and under $40 per month on a cable modem and are even allegedly available from **US West** (USW) at some $455 per month through DSL (As aggressive companies such as **Rhythms NetConnections** and **Northpoint** are showing, DSL is in fact more promising as a small business link than as a residential offering). After 1998, the appropriate business plan is not to hide under the umbrella but to blow it away with new bandwidth, fast turnaround installation, and drastically cheaper prices.

Moving even higher up the spectrum to 38 gigahertz is **Advanced Radio Telecom** (ARTT) of Bellevue, Washington, which is also integrating fiber-optic and broadband wireless technologies into packet-switched metropolitan-area networks. Like many vendors, ART touts its service as "wireless fiber," although real fiber commands a potential bandwidth literally millions of times larger. What wireless offers is rapidly deployable *access* to fiber backbones, which is actually more important. Like Teligent, ART is deploying an Asynchronous Transfer Mode (ATM) network supporting Internet access services, IP telephony, electronic commerce, native LAN services, and frame relay service.

Founded in 1993, the company went public in November, 1996, and holds rights to 358 licenses covering 210 US markets, including 49 of the top 50 and 90 of the top 100 markets, with a total population of over 186 million and channel pops of over 371 million. Hey, I bet you don't know what channel pops are. I didn't either. It is a number excogitated by multiplying the total population in a particular region by the number of 100MHz channels commanded by the system and by the total sales of Rice Krispies in the relevant Metropolitan Statistical Area (MSA). Ignore it. Conventional pops are altogether irrelevant. Relevant is the number of reachable buildings with potential customers and without fiber connections. ART, like Teligent, modestly estimates

150 thousand of these. Additional nationwide licenses cover the United Kingdom, Denmark, Norway and Sweden, reaching a population of over 77 million. But with half the 400 MHz spectrum of Teligent, ART will need to deploy more nodes to achieve the same coverage.

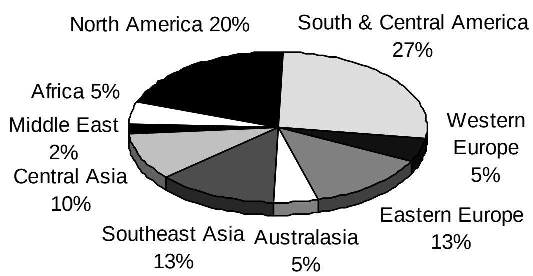
In March 1998, ART selected **Lucent Technologies** (LU) as network builder and systems integrator, setting up a race with the Teligent and Nortel team. Like all the firms in this field, ART is exploring the possibility of equipment that can receive calls from many customers at once.

Fixed microwave wireless has a line-of-sight narrow beam, requiring very small roof-top dishes (12-24 inches in diameter). The narrow beam offers a high capacity for frequency reuse, creating a large transmission pipe (currently as much as 28 T-1s, or DS-3, at 45 Mbps). Point-to-point connectivity is generally effective for distances of two miles at 38 GHz, and links have been successfully tested by ART for up to five miles. Rain fade has not appeared to be a significant problem (they speculate that the Crane rain fade tables, established at lower frequencies, are over-designed, and may not obtain at 38 GHz). The equipment required for microwave installations is highly portable, easily installed and readily adaptable.

Chart 13

Broadband Fixed-Wireless Subscribers

5 Million Worldwide



Source: Ovum Ltd.

Allegedly seeking to purchase ART is the pioneer at 38 GHz, WinStar, which commands double the spectrum of Teligent. So far, most of its income comes from content offerings and ordinary wireline operation. But it is rapidly rolling out wireless services. An exemplary project is for **CIGNA** (CI) Investments, a company that owns and manages commercial buildings across the country. WinStar is installing wireless links in 96 CIGNA office buildings nationwide, providing high-bandwidth connections to suit CIGNA's tenants' needs.

WinStar has won a total of 15 LMDS licenses (Local Multipoint Distribution Service) at 28 GHz in the recent FCC auction. As a result, WinStar now averages approximately 740 MHz in the top 50 markets, over a gigahertz in top markets such as New York, and total license coverage of more than 200 million people and more than *one billion channel pops*, not even including Rice Krispies. Coming down to earth, actual wireless deployments cover a few hundred buildings so far. Operating under the T-1 canopy, the company reports margins of some 70 percent on its wireless T-1 installations, charging customers 10 to 15 percent below the tariffed rate. With five nines of reliability (99.999 percent), the robust performance of these Winstar systems portends well for all wireless broadband carriers.

During the first quarter, WinStar activated an ATM-based, point-to-multipoint (PMP) broadband, fixed wireless trial network carrying voice, data, and video services in Washington, D.C. With a capacity of four DS-3s (each 45 Mbps), this system will provide a wireless base for wide area networks, where high capacity LANs can be spread across a corporate campus, and interconnected to other, remote, LANs across a city, or across the country.

In March, the company completed a private placement of $200 million in preferred stock, convertible into common stock at $49.61 per share, and $450 million in notes. WinStar currently has cash resources of approximately $800 million. Winstar has acquired GoodNet, a rapidly growing Internet backbone provider based in Phoenix.

A key WinStar equipment provider is **P-Com, Inc**. (PCMS). Competing with several other companies, including **Innova** (INVA), **California Microwave** (CMIC), **Triton Network Systems**, and **Stanford Telecom** (STII), P-Com designs and produces point-to-point, and point-to- multipoint broadband radio equipment. A complete offering of spread spectrum radio extended upward to some 45 megabits per second and downward to 19 Kbps, makes P-Com a unique one-stop-shop vendor for wireless operators.

Digital Microwave Corporation (DMIC) designs and manufacturers microwave radios with data transfer rates of up to 155 Mbps. This radio platform, called Altium, will cover frequencies from 6 to 40 GHz and is scheduled to ship by late 3rd quarter. These radios will be used for the mobile wireless interconnect market (cellular and PCS site links) and also for the access market (wireless local loop and network connections to the telcos).

Smart radios continue their advance. **Tadiran Ltd.** (TAD), an Israeli communications equipment company, has purchased Microwave Networks, which commands a new line of high-frequency radios, including 13 to 38 GHz systems. In-field frequency selection allows cellular providers to order radio equipment before finalizing frequency channel plans. And in early June, **Blue Wave Systems** (BWSI), which resulted from the merger of Mizar and Loughborough Sound Images, demonstrated its new SoftBand software radio at Supercomm 98 in Atlanta.

The new broadband wireless has imposed severe new demands on the oscillators that provide the RF signal. Introducing a newer type with at least five times the adjustable range of the prevalent dielectric resonance devices (DROs) is **Verticom**, a privately held firm that makes yttrium-iron-garnet (YIG) frequency synthesizers. These have bandwidth tuning capability of as much as 3 GHz.

Sawtek participates in an array of paradigm markets, from CDMA to broadband wireless.

TELECOSM TECHNOLOGIES

ASCENDANT TECHNOLOGY	REPORT(S) Volume: No.	COMPANY (SYMBOL)	Reference Price	Price as of 7/1/98
Cable Modem Service	I: 2, 3; II: 7, 8, 9, 11, 12; III: 6	*@Home* (ATHM)	19 1/2	53 1/2
Analog to Digital Converters (ADC), Digital Signal Processors (DSP)	II: 3, 7, 12; III: 2, 4	*Analog Devices* (ADI)	22 3/8	25 11/16
Java Thin Client Office Suite, Rapid Application Development (RAD)	II: 6, 7, 12	*Applix* (APLX)	4 1/2	3 13/16
Dynamically Programmable Logic, Silicon Germanium (SiGe), Single Chip Systems	III: 4	*Atmel* (ATML)	17 11/16	13 3/4
Single-Chip Broadband Data Transmission	II: 10; III: 3, 5	*Broadcom Corporation* (BRCM)	24 *	78 7/8
Digital Video Codecs	II: 5	*C-Cube* (CUBE)	23	19
Fiber Optic Cable, Components, Wave Division Multiplexing (WDM)	II: 9; III: 5	*Corning* (GLW)	40 15/16	34 7/8
Low Earth Orbit Satellites (LEOS)	I: 2; II: 1, 3, 4, 8, 10; III: 6	*Globalstar* (GSTRF)	21 3/4	26 5/8
Business Management Software	III: 4	*Intentia* (Stockholm Exchange)	29	35
Wave Division Multiplexing (WDM), Fiber Optic Equipment	III: 5	*JDS Fitel* (Toronto Exchange)	19 1/4	16 5/8
Broadband Fiber Network	III: 2, 3, 4	*Level 3* (LVLT)	62 1/2	71 15/32
Single Chip ASIC Systems, CDMA Chip Sets	II: 8	*LSI Logic* (LSI)	31 1/2	23 5/8
Telecommunications Equipment, Wave Division Multiplexing (WDM)	II: 1, 2, 7, 9, 10, 11, 12; III: 1, 2, 3, 4, 5, 7	*Lucent Technologies* (LU)	23 9/16	84 5/16
Single-Chip Systems	II: 8, 12; III: 4	*National Semiconductor* (NSM)	31 1/2	13 1/4
Telecommunications Equipment. Wave Division Multiplexing (WDM), Code Division Multiple Access ([illegible]MA), Silicon Germanium (SiGe)	II: 1, 7, 9, 11, 12; III: 1, 2, 3, 4, 5, 6, 7	*Northern Telecom* (NT)	46	56 1/16
Point to Multipoint System for 7-50 Ghz, Spread Spectrum Broadband Radios	II: 10, 11, [illegible]	*P-COM* (PCMS)	22 3/8	8 13/16
Code Division Multiple Access (CDMA)	I: 1, 2; II: 1, 3, 4, 7, 8, 9, 10, 11 III: 4, 5, 6	*Qualcomm* (QCOM)	38 3/4	56 1/8
Broadband Fiber Network	II: 9, 10, 11; III: 1, 2, 3	*Qwest Communications* (QWST)	20 3/8	36
Java Programming Language, Internet Servers	I: 1, 2, 3, 4; II: 1, 5, 6, 7, 8, 10, 12	*Sun Microsystems* (SUNW)	27 1/2	44 15/16
Optical Equipment, Smart Radios, Telecommunications Infrastructures	I: 1; II: 1, 2, 3, 9; III: 3	*Tellabs* (TLAB)	29 1/8	73 3/8
Broadband Wireless Services	II: 9, 10, 11, 12; III: 7	*Teligent* (TGNT)	21 1/2 *	28 3/4
Digital Signal Processors (DSP), DRAM	I: 2, 3, 4; II: 5, 8, 11, 12; III: 3, 4, 6	*Texas Instruments* (TXN)	23 3/4	60
Wave Division Multiplexing (WDM) Modulators	II: 7, 9, 10 III: 4, 5	*Uniphase (UNPH)*	29 3/8	63
Telecommunications, Fiber, Internet Access	II: 9, 10, 11, 12; III: 1, 2, 3, 4, 7	*WorldCom* (WCOM)	29 15/16	49 3/4
Field Programmable Logic Chips (FPGA)	I: 3 III: 4	*Xilinx* (XLNX)	32 7/8	35 9/16

* Initial Public Offering

Atmel Update: Due to continued weakness in the EPROM and flash memory markets, Atmel Corporation announced June 30, 1998 an acceleration of the reorientation highlighted in the April 1998 GTR. While reducing exposure in memory markets, Atmel will continue to invest in development of new products and technologies, specifically citing growing demand for logic, system-level integration and Temic group (including SiGe) products. Atmel's acquisition of Data Communications Technologies, announced June 22, expands Atmel's multimedia and communications IC business. And Atmel's June 30 announced alliance with QuestMark to establish a FPGA (field programmable gate array) design center will expand opportunities for Atmel's advanced FPGA architectures.

Note: This table lists technologies in the Gilder Paradigm, and representative companies that possess the ascendant technologies. But by no means are the technologies exclusive to these companies. In keeping with our objective of providing a technology strategy report, companies appear on this list only for these core competencies, without any judgement of market price or timing.

The YIG-based synthesizer could yield a radio capable of covering an entire spectrum band, adjustable on site.

Also exacting is the need for mixers that can down convert microwave signals to an intermediate frequency (IF) for digital processing. **Sawtek, Inc**. (SAWS), based in Orlando, designs and manufacturers electronic signal processing components based on surface acoustic wave (SAW) technology. During down conversion to baseband frequency, the received RF (radio frequency) signal is transformed to an IF, and then to an acoustic signal that travels across the surface of a quartz crystal, where it is purged of spurious elements. SAW filters are replacing the older LC (inductor/capacitor-based) filters. A favored **Qualcomm** (QCOM) supplier, Sawtek participates in an array of paradigm markets, from CDMA to broadband wireless. It will likely prosper as the up-spectrum campaign continues to impose acute demands for spurious-free dynamic range in mixers. Next step: 60 to 64 gigahertz.

George Gilder with Jeff Dahlberg, July 5, 1998

After much consideration, we have decided to allow ForbesASAP exclusive rights to publish an occasional adapted text from the reports some six to eight weeks following receipt by GTR subscribers. In practice this will mean there is a possibility of a second wave of impact after initial publication.

***Gilder Technology Report** is published by*
Gilder Technology Group**, **Inc**. and **Forbes Inc.
Editor: George Gilder; Associate Editors: Charles Frank and David Minor;
Director of Research: Kenneth Ehrhart.

Monument Mills P.O. Box 660 Housatonic, MA 01236 USA
Tel: (413) 274-0211 Toll Free: (888) 484-2727 Fax: (413) 274-0213
Email: gtg@gildertech.com