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LEOS AND GEOS: DUMB AND DUMBER

Satellites—though hundreds of miles above the surface of the earth—are emerging as major players in the "last mile."

"Why did the Mafia kill Einstein?" our gnomic publisher Richard Vigilante asked me late last month, as he prepared to leave for a vacation in Italy. Was he implying a conspiracy theory? Having never heard of an interesting secret kept by more than three people for more than three weeks (heck, you can't even hide the name of a new paradigm company from the Yahoos and Raging Bulls for more than three minutes), I am deeply skeptical of all conspiracy theories.

Furthermore, I want to point out that there is only slim circumstantial evidence to implicate sinister forces at *Business Week* and the entourage of Al Gore in planting the renowned "Rita" at Gilder, Gagnon, and Howe last month. GG&H turned out to be proud owners of a million shares of **Northeast Optical Networks** (NOPT) at the very time that we promoted the company to our list of Telecosmic stars. Over the four hours after we posted the letter at www.gildertech.com, these shares appreciated some $10 million. Rita is the helpful lady who confided to all callers to the GG&H offices in New York that her boss, Richard Gilder, is my beloved brother. Malicious mail thronged my modem: "All Wall Street knows you are brothers, pump and dump hustlers, inside trading colluders…" What could I say to counter Rita's deadly allegation, flashing around the Net at the speed of light like a photonic millipede? This Richard G. is a great guy, sure, but he's no more closely related to me than Secretariat.

I assume that Rita–who eventually will be revealed by DNA to be an unacknowledged daughter of Richard–merely suffered a pang of wishful homonymous pride, without any conspiratorial purpose. So when our publisher Vigilante made the charge about the Mafia and Einstein, I merely took it as an opportunity to display my famously rakish sense of humor. I laughed and said, "All right. I'll bite. Why *did* the Mafia kill Einstein?"

"It was because he *knew too much*," Richard confided.

I'm sorry, but in this GTR I am going to have to expose you to the possible fate of Einstein. For at least three minutes, you too are going to know too much. If through the magic of the Internet (or a courier on a camel), you can manage a purchase of the shares of **Globalstar** (GSTRF) or **Loral** (LOR) within the next month or so, you may well be in a position to make a killing yourself, over the next five years. If you don't believe me–or are facing problems with your password, your second wife, or the *Forbes* server, or have any further suspicions of insider trading or other conspiracies–by all means call Gilder, Gagnon, & Howe and ask for Rita. If she proves to exist, tell her Uncle George sent you.

Inform Rita as well that within less than six months, you will be able to reach her from nearly any point on the face of the earth, at any time of day or night, for a dollar per minute or less, on your Globalstar phone.

Some people are asking what is the big deal. After all, irradiating much of the land mass of Europe, Asia, North America, and South America, are terrestrial cellular antennas, LMDS (Local Multipoint Distribution Service) microwaves, and DBS (Direct Broadcast Satellite) streams. In addition, coax and fiber lines and

When told in 1995 that the Iridium architecture was "set in concrete," I summed it up: "Iridium will sink like a stone."

conduits loop redundantly around the globe. Every civilized point on the earth pulsates with power cables and their hidden optic ground wires, and is thronged with trillions of meters of twisted pair copper wires, their spectra bulging like engorged snakes with broadband signals using bulbous Digital Subscriber Line (DSL) algorithms. In Bangladesh and Somalia, the Grameen Bank is making microloans of under $100 to village women to purchase chickens, cows, and cellular phones. Even in the most remote reaches of Kenya, devoid of electricity, so my daughter reports from the front, small huts fashioned with a fragrant blend of mud and dung are sprouting solar panels to power the TV. Cellphones will be next. Terrestrial wireless and wireline service is available everywhere, at a price far below the cost of satellite minutes. Isn't that why Globalstar's precursor, **Iridium** (IRID), failed miserably?

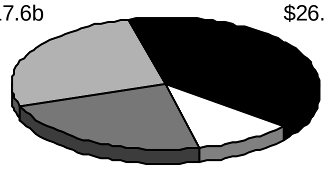
What's wrong with this picture?

The key error is the assumption of widespread cellphone coverage. Even in the US, cellphones reach less than 20 percent of the territory. At least 45 percent of the country will never be economically served by cellular. In China, where there are 500 thousand villages with no phone service at all, the current coverage is under one percent. Most of the world has no terrestrial phone service at all and will not have it for a decade or more.

Chart 1

Satellite Services and Manufacturing Lead Satellite Industry Revenues

1998: $65.9 Billion



Source: Satellite Industry Association

Globalstar Advantage

The opening price of Globalstar minutes will be one-seventh of Iridium's price and the Globalstar network remains 19 times more cost effective. Inflation adjusted, one dollar per minute was the average price of Long Distance Telephony in the US just 25 years ago. Incomes adjusted, the Globalstar price will be cheaper than most local telephony around the world just five years ago.

Globalstar is a key player in four dimensions of the paradigm–the collision with the lightspeed limit, the primacy of dumb networks with all the intelligence on the edge, the superiority of **Qualcomm**'s (QCOM) low powered Code Division Multiple Access (CDMA), and the worldwide spread of wireless communications. July 25, just as we were throwing up our hands in despair at the approach of another monthly deadline, Globalstar launched four more satellites into low earth orbit of 1400 kilometers on a Delta II rocket from Cape Kennedy, thus cleverly evading the lightspeed limit afflicting all ordinary geosynchronous satellites. These GEOs (geosynchronous earth orbit satellites) are located some 25 times farther away from the earth than Globalstar's LEOs (low earth orbit satellites). Using CDMA and other architectural efficiencies, Globalstar also escaped the functional rigidities and burdensome costs that blighted Iridium with its $7 per minute long distance charges. Globalstar will begin by charging thirty five cents a minute for most wholesale links. Its partners will probably set the price at about a dollar a minute, but later efficiencies can bring it sharply down over time.

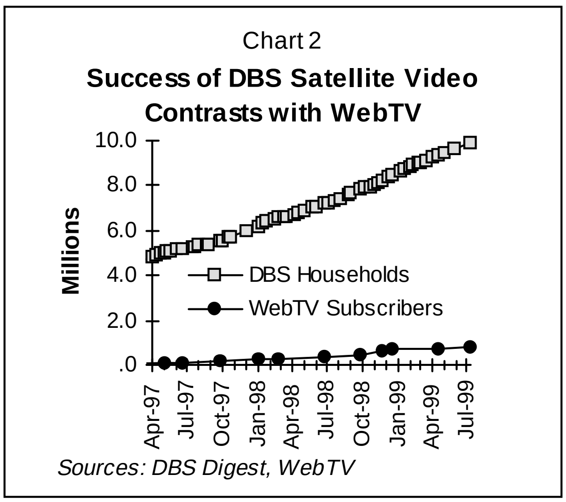
With just 400 thousand customers, Globalstar can break even. The system can currently accommodate four million users. Adding 12 more satellites to the 48 bird constellation raises the total to six million. That means under $700 in total capital outlays per customer, less than the cost of laying a twisted pair line to a home (without any other phone company facilities). A Globalstar customer will soon cost less money to service than a wireline phone customer who pays less than a tenth as much per minute.

As the only way to reach the entire surface of the globe at once, satellites play a key role in the paradigm. But their advocates often misjudge their real promise. The currently dominant geosynchronous birds in the Clarke orbit 23 thousand miles away will lose nearly all their network long haul trade to fiber optics. At an estimated 8.6 petabits a second, a single fiber cable with 864 strands could hold more potential bandwidth than all the satellites, aloft or planned, put together. For point-to-point services, satellites are relevant only where fiber does not reach. Fortunately, for the satellite industry, fiber reaches only a tiny portion of the world's destinations. Almost totally dominant for backbone services, fiber is sparse in the last mile. Thus rather than the links of the net itself, the best market for LEOs is the rich arena of links between customers and the net. Rapidly losing their remaining long distance applications to fiber, satellites–though hundreds of miles above the surface of the earth–are emerging as major players in the "last mile."

As the most promising of all the satellite projects, Globalstar is a supreme telecosmic play. Its hero is a Chinese engineer named Ming Louie. Although he was the best student in his high school, Louie was barred from advanced education during the 1960s Cultural Revolution because his father had gone to Columbia in the US in the 1930s. After four years hauling logs in a saw mill, Louie had had enough. In 1969, at age 22, he procured an inflatable pillow, crept by night with a friend several hundred miles through the mountains to the Chinese coast, slathered his body with vaseline for protection from the cold, and swam four hours across the straits to Hong Kong. There he got a job in a bakery (chosen because it had "plenty of food"). Happening into a bar during the Apollo lunar landing, he fixed on the image of the US flag planted on the moon. He decided to come to the US and become a rocket scientist.

A determined and tenacious man, by 1989 he emerged as a rocket scientist working for **Ford** (F) Aerospace in Palo Alto as a systems engineer on a project to connect all Ford automobiles to geosynchronous satellites for communications and locator services. He quickly encountered the lightspeed limit that currently imposes the most critical constraint on all network design. Whether on the silicon substrate of a microchip, on the mostly silicon substrates of continents and seabeds, or between the surface of the earth and the usual satellite orbits, the velocity of light is a showstopper. Governing the latency of off-chip memories, turnaround times, and point to point links, lightspeed increasingly shapes the configuration of all systems. At Ford, Louie found it was simply impossible to overcome the crippling delays (a half second for two way links) characteristic of GEOs 23 thousand miles away from the earth. With colleague Robert Wiedeman, he proposed a low earth orbit system. Ford dismissed it out of hand. But when the company was sold to Loral, Louie and Wiedeman revived the idea. It became Globalstar.

In *ForbesASAP*, I wrote in 1994, "New low earth orbit satellites mark as decisive a break in the history of space-based communications as the PC represented in the history of computing." Contemplating the narrowband LEO pioneer Iridium and its direct competitor Globalstar, my article condemned Iridium's technology and exalted Globalstar's. For those of you who missed it, I include the key paragraphs here.



[B]eyond the bold and ingenious concept (Russ Daggatt of Teledesic calls Iridium "the real pioneer of LEOs"), the system suffers from technical flaws. Were it not for Globalstar, perhaps these flaws would not have become evident until after the 66 birds were aloft. A far simpler and cheaper solution, Globalstar uses 48 satellites with no links between them. Each functions as a "bent pipe" transponder, receiving signals from a phone on the ground and passing them back to any gateway within the satellite's 1,500-mile-wide footprint, linked to locally available telephone networks…

Globalstar has capital costs (at $1.8 billion) one-half Iridium's, circuit costs one-third Iridium's, and terminal costs (at $750 each) one-fourth Iridium's. With no intelligence in space, Globalstar relies entirely on the advance of intelligent phones and portable computer devices on the ground; it is the Ethernet of satellite architectures. Costing one-half as much as Iridium, it will handle nearly 20 times more calls.

The advantages of Globalstar stem only partly from its avoidance of complex intersatellite links. Originating several years before spread-spectrum technology was thoroughly tested for cellular phones, Iridium employs time division multiple access (TDMA), *an obsolescent system that requires exclusive command of spectrum but offers far less capacity than code division multiple access, [which uses all the assigned spectrum for every call].*

Iridium could fly only if it offered radically superior performance or capacity. But TDMA dooms it to generally inferior performance and capacity.

When an Iridium engineer told me in 1995 that the architecture was "set in concrete," I summed it up: "So that settles it. Iridium will sink like a stone."

Globalstar by contrast is about to rise like a rocket. Although launch disasters and additional data features ultimately doubled the cost of the system, all the other projections of the 1994 article have come true. With lower orbits, requiring lower power signals and smaller antennas, Globalstar will lead the way to a new generation of two-way satellite services.

Caching plans are in a race with the growth of the Internet itself and its use of ever more dynamic web pages.

GEOs on the Edge

With their broad footprints, GEOs are intrinsically broadcast systems that can cover the entire world with downloads. But providing millions of individuals with distinct Internet transmissions from the far corners of the web quickly exhausts transponder capacities and solar power budgets.

Among currently available consumer satellite Internet services, the standout is **Hughes**' (GMH) DirecPC, which offers 400 kilobit downstream services and upstream links through telephone lines. But apparently DirecPC is still not ready for a prime-time marketing push. Last month's DirecTV-**AOL** (AOL) announcement focused not on the premium AOL Plus high speed Internet access service available through DirecPC but on AOL TV available through DirecTV. AOL TV is a flakey interactive TV offering labeled as Internet service. In addition to a DirecTV program guide, AOL will offer such familiar interactive trivia as the life-time batting average of the player at the plate, advertiser's product information, and other cosmetics for the corpse of broadcast television.

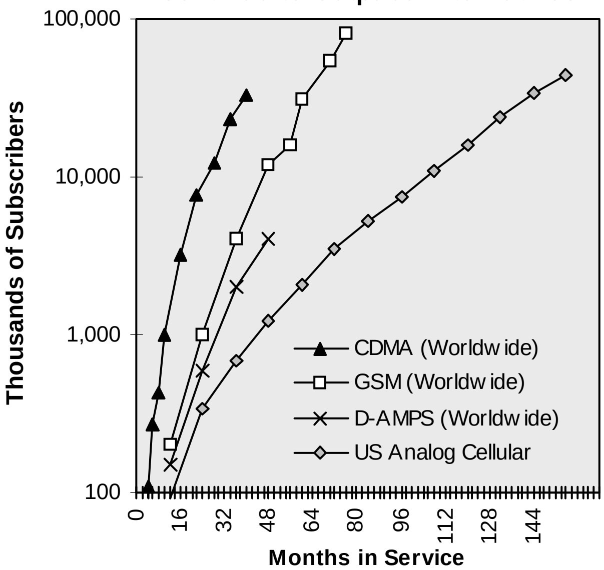
Similarly lame was the announcement of the **EchoStar** (DISH)-**Microsoft** (MSFT) WebTV alliance. Purchased for $400 million and upgraded with estimated billions, WebTV has been a spectacular failure. It garnered just 800,000 subscribers while PC Internet access won scores of millions of users. The WebTV interface for EchoStar will allow an interactive search of 350 to 500 channels of video content and enable shows to be digitally recorded to a hard-drive for pause, rewind, and resume functions. But its Internet capabilities are meager and interactive TV will always pale in comparison to the near infinite choice available through the Internet.

A more promising broadcast application is caching the most popular web content for transmission over

CDMA CONSOLIDATES LEADING POSITION

Chart 3

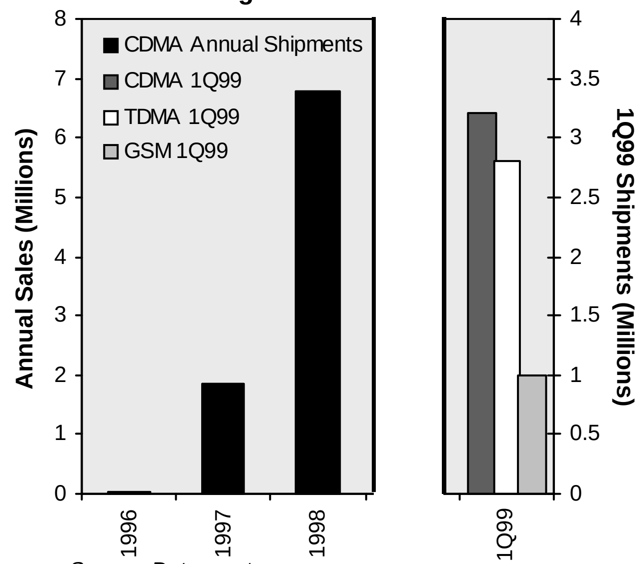
CDMA Wireless Adoption Rates Continue to Outpace Alternatives



Sources: CDG, GSM Association, Ericsson, CTIA

Chart 4

CDMA Takes the Lead in 1Q99 US Digital Handset Sales



Source: Dataquest

CDMA Subscriber Numbers Top Rivals' Earlier Achievements

*CDMA (Code Division Multiple Access) wireless technology passed 33 million subscribers worldwide in June, 1999. Introduced in 1996, at a time when critics led by GSM proponent Ericsson still argued the technology was a scam, CDMA is now well established with more subscribers than GSM had at the end of 1996 and as many as US analog cellular did at the start of 1996. The adoption rate of CDMA has outpaced rival technologies (***Chart 3***).*

CDMA Takes Lead in US Digital Handset Market

*Digital handsets surpassed analog in US wireless phone sales during 1998. And during 1Q99 CDMA handsets took the lead among digital handset technologies (***Chart 4***). The achievement of CDMA is based not only on the success of CDMA PCS–led by Sprint PCS which has passed 4 million subscribers–but also on CDMA digital cellular which is extending capacity and improving quality on cellular networks.*

*Profiting from its stewardship of CDMA, Qualcomm has passed rivals Motorola and Ericsson in US digital handset market share (***Chart 5***). Ericsson, the most vocal of CDMA's critics prior to its truce with Qualcomm, fell to third place from its position of dominance in 1996 (***Chart 6***). In July, Ericsson announced it will launch its own CDMA phone–using Qualcomm manufactured parts–in the second quarter of next year.*

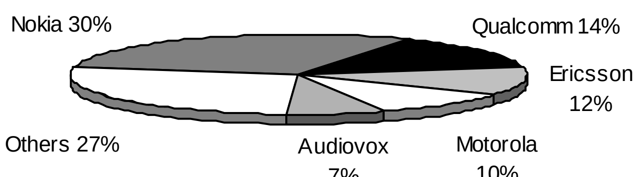
Rise in Usage Highlights Growing Importance of Wireless

*Wireless usage is surging with the fall in calling rates due to cheaper digital cellular and PCS services. Average monthly usage per subscriber–measured in minutes of use–is up 75% over last year (***Chart 7***). Users citing business as the primary use of their phone had the highest usage at 312 minutes, up from 165, but their share of users dropped to 22% from 27%. Those citing convenience as primary climbed from 27% to 34%, with their usage nearly tripling from 63 minutes to 181.*

-Ken Ehrhart

Chart 5

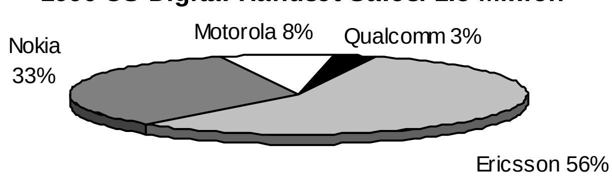
Qualcomm Jumps to Second Place As 1Q99 US Digital Handset Sales Hit 7 Million



Source: Dataquest

Chart 6

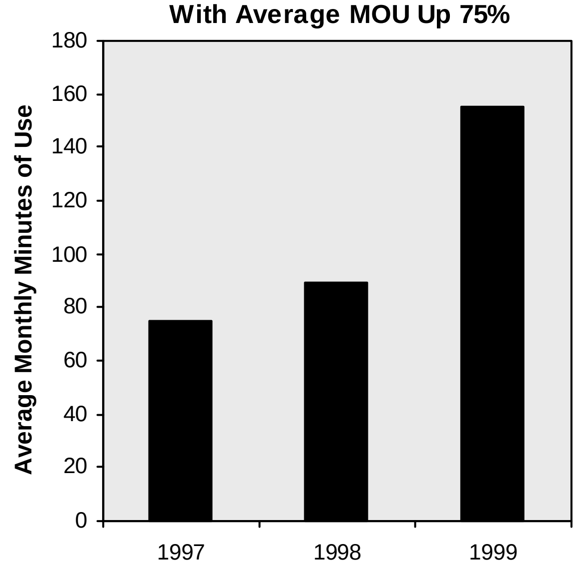
1996 US Digital Handset Sales: 1.5 Million



Source: Dataquest

Chart 7

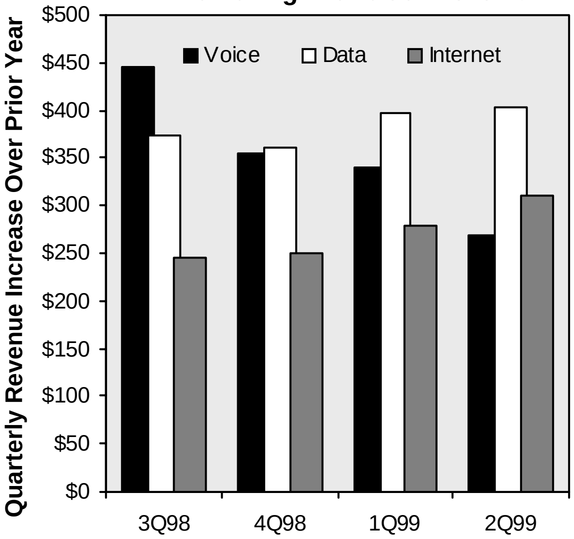
US Wireless Phone Usage Surges With Average MOU Up 75%



Source: IDC

Chart 8

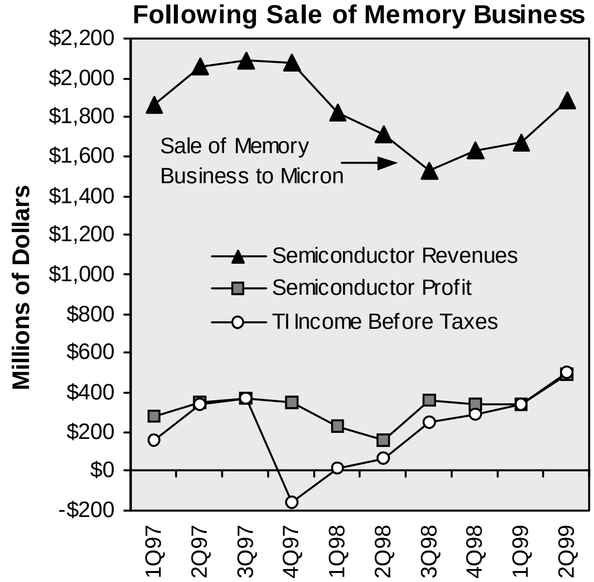
Data and Internet Revenues Pass Voice In Powering WorldCom Growth



Source: Company Reports

Chart 9

Semiconductors Power TI Growth Following Sale of Memory Business



Source: Company Reports

Data and Internet Revenues Power MCI WorldCom Growth

*WorldCom's Internet revenue growth rate (59%) is over ten times the percentage increase in its voice revenues (5.6%), and twice that of other data services (29%). The Internet's lead can now be measured in dollars not just percentages. In 2Q99, the dollar rise in Internet revenue ($311 million) surpassed the dollar rise in voice revenues ($268 million). And, Internet revenue is gaining on other data revenue, which had already passed voice in 4Q98. (***Chart 8***)*

TI Semiconductor Strategy Pays Off on the Bottom Line

*TI's leading position in digital signal processors and analog ICs, which are crucial in Telecosm wireless and broadband applications, has been strengthened through divestitures–including the shedding of its money losing memory business to Micron in 3Q98–and acquisitions. TI's purchase of Israeli cable modem chip maker, Libit, extends the company's analog and DSL modem portfolio to cable. And with TI's Libit, Broadcom, Conexant and Terayon on the Telecosm Technologies Table we now have the cable modem chip market cornered. TI saw the benefits of its strategy in 2Q99 when semiconductor division profits drove up company income (***Chart 9***).*

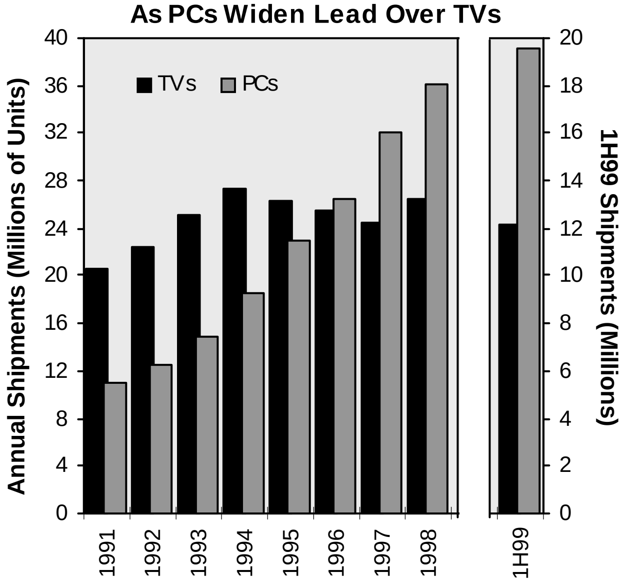
PC Market Continues to Amaze as Internet and "Free" PCs Drive Growth

Worldwide PC shipments rose 27% during 2Q99. US PC shipments surged 35%, with PC sales continuing their rise over stagnant TV sales (Chart 10). The jump in shipments was due to continued demand for Internet access and what IDC described as "fervor" in the consumer market over the arrival of "nearly free" PCs which have most of the purchase price rebated or exchanged for monthly Internet access fees. Cheap PC maker Emachines, which passed IBM to capture 3rd place in retail PC market share in June, joined the trend by offering rebates to those who sign up for AOL. Mirroring the US trends, Japan recorded the highest year-to-year growth of any region worldwide due to rising consumer demand. For the 1998 Japanese fiscal year ending in March 1999, PC sales in Japan returned to positive growth, following 1997 which marked the first decline in 5 years, while TV sales continued their decline (Chart 11).

-Ken Ehrhart

Chart 10

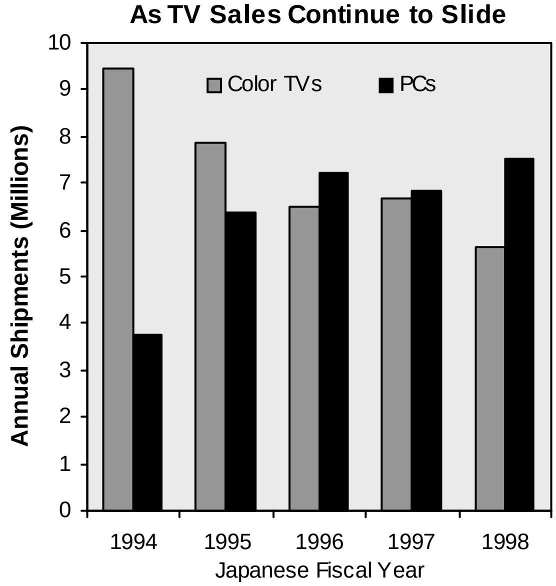
US 2Q99 PC Shipments Jump 35% As PCs Widen Lead Over TVs



Sources: Dataquest, IDC, CEMA

Chart 11

Japanese PC Sales Return to Growth As TV Sales Continue to Slide



Source: EIAJ, JEIDA

A simple law of the Telecosm is: Don't bet against Internet standards in favor of tricky private solutions.

satellite links. But caching plans are in a race with the growth of the Internet itself and its use of ever more dynamic web pages based on the new XML (extensible markup language) and XSL (extensible style-sheet language) standards that separate database storage from presentation graphics. This means that the webpage alone does not provide the content. Moreover, the amount and diversity of available content far exceeds what can be economically cached. Reported to catalogue only 16 percent of web pages, the best Internet search engines are foundering under the load, taking as long as 6 months to add new content. Also swamped by a runaway web, caching systems face the same difficulty and dilemma as the search engines.

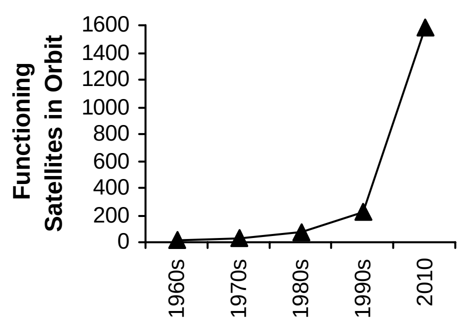
In 1998 GEO satellite providers made $180 million from Internet service providers, out of some $26 billion in total satellite service revenues. Capturing a growing share is Loral's Orion, supporting more than 120 ISP customers around the world. It currently delivers an aggregate capacity in excess of 300 Mbps, and expects Internet service revenues to represent 40 percent of this year's business. Using its implementation of DVB (digital video broadcast) technology Loral Orion can merge audio, video, and data into hundreds of encrypted streams of IP packets broadcast simultaneously through a 54MHz transponder at rates up to 58 Mbps, nearly double the typical 30 Mbps transponder data rate.

The showstopper for GEO satellites is the interplay between the speed of light limit and the TCP-IP (Transmission Control Protocol-Internet Protocol) standards that virtually define the Internet. Setting a transmission "window," TCP determines the number of bits that can be sent before an acknowledgement of their receipt is required as an okay to send additional bits.

The size of this TCP window puts an upper limit on the performance of a satellite. The original TCP receive window limit of 65,535 bytes per 585 millisecond roundtrip will restrict a connection to 112,000 bytes per second (896 kilobits per second), just half of a full T1 (1,536 kilobits/sec) connection. This basic problem is magnified by TCP's congestion avoidance mechanisms. When an acknowledgement fails to arrive within a certain time period, whether because of delays or errors, TCP reverts to a slower rate for retransmission. Based on research using NASA's ACTS (Advanced Communications Technology Satellite) Mark Allman, et al, in their 1997 paper, "TCP Performance over Satellite Links," for the International Conference on Telecommunications Systems, report that the slow start mechanisms of TCP can require 11 round trip times of approximately 6.5 seconds, until a transmission reaches full speed.

Chart 12

Satellites for Broadband Internet Data Help Drive a Surge in Launches



Sources: Historical Data, FCC Forecast

While many of the problems can be mitigated by modifying TCP, the needed changes must often be made throughout the network. Only if the satellite link is restricted to a "last mile" application can it be treated as a private network with a customized satellite brand of TCP. But between the satellite link and the Internet, this approach inserts a maze of gateways, proxy servers and protocol translators that would add substantial costs and delays to the end user Internet interaction. A simple law of the Telecosm is: Don't bet against Internet standards in favor of tricky private solutions.

LEOs Lack Latency

The only reason for tolerating the drawbacks of GEO latency is the lack of any alternative serving so many locations. As GEO users themselves increasingly recognize, LEOs are drastically changing that. **Telstra** (TLS), GEO partner with the Canadian giant **Teleglobe** (TGO), on June 24, 1999, signed an agreement with **Alcatel** (ALA)-Loral's broadband LEO project **SkyBridge**, giving Telstra the first option to become an equity partner and SkyBridge's service provider for Australasia and Southeast Asia. Even Hughes, which trumpeted the virtues of its SpaceWay GEOs in the face of Teledesic's LEO plans, has applied to the FCC for launch and operating authority for HughesNet, its own 70 satellite LEO system at 1,490 km.

LEOs also fit the low power paradigm. Signal strength drops by the square of the distance traveled, making low satellites far more power efficient than their GEO counterparts. Loral's new GEO satellite 20.20 can carry more than 150 transponders and other GEO satellites are able to narrowly focus a hundred spot beams on separate regional areas rather than broadcasting to entire continents, thus opening additional capacity. But these enormous GEOs will demand vast generating capacity. Hundreds of LEOs each collecting enough solar energy for its individual low-power mission will be far more efficient than dedicated space based power plants for GEOs.

Decentralization of service coverage also favors LEOs. GEO proponents have argued they can loft a couple satellites over densely populated areas and add service as demand grows elsewhere by adding new birds. Similarly **General Atomics** and others have proposed to launch dirigibles and circling automated airplanes to cover urban areas. But satellite service becomes paradoxically more valuable as populations thin out. It is economically perverse to build a market around the US and Europe where communications capabilities and fiber networks are the best in the world.

For the LEO perspective, consider the plans of Teledesic, which will offer a 500 Mbps capacity in any circular area 200 km in diameter. Such capacity in an urban area is almost laughable when cable, DSL, LMDS wireless, and direct fiber connections abound. But travel a short distance outside the city, head two hours north of New York City or west from Boston and you arrive in our own Berkshire Hills, a land that fiber forgot. We could use 500 Mbps. Head around the globe and you will find huge unsatisfied demand for cost effective narrowband and broadband communications. But that demand is not centered on those who can afford $3,000 handsets offering voice at several dollars per minute, as Iridium learned.

SkyBridge Races Teledesic

Echoing Teledesic's promotion of LEOs for data, long before Hughes jumped on the bandwagon, was Alcatel's SATIVOD proposal which became the Alcatel-Loral partnership SkyBridge in 1997. Unlike Globalstar with its focus on mobile voice and messaging, SkyBridge offers fixed broadband multimedia services through 80 satellites in two 40 satellite constellations at 1,469 km. While featuring fewer satellites than Teledesic (288 satellites), the selection of a "combined CDMA/TDMA/FDMA waveform" for SkyBridge's transmissions should give the system an advantage in power and capacity compared to Teledesic's current plans for using TDMA. SkyBridge hopes to provide more than 20 million users with download speeds of up to 20 Mbps and upstream links of 2Mbps, with higher rates available through channel aggregation, another task easier using CDMA than with TDMA.

The current three-month technical review being undertaken by Teledesic and **Motorola** (MOT) should revisit the issue of TDMA versus CDMA. Possibly serving as a wakeup was Motorola's fall from its pinnacle as the dominant cellphone maker to a fourth place share of the US digital handset market, while Qualcomm rose to second place, above **Ericsson** (ERICY) and behind **Nokia** (NOK), on the basis of the surge of CDMA handset sales beyond GSM and TDMA numbers (see page 4).

In plans for SkyBridge, Loral is also using the "bent pipe" strategy of Globalstar. Following the dumb network model of bits in, bits out, there will be no on-board processing of data. Data will take just one short hop from $700 end-user terminals to one of 200 worldwide terrestrial gateways owned and operated by partnering regional service providers. Reducing the complexity of the in-sky network through a dumb-network strategy should improve the efficiency of the system, eliminate cross-network satellite-link delays, and offer the possibility of simpler, lower-cost satellites. With SkyBridge system costs estimated at just $4.2 billion for the space segment and $1.9 billion for the ground segment, compared to over $9 billion for Teledesic, and SkyBridge service planned for 2002, versus Teledesic's 2003, the cheaper, simpler strategy seems to be paying off. The concentration of intelligence in the ground segment also allows for greater flexibility in evolving the system to meet local service demands or future needs.

Dooming most GEO satellite approaches–from **SkyCache** to DBS's new "interactive" TV–is their assumption of a centralized, US-centric, asymmetric network. These plans recall the old hope that a few generic TV networks providing least common denominator sit-coms could hold out against the variety of dozens then hundreds of cable channels. Now the GEO proponents hope that a few hundred or even thousands of interactive channels or gigabytes of cached pages can substitute for the diversity of millions of network users and the dynamic flexibility of millions of connected servers. But the Internet gains value at an exponential rate from the contributions of new users connecting to it, not because they are additional eyeballs for mega-site advertisers, but because each user can contribute to the content of the network.

In a world of multiplying choices, Loral seems a likely winner. It is participating in both Globalstar (42.6 percent ownership) and SkyBridge (17 percent). It can serve a wide range of markets, from CDMA-based LEOs to existing and contemplated GEOs (broadband GEO system **KaStar** has contracted for two Loral birds). Its "pure play" focus on space systems makes it a Telecosm Technology pick.

Currently the two CDMA LEO projects Globalstar and SkyBridge are separate, one dedicated to narrowband mobile voice and the other to broadband fixed data. But both projects join Alcatel, Loral, and Qualcomm. With the data superiority of CDMA and all the intelligence on the ground, Globalstar's initially paltry 9.6 kbps messaging links will grow by the leaps and bounds of Moore's Law to accommodate serious two-way data services in future generations. With no architectural changes, nine kilobits per second in 1999 means 64 kilobits per second in 2003, 128 kilobits in 2005 when SkyBridge will reach its prime, and a megabit per second in 2010. With larger solar panels and solar cell efficiencies, with better batteries, with enhanced modulation schemes, and with a new set of satellites slated for orbit in 2007, Globalstar should be scalable enough to force integration with SkyBridge. Indeed, the two CDMA systems can even jeopardize Teledesic if the Gates-McCaw project persists in its resolve to repeat the mistakes of Iridium.

–George Gilder, with Ken Ehrhart, August 4, 1999

Tut Systems was first profiled in the August 1996 issue of the GTR as a leader in developing copper-wire networking technologies and has been a pioneer in highspeed in-home networking over ordinary copper phone lines. Such technology can provide the missing link between broadband cable and xDSL modems and the telephones, computers and network appliances located throughout a home. We believe that such connectivity functions will increasingly be met by wireless networks. Meanwhile Broadcom may prove a better representative of the potential of in-house wiring to extend broadband networks into the home, due to Broadcom's ability to integrate its Epigram technology directly into its cable modem chipsets. In keeping with our desire to limit the Telecosm Technology Table to companies representative of ascendant technologies rather than offering a compendium of all companies involved in the technologies Tut Systems has been removed from the Table.

With SkyBridge's service planned for 2002, versus Teledesic's 2003, the cheaper, simpler strategy seems to be paying off.

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	Reference Date	Reference Price	July-99: Month End	52 Wk Range	Market Cap.
CABLE TECHNOLOGIES/SERVICES						
Cable Modem Service	@Home (ATHM)	7/31/97	9 3/4	45 11/16	11 3/4-99	11.48B
Cable Modem Chipsets	Broadcom Corporation (BRCM)	4/17/98	12 *	120 1/2	23 1/2-149 1/2	11.14B
CDMA Cable Modems	Terayon (TERN)	12/3/98	31 5/8	39 1/8	7-60 1/2	808.6M
MICROCHIP TECHNOLOGIES						
Analog, Digital, and Mixed Signal Processors	Analog Devices (ADI)	7/31/97	22 3/8	43 1/8	12-51	7.45B
Silicon Germanium (SiGe)based photonic devices	Applied Micro Circuits (AMCC)	7/31/98	22 11/16	94	12 1/4-95	2.50B
Programmable Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	17 11/16	29 13/16	6-32 13/16	2.99B
Digital Video Codecs	C-Cube (CUBE)	4/25/97	23	32 9/16	13 1/4-37 7/16	1.28B
Linear CDMA Power Amplifiers, Cable Modems	Conexant (CNXT)	3/31/99	27 11/16	62 7/8	13-70 3/16	6.07B
Single Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	31 1/2	50 3/8	10 1/2-53 5/8	7.43B
Single-Chip Systems, Silicon Germanium (SiGe) Chips	National Semiconductor (NSM)	7/31/97	31 1/2	24 9/16	7 7/16-29 3/16	4.15B
Analog, Digital, and Mixed Signal Processors, Micromirrors	Texas Instruments (TXN)	11/7/96	23 3/4	144	45 3/8-155 3/8	56.45B
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	16 7/16	62 3/8	14 7/8-65 1/8	9.79B
OPTICAL NETWORKING						
Wave Division Multiplexing (WDM) Systems, Components	Ciena (CIEN)	10/9/98	8 9/16	33 3/4	8 1/8-86 7/16	4.10B
Optical Fiber, Photonic Components	Corning (GLW)	5/1/98	40 15/16	70	22 7/8-75	17.08B
Submarine Fiber Optic Networks	Global Crossing (GBLX)	10/30/98	14 13/16	41 1/2	8-64 1/4	18.07B
Wave Division Multiplexing (WDM) Components	JDS Uniphase (JDSU)	5/1/98	19 1/4	90 3/8	15 5/8-90 3/8	7.99B
Broadband Fiber Network	Level 3 (LVLT)	4/3/98	31 1/4	53	22 3/8-100 1/8	17.98B
Carriers Carrier, AllWave Pioneer, Utility Rights of Way Strategy	NorthEast Optic Network (NOPT)	6/30/99	15 1/16	36 3/16	4 3/4-40 1/2	581.8M
WIRELESS TECHNOLOGIES/SERVICES						
Low Earth Orbit Satellite (LEOS) Wireless Transmission	Globalstar (GSTRF)	8/29/96	11 7/8	25 11/16	8 5/16-33	2.11B
Satellite Technology	Loral (LOR)	7/30/99	18 7/8	18 7/8	10 3/4-27 15/16	4.60B
Nationwide Fiber and Broadband Wireless Networks	Nextlink (NXLK)	2/11/99	40 7/8	112 1/8	10 9/16-112 1/8	4.01B
Point to Multipoint, Spread Spectrum Broadband Radios	P-COM (PCMS)	11/3/97	22 3/8	4 35/64	2 5/16-10 3/8	222.6M
Code Division Multiple Access (CDMA) Chips, Phones	Qualcomm (QCOM)	9/24/96	19 3/8	156	18 7/8-167 1/4	23.50B
Nationwide CDMA Wireless Network	Sprint PCS (PCS)	12/3/98	15 3/8	60 5/8	12 3/4-66 7/8	28.60B
Broadband Wireless Services,	Teligent (TGNT)	11/21/97	21 1/2 *	72 1/8	18 1/4-75 5/8	3.80B
INTERNET TECHNOLOGIES/SERVICES						
Internet Enabled Business Management Software, Java	Intentia (Stockholm Exchange)	4/3/98	29	22 7/16	17 1/2-35 1/4	540.0M
Telecommunication Networks, Internet Access	MCI WorldCom (WCOM)	8/29/97	29 15/16	82 1/2	39-96 3/4	153.5B
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	13 3/4	67 7/8	19 3/16-76 7/16	52.53B
BROADBAND TELECOM TECHNOLOGIES/SERVICES						
Wireless, Fiber Optic Telecom Chips, Equipment, Systems	Lucent Technologies (LU)	11/7/96	11 25/32	65 1/16	26 11/16-79 3/4	198.0B
Wireless, Fiber Optic, Cable Equipment, Systems	Nortel Networks (NT)	11/3/97	46	88 5/8	26 13/16-94 1/8	59.21B

Added to the Table: Loral Space and Communications; Removed: Tut Systems

* Initial Public Offering

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. Reference Price is a company's closing stock price on the Reference Date, the date on which the Telecosm Technology Table was generated for the GTR in which the company was added to the Table. Since March 1999, all "current" stock prices and new Reference Prices/Dates are based on the closing price for the last trading day of the month prior to GTR publication. Though the Reference Price/Date is of necessity prior to final editorial, printing and distribution of the GTR, no notice of company changes is given prior to publication.

Telecosm Technologies Table

We have redesigned our table of Telecosm Technologies. The companies are divided into sectors of the industry (including microchip technologies–the substrate of telecommunications) in order to better understand the range of important technologies represented.

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