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The Finance of the Fibersphere

Well financed power company Dynegy has contrived a global network over the last year that in some respects already rivals Global Crossing's

This was the month that Telecosm debtors faced their bankers and bondholders, and Taliban warriors defected into the arms of virgins in paradise. It was the month that your alert uniformed government economists descried at last the looming monster of global deflation that has been prowling the world for nearly half a decade. For this feat of detection, the economists used powerful new state-of-the-art Keynesian and monetarist technologies now being prepared for modular retrofit in airport luggage scanners. Although the new recognition that falling prices can wreak major destruction does not in itself address the problem, the redoubtable supply-sider David Malpass believes that liquidity is on its way and the monetary drought averted, along with depression.

In the face of it all, we perambulated a Telecosm conference around the country. By all reports it burst through as our most cosmic and telic ever. Beset at first with Delphic doubts and airport queues, the inverted virtual towers of Nasdaq and the pits of Battery Park, the itinerant confab straggled forth initially on September 11 at the Inn at Squaw Creek near Tahoe with Carver Mead, Nick Tredennick and Dr. Judy Canfield nearly alone reporting for duty.

Declaring a quorum, we mustered our tiny towering platoon at Bullwacker's Lounge, where Carver and Nick deployed at least three quarters of our usual Telecosm firepower. There, crouched below the glower of a television screen unreeling every ten minutes the fiery murderous loop of images from the murky air of Lower Manhattan, Carver noted: "At the outset, demonic sects have it all over democratic nations. What terrorists have going for them is chiefly our ignorance, our lack of knowledge of who they are and where and what they are doing. That is an information problem, addressable by information technology. And that's what we have, that's what we are, and that is why we will win." Promising a speech on the subject, he instructed us to reconvene in early November in San Francisco to develop an agenda for the new era.

Over many years we have found it pays to do what Carver says. So sure enough, on November 4, while Governor Gray Davis warned of bombs on the bridges, we climbed Nob Hill with our decimated army and invaded and occupied the Fairmont at the top. During a crystalline autumn week, with all bridges glowing peacefully in the sun, the conference ignited a stream of flares from the summit of the Telecosm. Two weeks later an echo of meteor showers answered from the heavens and **Global Crossing** (GX) shares vaulted above a dollar fifty.

The only destruction came from deflation—the 40 percent appreciation of money over five years against all commodities—which inflict-

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ed devastation on all endebted companies. Already beset by rivals plunging over technology cliffs of cost, debtors had to pay back loans with funds way more valuable than those they borrowed, while cash flow shriveled with contracting global business and with prices declining in all industry precincts unprotected by a solicitous Congress and the Pentagon. Sucked out swiftly was all capital destined for the fertile and competitive frontiers of the Telecosm.

With two years of rate hikes and wamings against irrational exuberance, Greenspan temporarily turned off the lights of the Telecosm

Once paragons of long term investment, even venture capitalists deployed cash mattresses, and went to sleep on them, dreaming of their overflowing money market depository accounts and keeping Milton Friedman awake with worries of the inflationary portent of expanding liquidity. Since debt is always crucial to ambitious infrastructure projects, deflation targeted the prime endeavour of the decade: the levered delivery of the Internet across vast reaches of the electromagnetic spectrum, from infrared streams down a hundred million miles of optical fiber, through the microwaves of a new generation of cable, cellular, and last mile wireless, and on to the storewidth spans where optics and electronics merge and mesh in information mines, global caches, warehouses, server farms, hubs, nodes, and data centers.

With two years of interest rate hikes, inflation alarms, and warnings against irrational exuberance, Alan Greenspan had temporarily turned off the lights of the Telecosm. Down with **Loral** (LOR) CDMA satellites ($3 billion in debt) and truncate **Metromedia Fiber** (MFNX) ($4 billion). Fibrillate the nets of **Broadwing** (BRW) ($4.5 billion). Depress **WorldCom** (WCOM) as a dire monopoly threat ($34 billion in liabilities). RIP **Exodus** (EXDS)($8 billion debt) and **Globalstar** (GSTRF)($3 billion). Let'er rip Global Crossing ($6 billion). But surfing high on cash, with paltry debt after a six year boom, are most of the semiconductor companies on the list, led by **Texas Instruments** (TI) with $3 billion in cash, **Analog Devices**(ADI) with $2.5 billion, **Altera** (ALTR) with $1 billion, and **Atmel** (ATML) with $750 million. Even partial chip house **Terayon** (TERN) commands some $500 million to go with its full DOCSIS certification for next generation cable modems. **National Semiconductor** (NSM) with $822 million of liquid assets may find its perfect wave in **Foveon**.

Mead discourses on terror

Foveon brings us back to its chairman and founder, Carver Mead. The Caltech prophet's last generation of researches in neuromorphic analog silicon now has enabled four major new ventures beyond Foveon, including **Synaptics**, the global leader in touchpads, **Sonic Innovations (SNCI)**, the technology pioneer in next generation hearing aids, **Impinj**, a Telecosm star from Washington state that is putting adaptive analog onto a Moore's law slope, and a stealthy startup in speech recognition.

In comments as sage and trenchant as ever, Mead opened the conference with a discourse on the technologies needed to find and filter terror. Crucial would be new applications of neural networks that could descry patterns sparsely spread through huge troves of data. Already used for credit card security and currency trading, these devices could offer real time scrutiny of everyone boarding a plane or entering a building. Combined with fingerprint or iris scanners, neuromorphic devices could enable ready authentication of identity for many contingencies. Mead also proffered a portrait of every guest, swiftly captured by his Foveon camera lurking in a room off the lobby. With the pellucid pictures from a CMOS silicon image plane ultimately scalable with Moore's law (think of disposable cameras some day with ten times the resolution of high end Kodachrome) came an implicit stock market cue. Owner of some 49 percent of Foveon is National Semiconductor.

For Telecosm companies, the counterpart of virgins in paradise is exponential Internet traffic growth. Contributing as much as anything to the stock market mania over bandwidth companies was the estimate of John Sidgmore of WorldCom/UUNet in 1997 that traffic was doubling every 100 days, or roughly ten times a year. New data confirms Sidgmore's claim for those vertiginous two years, when Netscape browsers, corporate email, and flat rate pricing ignited the rocket. Implying a thousandfold expansion in three years and a millionfold in six, the Sidgmore trend was obviously unsustainable, and it was not sustained. But even a threefold annual rise, as suggested by recent reports, would boost Internet traffic 244 fold over the next five years and more than 2000 fold over the next seven years. This kind of bonanza means huge demand for new optical and other networking equipment of all kinds.

Corvis amps up Broadwing

The big news from Telecosm came from Larry Roberts, the key founder of the ARPANET, now technical chief of an emergent terabit router company called **Caspian Networks**. Roberts confirmed the potential bonanza, finding that traffic had indeed risen at a rate near 2.8 times yearly until 1999 and 2000 when it ratcheted to a annual pace of nearly fourfold, which it maintained through April of this year. Although traffic growth did flatten briefly in May, perhaps as a result of the suppression of some 9.6 petabytes per month of Napster traffic (about one fourth of the Internet total), a new surge erupted between June and October, with a bulge after September 11.

Examining the available numbers from several sources, Charlie Burger of the *GTR* affirms the Roberts estimates of between 2.7 and 3.2 fold annual traffic growth (see chart story). More importantly, he compares Roberts' "Rule of Traffic Growth" doubling every seven months, with Moore's

law of electronic advance doubling every 18 months, and [Simon] Cao's law of optical bandwidth doubling every five months. Measured by lambda bit miles (bitrate on a wavelength channel multiplied by the distance between opto-electronic regenerators), optical capabilities are rising at least at the Cao's law pace.

In 1995, a state-of-the-art **Ciena** (CIEN) WDM system had four lambdas carrying 622 megabits per second 300 miles, for a total of 746 Gbps-miles. Earlier this year Broadwing deployed a **Corvis** (CORV) system capable of carrying 160 lambdas at 10 Gbps over 3,000 miles for a total of 4.8 million Gbps-miles. This is 6,434 times growth in five years, or a doubling every five months. The beat goes on. CIBC reports that Broadwing is now negotiating with Corvis an increase in channel count from 160 to 320.

Corvis reported at Telecosm that new and drastically cheaper Raman amplifiers would enable expansion of the fiber transmit window far beyond the current 50 terahertz between 1,260 nanometers and 1,625 nanometers possible with **Lucent's** (LU) Allwave. The new Raman window would open to 90 terahertz between 1,100 nanometers and 1,700 nanometers. Confirming this ever expanding horizon of optics was Terry Turpin of **Essex** (ESEX), who confirmed his claim in an earlier *GTR* (August 2001) that 16,000 lambdas could be put stably and efficiently on a single fiber.

Following Carver Mead's suggestion at last year's Dynamic Silicon conference, Doug Lockie of **Endwave** (ENWV) contended at Telecosm that a better estimate of Moore's law would include the rapid acceleration of microprocessor clock rates. Up from 100 megahertz in 1992 to 1.2 gigahertz this year and projected by **Intel** (INTC) to a theoretical high of some 60 gigahertz over the next decade, clock cycles are undeniably climbing fast. But because the principal driver of clock speeds is the very density of circuits that Moore's law describes, simply adding acceleration to density entails considerable double counting. While both Roberts and Lockie urge us never to bet against Moore's law, even a super Moore of near annual doubling cannot keep up with Internet traffic expansion. Traffic will ultimately outpace any core network technology dependent on electronics.

Although optics advances some 33 percent faster than traffic does, Cao's law of a five month optical doubling rate does not apply to access technologies. On visits to **Agilent** (A), **Scale Eight**, **BlueArc**, and **Qualcomm** (QCOM) I contemplated the residual scarcities of the Telecosm. They sum up to lightspeed, power, and silicon area, all converging tightly to constrain the domains of wireless bandwidth.

PCS sprints ahead

Speaking at the CDMA conference in San Diego in late October, I recalled the analysis of Andrew Viterbi—creator of Viterbi codes and co-founder of Qualcomm. Viterbi, following Shannon, argued the best way to achieve a higher signal to noise ratio and thus the highest effective transmission rate for any channel, was to use low-powered, broadband signals rather than "punching through" with high-powered, narrowband signals. "Wide and weak" became the key to the efficiency of CDMA, and to its present position of preeminence in wireless, with **Sprint PCS** (PCS) last month reporting 1.2 million new subscribers at rising average revenue per user (ARPU), and a 55 percent increase in year to year revenues. While rivals lust for more spectrum, Sprint's migration path, the CDMA2000 3G system offers 153 Kbps of data and conserves spectrum by a near doubling of voice capacity. With pin compatible chips, forward and backward compatibility, and a software upgrade, Sprint's new generation network costs are trivial compared to its rivals. Already in Korea the first CDMA2000 rollout has garnered over a million users.

Deflation destruction

The technology paradigm is still ascendant and its promise is greater than ever. During Telecosm and my interviews and speeches following it, however, I came to contemplate with new humility the ominous power of Telecosm debt. In a high growth economy, leverage was king so long as the federal reserve believed in growth and supplied the dollars to accommodate it. After watching the triumphs of MCI, McCaw Cellular, TCI, NewsCorp, **Comcast** (CCZ), Time Warner and other debt ridden suppliers of the infrastructure and content of the 1990s information economy, I regarded debt as a badge of entrepreneurial confidence, a promise of bold deployment, and a tool of tax avoidance. Rushing toward the Telecosm, impelled by Moore's law and Metcalfe's law, a company without debt was like a Formula One racer confined to low gear. A company without leverage was a triple taxed chump, maximizing for Uncle Sam. I saw the debt defying audacity of Bernie Ebbers of WorldCom, Bernie Schwartz of Globalstar/Loral, Steve Garofalo of Metromedia Fiber and Gary Winnick of Global Crossing as a warrant of their assurance and a tool of their sure success. I put most of my available family funds into Global Crossing. I celebrated Greg Maffei of **360networks** (TSIXQ). When Joe Nacchio bought US West, I bumped him from the list. I did not foresee deflation. Since starving an economy of liquidity and dooming most of its entrepreneurial debtors is the most perverse of monetary policies, I could not imagine it in America. Brother, was I ever wrong.

Damodaran's dark side

I have sometimes implied a conflict between the usual techniques of financial analysis and the paradigms of this letter, and not without reason. Most such techniques are either true but trivial, or nonsense. Most fundamental analysis, for instance, is not fundamenatal at all and depends entirely on the same faith in the continuity of trends that supports the chartist trumpery. In essence, prior earnings predict future earnings. True,

Casting portentous light on the future of the industry was the Internet traffic data of the top 19 carriers presented at Telecosm by Caspian's Larry Roberts. **Chart 1** plots Roberts' finalized traffic figures for April 2000 through April 2001. The figures used for April 2001 through October 2001 are based on Roberts' preliminary findings for the last 6 months. Despite a number of short-lived periods of 4X, 3X, and 0X growth during the last 18 months, the slope of the trend line in chart 1 depicts a steady 3.2X overall annual growth rate, resulting in an estimate of 91 petabytes (PB) of Internet traffic in the month of October.

In his presentation at Telecosm, Roberts quoted the same 3.2X annual growth rate figure, with the assertion that it has significant long-term validity. Is the 3.2X annual growth rate figure a valid long-term metric or is it simply an anomaly?

Chart 2 extends our 3.2X trend line back to December '94, the last month in which the National Science Foundation (NSF) actually measured and released Internet traffic figures. In doing so, we arrive at 33 terabytes per month of traffic, remarkably close to NSF's measured figure of 16 terabytes per month, in December '94. We're only three months off, in fact, crossing the 16 TB/month point in September of '94 rather than December.

Internet backbone traffic during the seven-year period from 1995 to present seems to be grown at a remarkably consistent rate, approximately doubling every seven months.

But the NSF annual traffic growth rate of data from 1990 to 1994, yields a consistent 2X annual rate. What happened in 1995 to cause an abrupt growth rate increase? Browsers made the Net user friendly and email, AOL, and Compuserve moved onto the Net—an instant usage explosion. The Internet established a new growth metric. Annual traffic surged to an unprecedented 9.7X yearly growth rate, doubling every 3.5 months, during the two-year period spanning 1995 and 1996.

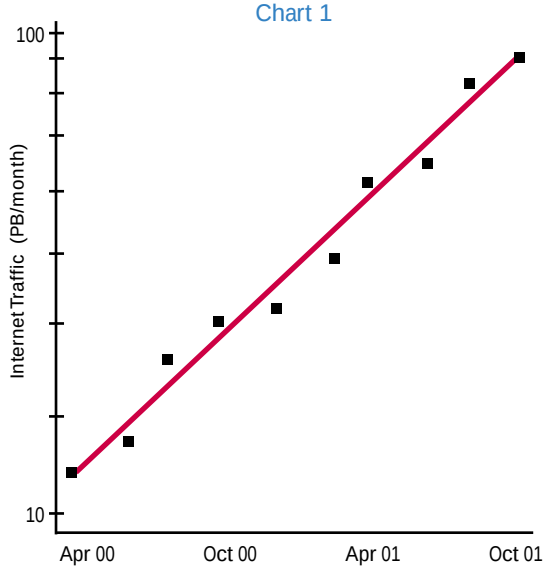
To further validate Roberts' figures we looked to an ongoing Internet traffic study conducted by University of Minnesota's highly revered Internet traffic expert Andrew Odlyzko, former member of AT&T Labs' research team, who estimated December '00 backbone traffic to be somewhere between 20 and 35 PB per month. Roberts' value is 31PB. Insomuch as Odlyzko is a firm believer in a 2X annual long-term Internet traffic growth rate, one should note his remarkable December 1996 traffic figure, plotted in **chart 3**, along with his traffic-range estimates for subsequent Decembers from 1997 to 2000 (plotted as tick marks).

Not only do Odlyzko's traffic estimates overlap Roberts' data for December '00, but they also overlap our original trend line for December '99. Furthermore, one can imagine a trend of alternating periods of rapid and sluggish growth (shown by the curved blue line) intersecting both Odlyzko's and Roberts' data and "settle" to reveal a constant 3.2X annual growth rate. An infinite number of similar curves, however, could also fit the two data sets. **Chart 4** shows a second example of such a curve. Considering the roughness of the "data" such a fine-tuned analysis is unjustifiable. Roberts extrapolated his figures based on carrier 95 percentile values, the accuracy of which depends on frequency of measurement and trusted sources hidden deep inside the highly furtive carriers. Odlyzko's figures were derived from a variety of publicly available information sources, but only a handful of ISPs. A high level of uncertainty is indicated by his broad possible value ranges.

Chart 5 shows a more reasonable linear trend, encompassing a period beginning in December '96, when the Internet began to "settle down" from its growth spurt. The trend line in chart 5 fits both Roberts' and Odlyzko's data sets, revealing—again—a constant long-term growth trend, this one a 2.7X annual growth rate and thus a doubling of Internet traffic every 8.5 months. Whether you accept the a rate of traffic doubling every 7 months, or a more conservative 8.5 months, it is clear that Internet traffic is growing at a fairly constant exponential rate.

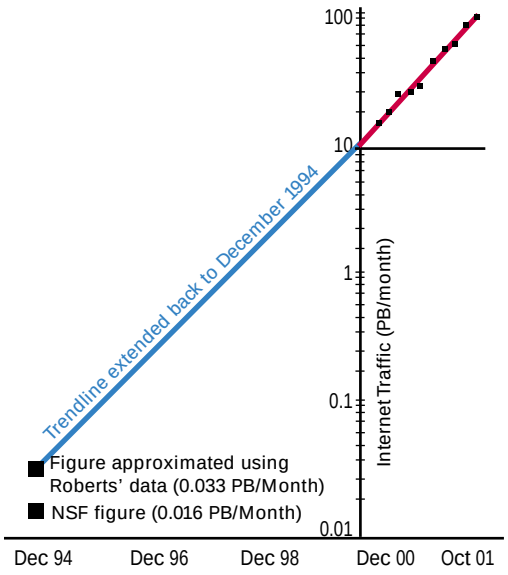
Internet traffic still booms,

Chart 1



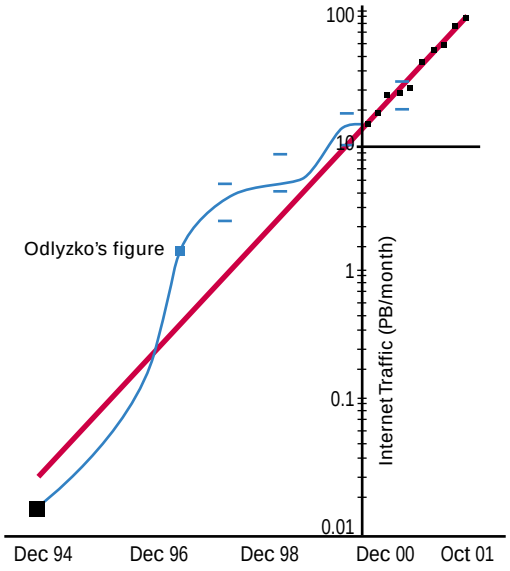
but is the law: 3.2X yearly?

Chart 2



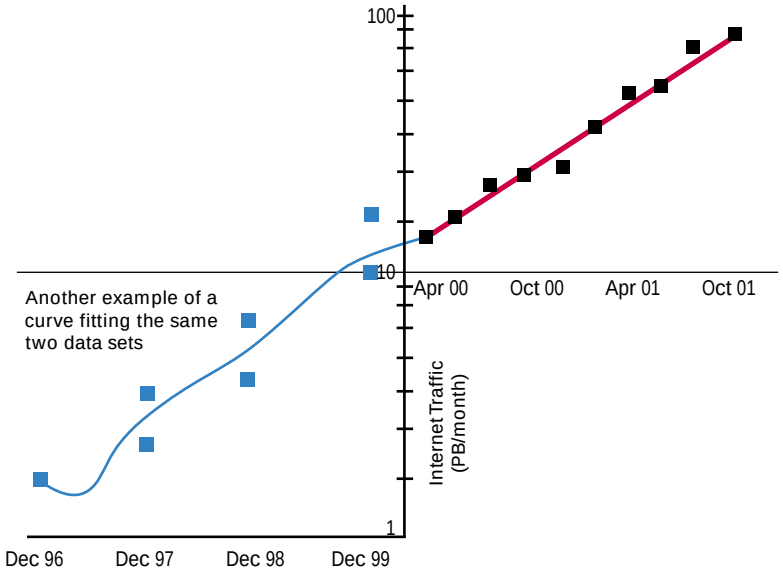
Yes, says AT&T study.

Chart 3



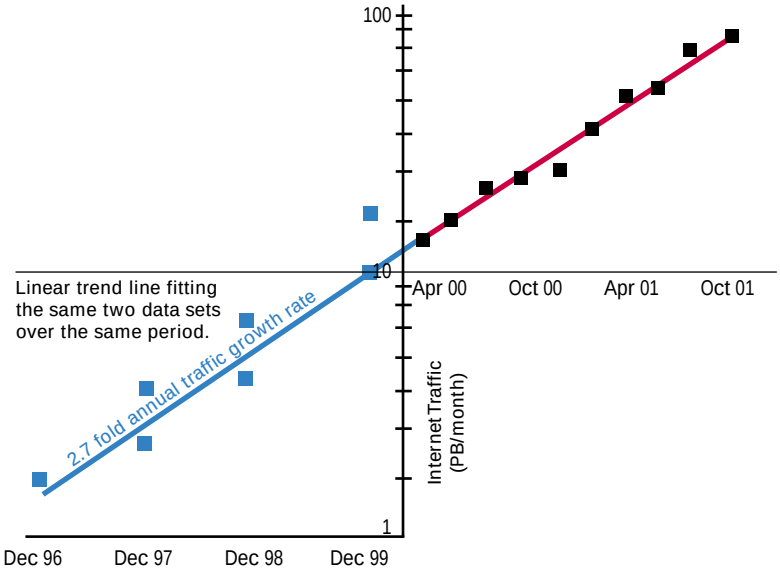
Or could it be 2X yearly?

Chart 4



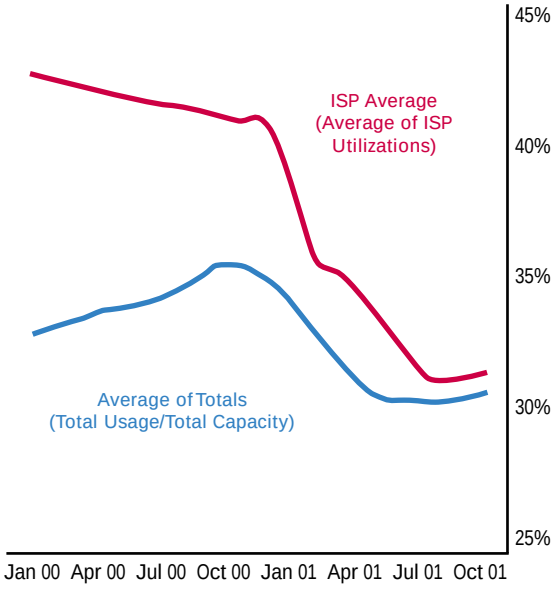
Burger confirms 2.7X,

Chart 5



as industry "wastes" bandwidth.

Chart 6



Sources: Roberts et al., Caspian Networks; K.G. Coffman and A.M. Odlyzko, AT&T Research Labs

Yet, Internet traffic is far from inelastic. Just as Moore's law predicts a doubling of computer power every 18 months and so Cao's law predicts the doubling of "optical power" every 5 months, so Roberts's rule predicts a doubling of Internet traffic every 7 to 8.5 months. The price elasticity of demand for bandwidth is indicated not only by the amount of traffic but also by the total bandwidth capacity used to accommodate traffic. As computer chips grew more powerful our use of the chips did not keep up with the increase in power, we just wasted more and more transistors. The same trend is true for bandwidth. Average percentage bandwidth utilization rates plummet as bandwidth gets cheaper and we waste more and more of it **(chart 6).** This is the heart of the paradigm.

- Charles Burger

but trivial, for very short time periods or for franchise companies in industries of glacial stability. In other words, companies of little or no interest. Lengthen the time period or focus on more innovative industries and the proposition that the past predicts the future becomes ever more nonsensical. Complicate the theory, add jargon, and smile knowingly, and it becomes nonsense on exponential stilts. All these models try to do without thinking. Rather than imagining the future they try to automate its prediction.

Nevertheless, Telecosm analysis clearly would benefit from a model that could test the imagined future against whatever is quantifiable in the present. My favorite candidate for the modeling task comes from Aswath Damodaran, whose *The Dark Side of Valuation* proposes a valuation method almost entirely congruent and complementary to the technology paradigm.

Damodaran cites evidence (p149) of near zero correlation between historic and future growth rates of earnings for most companies and even less correlation for tech firms (p150), though revenues align somewhat better with past trends. In other words a company that is growing fast now is scarcely more likely to grow fast next year than a slow grower is. He shows that analysts, if anything, do worse than historic trendline extension in projecting growth rates (pp156-158), and that well regarded management is a bad investment compared to badly regarded management (high regard being a reflection of the analyst's predictions rather than a determinant of them). And he shows that the more refinement of detail that enters a growth projection the less accurate it is likely to be. A general sense of paradigms, as I might put it, beats an intricate analysis of every product and its prospects.

Aswath Damodaran proposes a valuation method almost entirely congruent and complementary to the technology paradigm

Then, in a dramatic coup, Damodaran proves his rules by offering his own (rather detailed) projections for **Cisco** (CSCO), **Amazon** (AMZN), **Motorola** (MOT), **Ariba** (ARBA), and **Rediff** (REDF). Issued in June 2000, Damodaran's projections correctly predicted a slump of valuations from their year 2000 peaks, but failed utterly to anticipate the cliffs of 2001. Damodaran did not correct for deflation either. He assigned a value of $44.92 to Cisco, now at $16.08; $32.39 to Motorola, now at $17.19; $34.37 to Amazon, now at $7.87; $72.13 to Ariba, now at $2.31; and $19.05 to Rediff, now at 75 cents. I do not list these numbers to gloat. In my fiber glass house, I am in no position for Shadenfreude. Already amply stoned and deflated, I have no grounds from which to hurl any smithereens. But whether discounted cash, relative multiples, economic value added, or cash flow return on investment, financial analysis provides no alternative to fundamental appraisal of technology paradigms.

The last year has taught us, however, that even Telecosm vision needs to be quantitatively structured for particular companies. Damodaran's model provides a structure for appraisal of company values based on growth expectations. Almost entirely subjective, expectations are little correlated with historic trends.

Risky business

The dominant fundamental or intrinsic models all hinge on the discounted present value of future cash flows, which of course diminish sharply with risk. Yet all investment theories concur that entrepreneurial wealth comes from acceptance of risks. Resolving the paradox, Damodaran defines risk as variability of returns or beta and cites evidence that high beta stocks offer better returns than low beta stocks. Beta, however, is variability in relation to some market index. It is statistically definable and to some extent insurable through diversification. Entrepreneurial risk, as defined by Frank Knight in his canonical *Risk, Uncertainty and Profit*, is uninsurable, because every instance is unprecedented by definition. Entrepreneurship may be defined as the launching of innovations, which are inherently unique, at least in some crucial property. Indeed, the more unique an innovation the more likely it can confer a proprietary advantage, with barriers to entry, that imparts outsized profits. But a unique instance creates uninsurable risk. This form of risk is absolute and irremediable. Thus, it should lift to near prohibitive levels the "risk premiums" employed in net present value calculations of the worth of its speculative cash flows. Such a method would block most innovation and thus most business profits and consequently most stock market capital gains. It would orient the investor precisely toward those projects least likely to yield a profit beyond the risk free interest rate.

Damodaran's solution is a "real option" model. The investment is gauged neither by the calculable risk adjusted valuation of its projected cash flows, nor by its opportunity costs as measured by the rewards of other safer ventures, but by the opportunity payoff: the options opened up to pursue unique goods and services or to pioneer in contiguous markets or to engineer related innovations. Amazon's Latin American venture, for example may well destroy value in discounted cash flow terms while at the same time buying an "option" to enter the Latin American market in a broader range of businesses, when the opportunity presents itself.

The "real option" equation is formidably complex, involving the creation of simulated or replicated set of risk and reward components, estimation of the current value of the underlying asset, and the variation in that value. The central insight is that for technology companies risk is defined as variability of returns—the dynamic range of outcomes—and this risk index will reduce the net present value of existing assets, but raise the value of

real options. Representing opportunities and potential projects, they can be modeled the same way as financial options or "calls." They combine the *cost* of the option, which is the expense of staying in the business or purchasing the license or patent or continuing the R&D, with the *strike price*, which is the cost of actually entering production, launching the product or commercializing a development or project. The net payoff is the yield of the asset minus the cost of the option. Cisco, by this standard, is chiefly an aggregator of options (commercializer of acquired projects) and its long outsized returns benefited from risk. Thus, a discounted present value calculation, with a risk penalty, is an inappropriate gauge of Cisco's worth. As an aggregator of options Cisco can flexibly exploit a range of networking technologies that are not yielding significant revenue today. Some options will remain under water (Monterey Networks). But most will pay off to some degree (Cerent, Arrowpoint, Andy Bectolsheim's Granite for gigabit Ethernet).

GX's real business begins

Damodaran provides a practical guide for valuing several of the Telecosm companies. He even supplies a specific example in his appraisal of Motorola, which he saw as undervalued. As we went to press, he also gave us an appraisal of Global Crossing that valued the company at $2.9 billion ($3.22 per share) at a time it was valued by the market at $1.52 billion dollars or roughly $1.67 a share. Bret Swanson challenged some of his premises. Key to Damodaran's model are revenue growth assumptions, and with the benefit of hindsight and a paradigm, we see reason to question his findings in several important respects.

Damodaran's suggested growth path for GX starts at zero percent in year one (2001) and progresses through 40, 30, 20, 10, 10, 10, 8, 6, and 5 for the next nine years.

Through the sale of undersea IRUs (simple capacity mostly across the Atlantic), GX achieved a billion dollars in sales faster than any other company in history. Then increased competition slowed growth rates to a still-blistering 40 percent from more than 100 percent. But the "real option" created by GX's so far uniquely seamless global network is not Atlantic IRU sales, which were a stop-gap measure to finance the network. The "real option," the real business, is the ability to offer IP network services to global enterprises without the burden of management and transaction costs entailed in network border crossings. It was precisely to create this option that the network was built. Until it has been "exercised" GX's business can hardly be said to have begun.

Global Crossing Growth Path

Figure 1

Year	Damodaran	GTR
2001	0%	0%
2002	40%	30%
2003	30%	40%
2004	20%	40%
2005	10%	30%
2006	10%	30%
2007	10%	20%
2008	8%	10%
2009	6%	10%
2010	5%	5%
Compound Avg Growth Rate	10%	17%
Share Price	$3.22	$21.56
Equity Value	$2.9b	$19.9b

CEO Legere says it begins now. If it does, two factors will control GX's growth. The first is the severe challenge of signing up as customers the Forbes 500 global companies who are the world's biggest users of telecom and Internet services but have large, complicated, facilities-based, IT-entrenched contracts with the current telecom players. Not easy.

Facilitating the job of GX's sales force is the threefold annual pace of Internet traffic growth, which will force such customers to seek as a second source anyone with global capacity. Assuming a) that GX survives its cash crunch long enough to exercise its option, b) that the initial sales job is tough, and c) that traffic growth both triggers the initial sales and drives out- year revenue growth, GX's growth curve could vary dramatically from Damodaran's suggestion.

Given all these factors, including a world economy that will take some time regaining its health, we offer this alternative (see figure 1). Plugging different growth assumptions into Damodaran's model, Bret came up with a valuation of $19.9 billion or a stock price of $21.56.

Dynegy challenges GX

Assuming it survives the next 18 months, the chief challenge for Global Crossing will be technology management. Advancing at an ever accelerating pace, the optical capabilities of the Global Crossing network will be available at far cheaper prices to new entrants. One, the well financed power company **Dynegy** (DYN) of Houston (now maneuvering to buy Enron) has contrived through a combination of leases and buildouts a global network over the last year that in some respects already rivals Global Crossing's. Using **Tellium** (TELM) optical switches and **Fujitsu** (FJTSY) advanced WDM multiplexing–reportedly based on the **Avanex** (AVNX) PowerMux–Dynegy has 16,000 miles of domestic routes and an emerging global presence. Dynegy's network could become fully competitive with Global Crossing's if the company does not adopt new technologies aggressively. As the Roberts trend of annual tripling of Internet traffic extends around the globe, John Legere must make his company a worldwide leader in testing and applying the new lambda technologies and integrating them with its current industry leading IP/MPLS (multiprotocol label switched) offerings.

- George Gilder
November 20, 2001

TELECOSM TECHNOLOGIES

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	REFERENCE DATE / PRICE		OCT '01: MONTH END	52 WEEK RANGE	MARKET CAP
FIBER OPTICS						
Optical Fiber, Photonic Components	Corning (GLW)	5/1/98	13.64	8.06	6.92 - 79.75	7.6B
Wave Division Multiplexing (WDM) Components	JDS Uniphase (JDSU)	6/27/97	3.63	8.09	5.12 - 83.00	10.7B
Adaptive Photonic Processors	Avanex (AVNX)	3/31/00	151.75	4.96	2.70 - 108.63	329.5M
All-Optical Cross-Connects, Test Equipment	Agilent (A)	4/28/00	88.63	22.27	18.00 - 68.00	10.26B
Tunable Sources and WDM Components	New Focus (NUFO)	11/30/00	20.31	2.90	2.10 - 68.00	218.9M
Crystal-Based WDM and Optical Switching	Chorum (private)	12/29/00	—	—	—	—
WDM Metro Systems	ONI (ONIS)	12/29/00	39.56	4.91	3.50 - 82.50	677.3M
WDM Systems, Raman	Corvis (CORV)	3/30/01	7.03	2.24	1.19 - 68.25	806.6M
Metro Semiconductor Optical Amplifiers	Genoa (private)	3/30/01	—	—	—	—
Optical Processors	Essex (ESEX.OB)	7/31/01	5.90	5.85	1.50 - 6.70	29.0M
LAST MILE						
Cable Modem Chipsets, Broadband ICs	Broadcom (BRCM)	4/17/98	6.00*	34.41	18.40 - 227.50	8.9B
S-CDMA Cable Modems	Terayon (TERN)	12/3/98	15.81	11.35	2.36 - 25.81	776.2M
Linear Power Amplifiers, Broadband Modems	Conexant (CNXT)	3/31/99	13.84	10.15	6.57 - 33.50	2.6B
Broadband Wireless Access, Network Software	Soma Networks (private)	2/28/01	—	—	—	—
WIRELESS						
Satellite Technology	Loral (LOR)	7/30/99	18.88	1.27	1.03 - 6.56	423.3M
Low Earth Orbit Satellite (LEOS) Wireless Transmission	Globalstar (GSTRF)	8/29/96	11.88	0.53	0.20 - 3.94	58.5M
Code Division Multiple Access (CDMA) Chips, Phones	Qualcomm (QCOM)	7/19/96	4.75	49.05	38.31 - 107.8	37.3B
Nationwide CDMA Wireless Network	Sprint (PCS)	12/3/98	7.19 *	22.30	15.72 - 38.44	20.9B
CDMA Handsets and Broadband Innovation	Motorola (MOT)	2/29/00	56.83	16.37	10.50 - 26.25	36.1B
Wireless System Construction and Management	Wireless Facilities (WFII)	7/31/00	63.63	6.59	3.31 - 54.75	297.9M
GLOBAL NETWORK						
Metropolitan Fiber Optic Networks	Metromedia (MFNX)	9/30/99	12.25	0.73	0.25 - 23.50	447.5M
Global Submarine Fiber Optic Network	Global Crossing (GX)	10/30/98	14.81	1.13	0.38 - 25.88	1.0B
Regional Broadband Fiber Optic Network	NEON (NOPT)	6/30/99	15.06	3.07	2.16 - 19.94	65.5M
National Lambda Circuit Sales	Broadwing (BRW)	6/29/01	24.45	9.26	8.82 - 28.88	2.0B
Internet Backbone and Broadband Wireless Access	WorldCom (WCOM)	8/29/97	19.95	13.46	11.50 - 25.69	39.8B
STOREWIDTH						
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	6.88	10.15	7.52 - 57.49	32.9B
Network Storage and Caching Solutions	Mirror Image (XLA)	1/31/00	29 .00	1.84	1.00 - 15.25	208.8M
Remote Storewidth Services	StorageNetworks (STOR)	5/31/00	27.00*	5.06	3.65 - 73.69	490.3M
Hardware-centric Networked Storage	BlueArc (private)	1/31/01	—	—	—	—
Virtual Private Networks, Encrypted Internet File Sharing	Mangosoft (MNGX.OB)	1/31/01	1.00	0.84	0.34 - 5.69	22.7M
Massively Parallel Global Storewidth Solutions	Scale Eight (private)	8/31/01	—	—	—	—
MICROCOSM						
Analog, Digital, and Mixed Signal Processors	Analog Devices (ADI)	7/31/97	11.19	37.98	29.00 - 68.00	13.7B
Silicon Germanium (SiGe) Based Photonic Devices	Applied Micro Circuits (AMCC)	7/31/98	5.67	11.04	6.01 - 88.25	3.3B
Programming Logic, SiGe, Single-Chip Systems	Atmel (ATML)	4/3/98	4.42	7.96	5.48 - 18.44	3.7B
Single-Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	15.75	16.95	9.78 - 33.00	6.2B
Single-Chip Systems, Silicon Germanium (SiGe) Chips	National Semiconductor (NSM)	7/31/97	31.50	25.98	17.13 - 35.10	4.6B
Analog, Digital, and Mixed Signal Processors, Micromirrors	Texas Instruments (TXN)	11/7/96	5.94	27.99	20.10 - 54.69	48.5B
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	8.22	30.50	19.52 - 74.56	10.2B
Seven Layer Network Processors	EZchip (LNOP)	8/31/00	16.75	5.40	2.70 - 31.25	34.8M
Network Chips and Lightwave MEMS	Cypress Semiconductor (CY)	9/29/00	41.56	19.75	13.72 - 39.69	2.4B
Field Programmable Gate Arrays (FPGAs)	Altera (ALTR)	1/31/01	30.25	20.20	14.66 - 42.00	7.8B

* 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.

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