Death of Innovation (Revisited)

By Bart Stuck and Michael Weingarten

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In 1997, we wrote an article called "The Death of Innovation?" (Business Communications Review, April 1997; downloadable at www.signallake.com/publications) questioning the continuing ability of the US electronics high tech industry to innovate.

The article was prompted by the October 1996 spin-off of Lucent from AT&T, and with it, Bell Labs – an organization that was funded by cashflow from the telephone monopoly. Bell Labs used that money to invent the traveling wave tube, the transistor, lasers, UNIX, as well as 800/700/900 services. It also was a major innovator in loading coils, the coaxial cable, millimeter waveguide, fiber optics and cellular telephony. In the absence of monopolist cashflow, we wondered where new innovation was going to come from – particularly since our review of the top 20 telecom innovations of the previous 25 years suggested that many of them originated from these labs (Table 1).

On the other hand, we recognized that the emergence of the venture capital model potentially could be a replacement (at least in part) for the monopolist corporate lab. Clay Christensen's book The Innovator's Dilemma (also published in 1997) points out that corporations over-emphasize line extensions and synergy opportunities, and avoid disruptive technologies. In theory, VC-backed startups, with nothing to lose and everything to gain, might be the ones leading the charge with brilliant innovations.

It's now 2004. What's happened since then? Are we seeing continuing technological innovation, or Houston, do we have a problem?

Methodology: Defining The Relevant Data Base

As with our 1997 article, we have chosen to structure our review around a set of data that, with appropriate analysis, could generate quantifiable results. Our initial thought was to repeat the 1997 thought experiment; i.e., come up with a list of the most important innovations since 1997 and see if the annualized level of innovation is increasing or decreasing. The problem with this is that Table 1 was created to discuss, for twenty particularly important innovations, where those innovations came from originally and where they were commercialized. The innovation list was never intended to be complete, and in particular, did not include innovations of second, third or fourth rank. We therefore did not have a sufficiently complete baseline set of innovations against which to calculate changes in the rate or level of innovation going forward.

TABLE 1 Fundamental Telecommunication Advances, 1960–Now

Advances	Conceptual Originator	Leading-Edge Commercialization
Transmission—Wireline:		
1. Laser	Bell Labs	SDL Lasertron
2. Optical Fiber	Corning	Corning AT&T
3. Optical Amplifier	Polaroid Univ Southampton (UK)	Pirelli Corning
4. Optical Amplifier	Bellcore Bell Labs	Ciena Pirelli Lucent Nortel
Transmission—Wireless:		
5. Cellular	Bell Labs	Ericsson Motorola
6. Spread Spectrum	UK Military MIT Lincoln Labs	Qualcomm
7. Satellite Transmission	Bell Labs	Hughes
Transmission—Digital Signal Processing:		
8. xDSL	Bellcore	PairGain
9. Video Compression	Bell Labs	PictureTel
Switching—Circuit:		
10. Time Slot Interchanger	Collins NTT	Rolm Mitel Intecom Nortel
Switching—Packet:		
11. SNA	IBM	IBM
12. TCP/IP	DARPA	Sun Cisco Systems
13. Ethernet	Xerox	3Com Bay Networks Cabletron Cisco
14. Frame Relay	Bell Labs	Cascade
15. ATM	Carnegie Mellon	Fore Systems
16. Multiprotocol Router	Stanford Univ	Cisco Systems
17. World Wide Web	CERN Univ of Illinois	Netscape Sun
Control:		
18. Operating System: Unix	Bell Labs	Sun Hewlett-Packard
19. Language: C, C++	Bell Labs	Borland Sun Microsoft
20. Language: Java	Sun	Sun

Legend:
Large Integrated Equipment/Network Provider
University
Government
Large Equipment/Software Company
Network Provider
Small Entrepreneurial Company

Accordingly, we decided to take a different approach for this article: find a relatively complete set of high-technology startups that came to fruition in the post-96 period, and test the extent to which they represent significant technology innovations. We could then compare the level of innovation to the period just prior, to see if innovation is increasing or decreasing.

After considering various alternatives,[1] we were able to find such a list in the Morgan Stanley Technology IPO Yearbook. This comprehensive report lists 1,303 electronic high tech IPOs for 1993-2002, including market capitalizations as of the IPO date and at year-end 2002 (Table 2). Some of these IPOs (like Lucent or Accenture) clearly were spinoffs or recapitalizations of established companies rather than successful innovation-based startups. After excluding these, we had a database of 1,281 companies that we could review.

We further decided to eliminate from consideration any Internet IPOs relying on e-commerce business models (ie, Ebay), rather than on new technologies. This left us with 823 high-tech IPOs for review.

Table 2
Number of High Tech IPOs

	Number of IPOs 1993-2002
Total IPOs	**1,303**
Less: Spinoffs	22
Subtotal ex Spinoffs	1,281
Less: Internet E-Commerce	458
Net High Tech IPOs For Review	**823**

Source: Morgan Stanley Technology IPO Yearbook; Signal Lake Analysis

Having defined our data set, our next step was to divide it into two periods: a baseline, and a follow-on period that we could use to measure innovation changes over time. Using the late 1996 Lucent divestiture as our line of demarcation, we decided to use 1993-1996 as our baseline, and 1997-2002 as the follow-on period (the latter also corresponding fairly well to an upsurge in VC spending, which in theory should have resulted in an increase in level of innovation).

[1] In addition to IPOs, we considered looking at innovations from corporations and startups that did not go public or which were acquired by companies (for example, Cerent and Chromatis, which were acquired by Cisco and Lucent). In the end, we decided that (a) the IPO data base was sufficiently large to reach meaningful conclusions; and (b) we did not have a sufficiently complete list of non-IPO-based innovations to feel comfortable with drawing conclusions.

However, we were able to develop a list of 213 acquisitions of privately-held startups by companies such Cisco, Lucent, and Nortel, and tested these according to our T1-T5 methodology. The results are reviewed in the sidebar "What About Non-IPO Innovation?"

Results: Aggregate IPO Trends

The results are shown on Table 3. In the 1993-1996 period, there were 455 IPOs; this declined to 368 IPOs for 1997-2002. Adjusted for the differing number of years in each period, high-tech IPOs per year declined by around 50%, from 114 in 1993-1996, to 61 in 1997-2002. Thus, *compared to our baseline period, we observed a surprisingly sharp decrease in the number of IPOs.*

Table 3
Number of High Tech IPOs
Excluding Internet E-Commerce Plays

Period	# Years	Net High Tech IPOs	High Tech IPOs Per Year
1993-1996	4	455	113.8
1997-2002	6	368	61.3
Total	10	823	82.3

Source: Morgan Stanley Technology IPO Yearbook; Signal Lake Analysis

Why this decline in IPOs (at a time when VC investment was up sharply)? One possible contributing factor was that Internet IPOs crowded out more traditional high tech deals. Looking at Table 4, which includes Internet IPOs, the number of IPOs per year was consistent during both periods at around 128. So apparently, the market had an appetite for around 10 IPOs per month, and as Internet deals became hot, non-Internet deals were forced to take a back seat.

A second possible contributing factor is the 'Cisco effect.' As discussed in greater detail in our sidebar, "What About Non-IPO Innovation?," Cisco made 14 acquisitions in 1993-1996, at a time when few competitors were actively buying companies. By 1997, with Lucent and others feeling the need to compete with Cisco by acquiring companies with new technologies, the number of private acquisitions shot up dramatically – perhaps at the expense of IPOs. Even if we include these private acquisitions, however, we still observe a 20% drop-off, after including 196 private acquisitions made by 14 leading networking companies during the 1997-2002 period.

Table 4
Number of High Tech IPOs
INCLUDING Internet E-Commerce Plays

Period	# Years	Net High Tech IPOs ***Including Internet Plays***	High Tech IPOs Per Year ***Including Internet Plays***
1993-1996	4	518	129.5
1997-2002	6	763	127.2
Total	10	1,281	128.1

Source: Morgan Stanley Technology IPO Yearbook; Signal Lake Analysis

So net-net, measured by the number of IPOs, we don't see an increase in innovation. Just the reverse.

Arguably, however, one should measure innovation based on quality, not quantity. After all, even if there were fewer high tech IPOs per year, perhaps a greater number of these represented 'true' innovation, as opposed to simply replicating already-existing technologies. We therefore turn to a review of innovation level:

Methodology: Ranking IPOs By Level of Technological Innovation
To test for level of innovation among the 823 non-Internet IPOs in our data set, we ranked each company on a scale of 1-5 (with 1 being high and 5 being low):

Our criteria for ranking degree of innovation was as follows:

- We reserved our highest rank (T1) for new technologies representing a fundamental departure from anything existing previously, and whose commercialization made possible an entirely new (and important) business market. A good example is the invention of xerography.

- Moving down one notch, we ranked a company as T2 if it was able to demonstrate fundamental technology improvement in an existing product category. These include Clay Christensen's 'disruptive technologies;' i.e., new technologies that supplanted old technologies in already-established markets, rather than creating new markets.

- Our T3 designation was reserved for companies able to demonstrate non-trivial technical improvements in existing product categories. However, the nature of the improvement was largely one of extending existing technologies (i.e., by using ASICs with .13 rather than .18 nm traces). The result of T3 innovations could well be the next Moore's Law jump in speed/computing capability. However, we see these as obvious (if non-trivial) serial extensions in existing technologies rather than truly disruptive innovations. We also tend to see T3 improvements as substantially less defensible long term than T1s or T2s (unless first mover advantage results in long-term customer lock-in). After all, a first-mover Moore's Law announcement by Player A invariably is matched within months by Players B, C and so on.

- Our T4 designation was used for companies able to demonstrate modest improvement in existing technologies, perhaps by repackaging a combination of already-commercialized technologies in novel ways. In many ways, T4 is like T3 but with less significant improvement over what came beforehand.

- Our T5 designation was used for companies who did not create new technology, but were able to successfully market existing technology. Alternatively, companies developing *new business models* using well-established Internet technologies (i.e., Ebay or Amazon) would receive T5 designations.

Ranking Results
The results of this process (Table 5) were startling, in that ***they indicated a surprisingly low degree of technological innovation generally, and a sharp reduction in the level of innovation since 1996****:*

- **There were very few T1/T2 companies in general, and a sharp decrease in the number of T1/T2 companies over time:** In 1993-1996, there were only 20 T1/T2s, representing 4.4% of total IPOs (and 5 IPOs each year). In contrast, the numbers for 1997-2002 were substantially worse: 5 T1/T2s, representing 1.4% of total IPOs (0.8 IPOs per year).

  For a list of T1 and T2 IPOs, see table 6.

- **The number of T3s, while significant in the 1993-1996 time period, decreased substantially in the 1997-2002 time period:** In 1993-1996, there were 29 T3 IPOs per year (25.7% of all IPOs). By 1997-2002, there were only 7 T3s per year (11.4% of all IPOs).

  Our T3 list includes a number of companies that were acquired for large premiums (for 1993-1996: Ascend, Lycos, Cascade, Etec Systems, XYLAN, and DSP Communications; for 1997-2002: E-Tek, MMC, Galileo).

  The list also includes companies that were not acquired and were worth $1B or more as of 12/31/02 (for 1993-1996: DST, Siebel, Network Appliance, Checkpoint, Etrade, National Instruments, Checdkfree, IDT, TMP, Adtran and Cymer; for 1997-2002: Juniper, Marvell, Broadcom, Netscreen, BEA, nVidia, RFMD, AMCC and Maxtor).

- **Most of the IPOs were T4s:** In 1993-1996, 66% of all IPOs were T4s, increasing to 87% in 1997-2002.

  For 1993-1996, some major T4 companies included: Netscape, Intuit, Aspect Development, Microchip Technology, Jabil Circuit, Mercury Interactive, Spyglass, Sanmina and Citrix Systems.

  For 1997-2002, some major T4 Companies included: Network Solutions, Tycom, Alteon Websystems, Verio, broadcast.com, Arrowpoint, LHS Group, and L-3 Communications.

  There was a relatively few T5s in either period: This reflects the fact that we excluded most Internet e-commerce plays, many of which would have been ranked T5.

Table 5: IPOs By Technology Ranking and by Time Period

Technology Ranking	1993-1996 # Companies	1993-1996 % Of Total Companies	1993-1996 Companies Per Year	1997-2002 # Companies	1997-2002 % Of Total Companies	1997-2002 Companies Per Year	Ratio 97-02/93-96: Companies Per Year
T1	5	1.1%	1.3	2	0.5%	0.3	0.27
T2	15	3.3%	3.8	3	0.9%	0.5	0.13
Combined T1/2	*20*	*4.4%*	*5.0*	*5*	*1.4%*	*0.8*	*0.17*
T3	117	25.7%	29.3	42	11.4%	7.0	0.24
T4	301	66.2%	75.3	320	87.0%	53.3	0.71
T5	17	3.7%	4.3	1	0.3%	0.2	0.04
Total	**455**	**100.0%**	**113.8**	**368**	**100.0%**	**61.3**	**0.54**

Source: Morgan Stanley Technology IPO Yearbook; Signal Lake Analysis

Table 6
T1 and T2 Companies by Time Period

Technology Ranking	1993-1996	1997-2002
T1	Yahoo! Security Dynamics (RSA Security) Illinois Superconductor Superconductor Technologies Conductus	Akamai VeriSign
T2	Versant Object Tech. (Versant) Rogue Wave Software Orckit Communications MindSpring Sawtek Pixar SDL Maxis ParcPlace-digitalk (Object Share) Fore Systems Ortel Veritas Software Uniphase (JDS Uniphase_ TriQuint Semiconductor Level One Communications	RealNetworks Ciena Inktomi

Source: Signal Lake Analysis

Examples of Successful T3 Companies
Given that our rankings are surprisingly low, we thought that we should illustrate why some specific companies (generally considered to be high tech success stories) deserve to be ranked, as say, T3, rather than T1/T2 (the rankings for T4 and T5 being more obvious).

Our first example is Juniper, which we rated as T3. Juniper is an excellent company, with a market value of $2.55B as of 12/31/02 and $11B as of February 2004. That's not bad, particularly when compared to Lucent's $18 billion. As VCs, we would have been happy to have been Series A investors.

So why did we rate Juniper as T3? The answer is that we see it largely as a successful execution play rather than as a poster child for brilliant innovation. After all, what did Juniper do? It took well-established routing technology (already commercialized by Cisco, Ascend and Cascade), and created custom ASICs that allowed it to sell the first 1 gbps router, filling a gap left open by Cisco. That's nice, but it's not an example of developing fundamentally new technology or opening up a new product area. At best, it's a T3 Moore's Law advance.

What really made Juniper a success was not its technology per se, but rather its ability to get funding/support from Lucent, Nortel, Siemens and Ericsson simultaneously, and a skilled management team able to fill a market need quickly to the exclusion of others like Redback and Avici (who had similar technology, but failed to gain traction).

A second example is Broadcom. Broadcom began by working with the CATV industry on the detailed specs for its DOCSIS cable box technology. It then was able to leverage that detailed knowledge by creating chipsets for cable boxes. There wasn't anything particularly innovative about that; simply the leveraging of asynchronous knowledge.

A third example is E-Tek. E-Tek was developing a variety of optical networking components, based on innovative views of market needs and materials and technical capabilities. As such, E-Tek was not innovating per se, but using a sharp focus on market needs to drive product engineering.

A final example is BEA. BEA was originally set up to provide to the Global 200 the open standards based software needed to run enterprises, rather than relying on proprietary IBM oriented offerings. As such, BEA originally bought the Tuxedo transaction processing monitor from Novell, which provided a customer base, and then extended this in a very astute acquisition of Web Logic to move into the Internet based enterprise market. As such, BEA was not innovating per se, but again, using a sharp focus on market needs to drive product development and acquisitions.

Conclusion
After looking at 1,300 high tech IPOs over a ten-year period, we conclude that there wasn't all that much technological innovation generally – and that the level of innovation – measured by the total number of IPOs per year and by the level of innovation -- decreased dramatically in the 1997-2002 period, compared to the four year period just prior – all this, despite the fact that VC spending did just the reverse (Table 7). Apparently, a 10x increase in venture funding led to an 83% reduction in the number of T1 and T2 IPOs each year!

What's driving the reduced innovation? We'll deal with different theories in follow-up articles.

Table 7
Annual US Venture Capital Funding

Year	Number of Companies	Venture Financing
2002	3,134	$30,438
2001	5,267	52,212
2000	8,859	131,984
1999	4,890	63,990
1998	2,860	24,822
1997	2,122	13,194
1996	1,797	10,457
1995	1,133	6,417
1994	746	2,990
1993	671	2,469
	Per Year	**Per Year**
97-02	**4,522**	**52,773**
92-96	**1,087**	**5,583**

Source: Venture Economics quoted in Morgan Stanley Technology IPO Yearbook; Signal Lake Analysis

Sidebar:
What About Non-IPO Innovation?

Our focus on IPO innovation raises the logical issue of whether we would see markedly different results if we were to look at innovation at startups that did not go IPO, but which instead were acquired privately by large high tech companies.

Despite the fact that we did not have a comprehensive list of high tech private startup acquisitions, we were able to put together a list of 213 private acquisitions by fourteen leading high tech firms.[2] We decided to review the level of innovation for these companies, to test our IPO-based conclusion that recent innovation levels have been surprisingly low. The 213 companies include nine high-profile private deals that in total were acquired for $28 billion (Cerent, Chromatis, Qtera, SiByte, OCLI, Andiamo, Kenan, Xros, and Coretek); total acquisition price for all 213 companies was in excess of $67 billion.

Number of Companies
There was a substantial increase in the number of private transactions over time (Table 8). In 1993-1996, there were seventeen private transactions. This increased by a factor of 11.5 times to 196 transactions in 1997-2002, and with a much broader level of participation by other acquiring companies.

Looking at what happened, we think that what happened was 'the Cisco effect." In the 1993-1996 period, 14 of the 17 private transactions were by Cisco, at a time when other players tended to have a Not Invented Here mentality and did not believe in spending lots of money for outside technology. Given Cisco's clear success in expanding its product line via acquisitions and generating a clear market value premium versus competitors, competitors took notice and began to buy companies as a means of competing with Cisco. By 1999, the situation got so-overheated that companies with 10-15 engineers and no working product or sales were being sold for hundreds of millions of dollars.

These trends are in marked contrast to our previously observed sharp decline in high tech IPOs, which halved (see Table 8). Apparently, the bidding war for new technology got so overheated that companies sold out without needing to wait for an IPO.

However, if we add together the high tech IPOs with the private transactions, we still observe that the total number of deals per year declined 20% from 118 companies in 1993-1996, to 94 companies in 1997-2002.

[2] Alcatel, AMCC, Broadcom, Cisco, Conexant, Ericsson, GlobeSpan, Intel, JDS Uniphase, Lucent, Nokia, Nortel, PMC Sierra, and Siemens

Table 8
Number of High Tech IPOs and Private Acquisitions Over Time

Period	# Years	High Tech IPOs (ex e-Commerce)	Private Acquisitions	Total IPO + Private Acquisitions	High Tech IPOs PER YEAR	Private Acquisitions PER YEAR	Total IPO + Private Acquisitions PER YEAR	Index
1993-1996	4	455	17	472	113.8	4.3	118.0	100
1997-2002	6	368	196	564	61.3	32.7	94.0	80
Total	**10**	**823**	**213**	**1036**	**82.3**	**21.3**	**103.6**	**88**

Source: Morgan Stanley Technology IPO Yearbook, convergedigest.com, Signal Lake analysis

Company Ranking
Looking next at T1-T5 ratings for private acquisitions (Table 9), we did not find many companies with high innovation levels.

- For 1993-1996, we did not give any companies a T1 or T2 rating.
- For 1997-2002, we gave no companies a T1 rating and and we gave five companies a T2 rating. These included: Cronos, OCLI, Epitaxx, Ramar and Qtera. Interestingly, JDSU acquired four out of five of these, with Nortel buying Qtera.

  The five companies represented 2.6% of all private acquisitions for 1997-2002; this compares to 4.4% of IPOs during 1993-1996 and 1.4% of IPOs during 1997-2002.

Table 9
High Tech Acquisitions by 14 Networking Companies
Ranked By Technology Level

Technology Ranking	1993-1996 Number of Private Acquisitions	1993-1996 Percent of Total Private Acquisitions	1997-2002 Number of Private Acquisitions	1997-2002 Percent of Total Private Acquisitions
T1	0	0.0%	0	0.0%
T2	0	0.0%	5	2.6%
T1/2	**0**	0.0%	**5**	2.6%
T3	5	29.4%	55	28.1%
T4	12	70.6%	134	68.4%
T5	0	0.0%	2	1.0%
Total	**17**	**100.0%**	**196**	**100.0%**

Source: convergedigest.com, Signal Lake analysis

Conclusion
Broadly speaking, the private acquisition results confirm the results of our IPO analysis. There were a substantially higher number of private transactions in the 1997-2002 period, which offset partially (but not entirely), the sharp drop-off in IPOs. However, even if we added private with public deals, there still was a 20% drop-off in number of total deals, compared to the baseline 1993-1996 period.

In addition, the technology rankings for private acquisitions show relatively few T1/T2 companies (as was the case for IPOs).

So at the end of the day, we are left with a sense that the level of technological innovation is low and declining. The question remains, why?