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The Role Of University Of California Scientists and Engineers In The State's R&D-Intensive Communications Industry

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Executive Summary

Scientific breakthroughs over the past thirty years in the fields of physics, engineering, chemistry and biology formed the basis for new technologies that spurred the growth of entirely new industrial sectors. As this phenomenon has become more widely recognized, investment in research and development, including basic research at academic institutions, is becoming a common element in economic development efforts in California and elsewhere.[1] Although there is a broad consensus about the general benefits of such investment, understanding of the specific means by which such investments contribute to the economy remains incomplete.[2]

This paper describes a pilot study that aims to improve understanding of the increasingly direct role in the economy of public investment in early, discovery research, by assessing the contributions of academic faculty, students and research scientists. The primary focus of the study is the relationship between University of California scientists, and R&D-intensive communications firms in the state. The development of fundamentally new communications technologies, including the Internet and wireless networks, has been made possible in part by academic research in information technology, materials sciences, physics and electrical engineering.[3]

Building on these advances, California companies have been leading innovators and major providers of the sophisticated equipment and software that has enabled new communications products and services to enter the marketplace. Overall, California is home to 27% of the communications companies in the U.S, roughly 2.5 times that of the closest competing state, Illinois, which boasts 11%.[4]

In this study, we focus specifically on those California companies that are actively engaged in research and development in communications-related applications, including those relating to the Internet backbone and related computer networks, as well as satellite and wireless communications. Included are firms that design, manufacture or test hardware for networks such as routers, transceivers, switches, and network interface cards; and those that provide software that improves network efficiency and enables Internet and wireless communications activities. Excluded are companies that provide commodity products and services, such as simple telephone handsets, wired and wireless phone service,

Internet access, Web hosting, and other Internet services such as search engines.

The R&D intensive communications companies we identified are of interest because they are engaged in developing the innovations that will likely form the basis for tomorrow's technologies. In this setting, it is important to note that this study provides a snapshot of the California R&D-intensive communications industry as of March 1, 2002. Ongoing financial troubles in the sector, which in 2002 were strongly affected by the downfalls of telecommunications service providers, including WorldCom and Global Crossing, may not be fully reflected here.

Analysts including the Wall Street Journal's Dennis Berman have attributed current problems in this sector in part to over-investment in capacity during the late 1990's, when the sector was strongly affected by what in retrospect appears to have been an investment bubble in the high technology sector more generally. At its peak, annual capital expenditures by telecommunications firms reportedly exceeded the total value of their sales, compared to the normal investment level of 15%.[5] Alleged accounting irregularities have added to the dramatic decline in share price for public telecommunications firms, and to the generally difficult financial situation for firms in this sector. A review completed on July 1, 2002 of the firms included in this study, however, suggests that nearly all of the R&D-intensive communications firms in California have maintained their operations despite the chillier financial climate, at least for now.

Altogether, over 700 California communications companies were identified from industry directories and membership lists for communications-related trade organizations. Each candidate firm was screened for relevance and R&D intensity, producing a subset of 368 companies, each having active communications-related R&D operations in California. The criteria used for assessing relevance are described in the introduction of the report.

For the cohort of companies that met our criteria, public sources were used to collect information including founding date, address, number of employees, annual revenues, and the names and academic backgrounds of company founders and executives. Further, because venture capital is of such importance as a source of funds for entrepreneurial firms, we identified which of the 368 companies in this cohort received venture investments, using data reported in the PriceWaterhouse-Coopers Money Tree Survey for the period January 1996 - July 2002. Venture capital investments were reported for 214 firms in the cohort (59%) over this period.

Initial information about the founders and executives of this cohort of R&D-intensive California communications firms reveals major contributions by the University of California:

- **1 in 6** California R&D-intensive communications companies was founded by UC scientists and engineers;
- **57%** employ UC scientists and engineers in key executive positions;
- **83%** of California R&D intensive communications firms with UC founders received venture capital investments in the past seven years.

It was also found that California's R&D intensive communications firms are young; 65% were founded within the past seven years, and 55% have 200 or fewer employees.

While it is too early to tell how these firms will contribute to the economy in the long run, they represent innovative capacity that may form the basis for future economic development in the state. It should be noted that this study, conducted in spring 2002, provides a snapshot of a fast-changing industry. Annual updates will facilitate analyses of changes over time.

Further work is under way to characterize more completely the linkages between these R&D-intensive, entrepreneurial firms and UC scientists and engineers, and to understand more fully the role the University has played in the emergence and growth of the R&D-intensive communications industry in California. We will also examine the differences across UC campuses in the dates communications-related engineering research centers and education programs were launched, and plot this information against our other findings, to provide a more complete understanding of the relationship between campus programs and industry development. More broadly, further work will address the question of whether relative R&D-intensity in the communications sector is changing, and whether California firms differ from those in other states in the extent to which they focus on research and innovation.

This is a preliminary report, intended to stimulate discussion and spur additional research. We anticipate producing a final report in Spring 2003.

Introduction

Scientific breakthroughs over the past thirty years in the fields of physics, engineering, chemistry and biology formed the basis for new technologies that spurred the growth of entirely new industrial sectors. As this phenomenon has become more widely recognized, investment in research and development, including basic research at academic institutions, is becoming a common element in economic development efforts in California and elsewhere.[6] Although there is a broad consensus about the general benefits of such investment, understanding of the specific means by which such investments contribute to the economy remains incomplete.[7] Economic studies using the most common measures of academic research output, patents and publications, have generally supported the importance of basic research, but provide only an indirect view of the process by which investments in research contribute to economic activity.[8]

This paper describes a pilot study that aims to improve understanding of the increasingly direct role in the economy of public investment in early, discovery research, by assessing the contributions of academic faculty, students and research scientists. The primary focus of the study is the relationships between University of California scientists, and R&D-intensive communications firms in the state. The development of fundamentally new communications technologies, including those related to the Internet, optical networking, satellite communications and wireless networks, has been made possible in part by academic research in information technology, materials sciences, physics and electrical engineering.[9]

The communications industry is made up of companies that provide products, including hardware and software, and services that enable the transmission of voice, data, and other forms of information. Many of these firms sell their wares to telephone companies like Pacific Bell and Internet connectivity firms like AOL, among many others, which in turn sell communications products and services to consumers, businesses and other enterprises throughout the economy. These communications service providers are not included in the study.

This study focuses on the cohort of R&D intensive communications companies in California. An R&D-intensive California communications company is defined as:

> A for-profit entity that has active R&D operations in California, and performs one or more of the following activities:
>
> - Designs, manufactures and/or tests hardware that can be used for the Internet or other large-scale computer networks, including network cards, hubs, repeaters, transceivers, switches, routers and modems
> - Provides Internet backbone, wireless communications or satellite communications services
> - Provides software that improves network efficiency and enables Internet, wireless and other communications activities

The term "company" refers to a business entity that is either an independent enterprise, or an identifiable division or operating unit of a larger enterprise. Thus, TRW Space and Electronics Group is counted as a company, as is Nokia Research Laboratories of San Diego, along with firms like Qualcomm, Broadcom, and PacketLight Networks, Inc.

The initial list of firms was developed using a variety of industry sources. Altogether, over 700 companies were considered for inclusion in this study. A list of data resources used is listed in the Methodology Section, and a complete list of companies considered appears in Appendix D. To the extent that they were identifiable, we included companies that primarily serve the communications or navigational purposes of the military, although coverage of these firms is likely incomplete, both because public information about them is difficult to obtain, and because as defense contractors, their business model may be quite different from other firms in this study. This remains an area for further study.

A Brief Overview of the Communications Industry

The communications industry has greatly evolved since the invention of the telegraph, and later the telephone, both of which were in use well over a century ago. These changes are due to both the development of new technologies and the partial deregulation of the industry, which have had the combined result of a highly competitive, high-risk marketplace.[10]

From Monopoly to Competitive Industry

For the years spanning 1907 through 1982, AT&T and the Bell System operated as a legally sanctioned, regulated monopoly telephone product and service provider for the United States. In settlement of a 1974 lawsuit filed by the US Justice Department and MCI against AT&T, the company was forced to divest itself of its local phone service businesses, as of July 1, 1984, which facilitated competition in telecommunications services and products.[11] Long distance service was further deregulated with the Telecommunications Act of 1996, which lifted restrictions and enabled companies to diversify their involvement in the telecommunications industry. [12] Increased domestic competition and accelerated privatization of former state-owned monopolies abroad have led to the proliferation of alternative carriers providing improved services and lower end-user costs.

Public Investments Drive Creation of the Internet

The advent of the Internet and concomitant developments in computer networking have had equally profound effects on the communications industry. UCLA professor of computer science Leonard Klienrock is widely credited with producing the seminal work on computer networking that laid the foundation for the Internet. His 1962 MIT PhD thesis laid out the basic principles of packet switching and queuing theory, which he continued to develop after joining the

UCLA faculty in 1963. With funding from ARPA (the US Department of Defense Advanced Research Projects Agency) Klienrock's UCLA team created the world's first multi-computer network, involving a data exchange between two computers at the campus in 1968.[13] Thus was launched ARPANET, a tool designed to allow US scientists to share supercomputers for defense-related research, initially by linking between host computers at UCLA, the Stanford Research Institute, UC Santa Barbara, and the University of Utah.[14] Communication via email quickly became one of the most popular uses of the network.

UC Berkeley electrical engineers made several critical contributions during this same period. Most large Internet servers, as well as major academic institutions and businesses, use the UNIX operating system, released commercially by AT&T's Bell Laboratories in 1971. Kenneth Thompson, a Bell Labs research and 1966 graduate of the UC Berkeley electrical engineering department, and his colleague Dennis Ritchie, received the 1999 US National Medal of Technology in part for their contributions to the development of UNIX.[15]

Bill Joy, who came to graduate school at UC Berkeley in 1975, was a principal designer of Berkeley UNIX, and developer of the Berkeley Software Distribution (BSD), a pioneering open-source version of UNIX initially distributed in 1977. Joy earned a master degree in electrical engineering at Berkeley, and went on to co-found Sun Microsystems in 1982. [16]

Important contributions were also made by Stanford professor Vinton Cerf and his colleague Robert Kahn, who published a seminal paper in 1974 specifying the design of a data transmission control program (TCP) that formed the foundation for development of interconnectivity across a wide variety of computers.[17]

The World Wide Web Expands the Impact of the Internet

With support from the US National Science Foundation in the 1980's, many universities became engaged in development and use of the Internet. Also during this period, Tim Berners-Lee and Robert Cailliau at CERN (the European Laboratory for Particle Physics) developed hypertext transfer protocol (http), providing the basis for the World Wide Web.

Scientists at the University of Illinois National Center for Supercomputer Applications developed the first widely disseminated web browser, Mosaic, released in 1992.[18] The mid-to-late 1990's was characterized by a dramatic expansion in the commercial use of the Internet, which fueled the investment boom in Internet-related start-up companies. While the euphoria of 1998-2000 has dissipated, the Internet has become a ubiquitous communications resource used by millions. New software is enabling service providers to automatically manage the bundling of a range of products, such as telephone, cable television, and Internet access.

Innovation And the Evolving Communications Industry

Technological advances over the past few decades have allowed wide scale deployment of fiber optical cables for mass transmission of voice and data over fixed systems, as well as wireless systems for phones, geographic data systems, and Internet access.

Emergence of Wireless Communications

Irwin Jacobs, one of the first faculty members of the UC San Diego department of Electrical Engineering, undertook important research on wireless communications. With UCLA professor Andrew Viterbi, Jacobs founded LINKABIT, an engineering research firm, in 1969. Jacobs left UCSD in 1971 to lead the company full-time. There he directed the development of the first microprocessor-based, spread spectrum, satellite communication modem for military anti-jam airborne applications. Jacobs and Viterbi went on to found QUALCOMM, a leading mobile satellite communications and wireless digital telephony company, in 1985.[19]

Computer Networks Expand Need for Equipment and Software

The expanding use of computers throughout the economy, and the value inherent in linking them together, gave rise to a set of companies that specialize in developing and producing networking equipment and software. Most networking companies, including Cisco Systems, Conexant Systems, and Lucent Technologies, were started up, or, in the latter two cases, spun out from a corporate parent, within the past 25 years.

Many communications components are controlled by specially designed integrated circuits, and standards are needed to ensure the compatibility across products from various vendors. No single technology or set of standards has been universally adopted, however. For example, two standards currently enjoy widespread use in mobile communications – the global system for mobile communications (GSM), serving about 70% of the world's mobile phone users with chips provided largely by Texas Instruments, and code division multiple access (CDMA), 90% of the chips for which are supplied by Qualcomm.[20] Telephony is migrating from circuit-switched analog systems to digital packet-based architecture, similar to that currently used for Internet data traffic.[21]

Continuing Evolution of Communications Tools

The convergence of technology for transmitting voice and data, and the growth in data traffic as compared to voice, has impelled development of a single, integrated transmission system. Concurrent with growing demand for wireless voice service, there is an increasing demand for wireless networking, which has resulted in technologies ranging from local-area wireless networking to wide area satellite networking systems.[22] Wireless systems for local area networking, such as the much-discussed Bluetooth technology, allow users to seamlessly connect

and disconnect with various proximate computer devices. Third generation (3G) wireless networking technology focuses on delivering faster wireless connectivity (2Mbps to stationary users and 384 Kbps to mobile users).[23] While this technology holds potential to deliver greater bandwidth capabilities, and has taken off in Europe and Asia, the United States, which has yet to allocate spectrum for the technology, is not likely to see it take off for several years.[24]

New Frontiers

Other advances in networking include self-organizing networks and intelligent networks. Self-organizing networks are networks of components, such as sensors designed to detect light, temperature, motion and/or toxins, which connect to one another automatically, without human intervention.[25] Intelligent networks aim to improve the way data travels across the Internet by routing traffic through the most cost effective and high performance path versus the shortest path, the method that is currently employed.[26]

Recent Events Affecting the U.S. Communications Industry

While as noted above there is not a specific, universally accepted definition of the communications industry, a broad estimate of industry size can be gained from a U.S. Department of Commerce report showing that the value of shipments of the domestic telecommunications equipment market alone (not including software or services) was $91.5 billion in 1999.[27] The communications sector expanded rapidly in the mid-to-late 1990's, in correlation with the growth of the Internet and wireless telephone usage, but has suffered a dramatic slowdown in recent years along with the other Internet-related sectors.

Industry Weakness Persists

As of September 2002, the communications industry remains financially weak, and the Wall Street Journal's Dennis Berman, among others, attributes the current problems in this sector in part to over-investment in capacity during the late 1990's. At its peak, Berman reports, annual capital expenditures by telecommunications firms exceeded the total value of their sales, compared to the normal investment level of 15%.[28] Nonetheless, some analysts have suggested that the substantial investments in communications and related information technologies that characterized the period 1995-2000 may have contributed to enhanced productivity in many sectors of the economy.[29] Alleged accounting irregularities at major communications carriers WorldCom and Global Crossing have added to the dramatic decline in share prices for public telecommunications firms, casting a pall over the entire sector.[30]

It should be emphasized that this study serves simply as a snapshot of the industry as it stood in March 2002, and future work will be required to examine the long-term economic and technological implications, if any, of the relationships described below between UC scientists and R&D intensive communications firms in the state.

California's Relative Position in the US Communications Industry

California is a world leader in the communications industry.
According to the US Census Bureau, more than 27% of the nation's communications equipment manufacturing workforce is located in California, over 2.5 times the size of the workforce in the next largest state, Illinois. As Table 1 illustrates, this segment of the communications industry provided 291,000 jobs in 2000, of which 78,500 were in California. California firms generated 33% of the total value of communications equipment shipments for the U.S, more than $39 billion.

Venture Capital Investments are Highest in California
California leads the nation in total amount of venture capital invested, and the communications sector has been a major recipient of those investments. Of the $19.2 billion in venture capital invested in US communications-related companies in 2000, California companies received $8.1 billion, or 42%. The state with the next highest level of venture investment, Massachusetts, received $2.2 billion in venture capital investments, or 11% of the total.

California, and to a lesser extent Massachusetts, are unique among the states in that they lead the nation in the total size of the industry as a whole, measured by total employment and sales in the communications equipment industry, as well as in entrepreneurial start-ups, as measured by venture capital investments. Illinois and Florida, in contrast, had high levels of employment, but much less venture capital-backed entrepreneurial activity than the leading states.

Table 1. The Communications Equipment Industry, By State (2000)

State	Employees		Sales		Venture Capital Investments†			
	Number	*% of US*	*Value in $1,000,000*	*% of US*	*Number*	*% of US*	*Value in $1,000,000*	*% of US*
California	78,504	27%	39,096	33%	354	40%	8,123	42%
Illinois	31,027	11%	11,914	10%	19	2%	446	2%
Texas	24,323	8%	12,489	10%	62	7%	1,297	6%
Florida	19,633	7%	5,210	4%	20	2%	663	3%
Massachusetts	18,047	6%	10,795	9%	93	10%	2,179	11%
All others	119,588	41%	39,824	33%	310	35%	5,258	27%
U.S. Grand Total	291,122	100	119,328	100	884	100%	19,210	100%

Source: U.S. Census of Manufactures 2000. U.S. Bureau of the Census. February 27, 2002.
†Venture Capital Investment data are for Q4 1999 – Q3 2000, for the categories Networking & Equipment and Telecommunications

While these data reflect only those firms categorized as communications equipment manufacturers, other telecommunications industry data paint a similar picture. For example, the Telecommunications Industry Association, a prominent industry group, reported in June 2002 that it had 800 members throughout the U.S., 223 (28%) of which are located in California. Overall, there are at least fifteen major industry groups that represent various segments of the telecommunications and networking industry, often organized around developing a particular set of standards, or legislative advocacy. A representative list is presented in Appendix A.

California's Communications Start-ups Continue to Attract Venture Capital

The continued interest of venture capital investors in California communications firms, given the chilly financial climate of 2002, may be an indicator of the perceived growth potential for these firms. A review of recent venture capital investment in the communications equipment and software industry shows that together, Silicon Valley, Los Angeles, and San Diego attracted 53% of the investment dollars, in 42% of the deals. Strong competing sectors include the Greater Boston area, the New York Metro Region, and the state of Texas.

As can be seen in Table 2, which presents data from the PriceWaterhouse-Coopers Moneytree Survey showing counts of deals and the total dollars by region for July 2001-June 2002, these six regions alone accounted for more than 80% of the venture investment, and 70% of the deals.[31]

Table 2. Communications and Networking-related Venture Deals July 2001-June 2002.

Region	*Number of Deals*	*%*	*$ Amount (millions)*	*%*
Silicon Valley	113	27	1,124	31
Greater Boston Region	54	13	501	14
New York Metro Area	40	9	351	10
Texas	32	8	440	12
Greater Los Angeles Region	25	6	260	6
San Diego	13	3	121	3
All Others	144	34	945	26
Total	421		3,680	3,680

Source: PriceWaterhouseCoopers Moneytree Survey of Venture Capital firms, Q3 01- Q2 02.

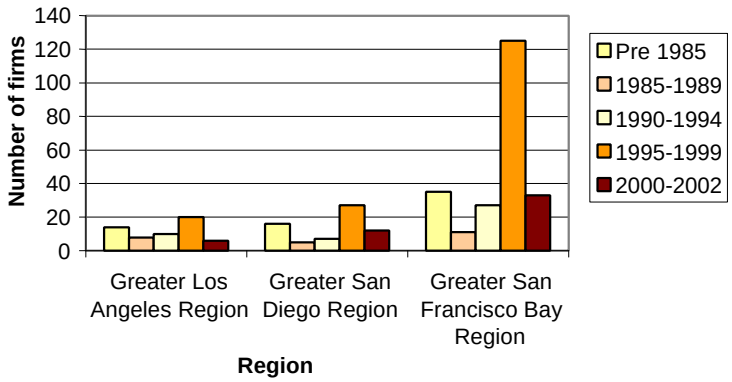
Initial Findings of the California R&D-intensive Communications Industry Study

This study examines companies in business as of March 1, 2002, and is best viewed as a snapshot of the state of the industry at that time. Annual updates will allow analyses of changes over time.

The California R&D-intensive Communications Industry is Young

One of the most prominent features of the California R&D-intensive communications cohort is that the companies are generally young. The majority of R&D-intensive communications firms that were in operation in California as of March 1, 2002, were founded between 1995 and 1999 (51%); 14% were founded in the period 2000-2002, and just 35% were founded before 1995. As can be seen in Figure 1, which shows data for the 357 companies that report their founding date, the greatest number of R&D intensive communications firms founded in California in the late 1990's were located in the Greater San Francisco Bay Area, primarily in the Silicon Valley. Although the rate of new firm establishment has cooled across the state, this area still hosts the largest number of start-ups.

Figure 1. California R&D-Intensive Communications Firms, By Date Founded and Region (n=356)



Altogether, as of March 2002, there were 231 R&D intensive communications companies located in the Greater San Francisco Bay area, comprising 65% of the entire cohort, with 67 located in the Greater San Diego Region (19%) and 58 in the Greater Los Angeles Region (16%).

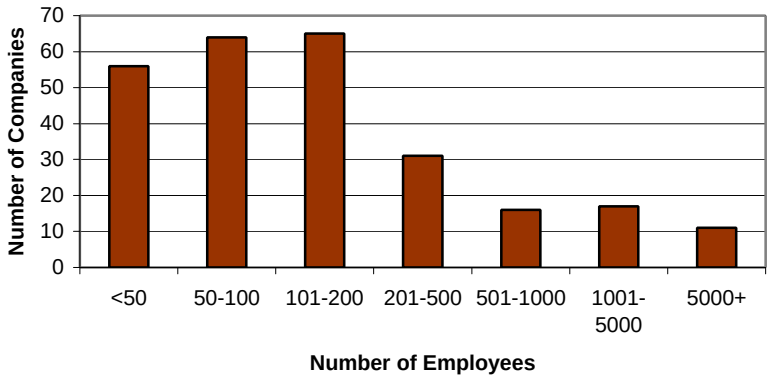
Most R&D Intensive Communications Firms are Small

As might be expected in an industry sector characterized by young companies, the members of the California R&D-intensive communications cohort are generally small, both in terms of the number of people they employ, and with respect to their total revenues

Employment

The US Small Business Administration defines a small business as one that employs 500 or fewer people. As Figure 2 illustrates, 260 companies in the cohort reported how many people they employed in 2001, and of these, 216 (83%) met the US government's definition of a "small business," employing 500 people or fewer. Fifty-six companies (22%) reported fewer than 50 employees.[1]

Figure 2. Most California R&D-Intensive Communications Firms Have 200 or Fewer Employees (n=260)

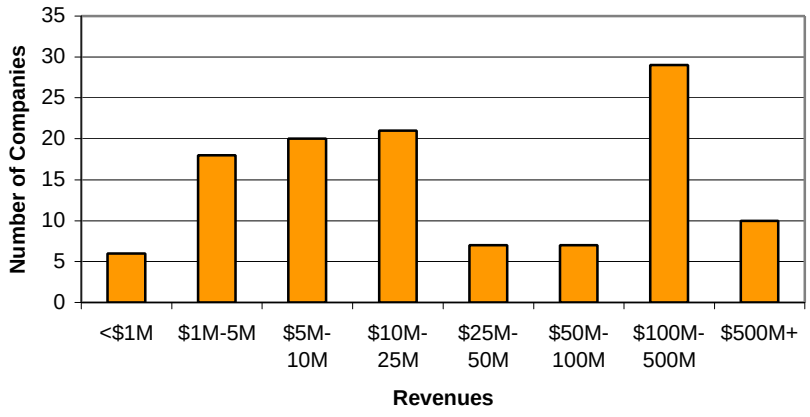


It should be noted that the figures reported encompass all employees of these companies, worldwide, not just those located in California. Altogether, these firms employed 408,000 people. It is hard to discern exactly how many of these employees are in California, as just 135 firms report California-specific numbers. For these firms, total 2001 employment in the state accounted for 48% of their overall employment, or 67,500 out of 139,400.

Revenues

Total revenue is another commonly used measure of company size. Only companies with publicly traded stock are required to provide this information, however, which limits the availability of revenue data for this cohort since only 118 are public companies. Even for this limited sample, however, it can be seen in Figure 3 that many firms in this cohort had relatively limited

Figure 3. California R&D-Intensive Communications Companies By Annual Revenues (2001) (n=118)



[1] These data are the most recent reported by firms, with 204 observations from 2001 and 56 from 2002.

revenue streams in 2001, with 39 (37%) reporting revenues of $10 million or less. This is similar to the situation for other R&D-intensive industry cohorts such as biotechnology, in which companies engaged in the research and development activities required to bring innovations to market may not generate significant revenue streams through their operations. Funding through other mechanisms is of particular importance to these firms' ability to sustain their businesses until their new products, processes or services reach the market.

UC Contributes to the Establishment and Growth of California's R&D Intensive Communications Firms:

Business Formation

The R&D-intensive communications sector in California is characterized by a substantial number of entrepreneurial small businesses, as illustrated in the previous section. The University of California has been a major contributor to the establishment of new firms in this sector, through undergraduate and graduate education, as well as faculty and postdoctoral research. Of the 189 businesses that provide information on the educational background of company founders, more than 30% of companies had founders with UC degrees, postdoctoral appointments or faculty positions. Using the most conservative possible estimate, 57 out of the 356 (16% or 1 in 6) companies in the cohort were founded by UC alumni, postdocs and/or faculty.

Table 3. Academic Affiliation of California R&D-Intensive Communications Company Founders

	Number of Companies
UC Founders	57
No UC Founders	129
No Data	170
Total Firms in Cohort	356

The contributions of University of California scientist-entrepreneurs are particularly striking when viewed in the context of the number of California R&D intensive communications firms founded by Stanford University scientists. As a private institution that has been credited with launching the high tech industry in the Silicon Valley, it is not surprising to see that Stanford scientists are well represented among the founders of firms in this cohort.

Based on the data available in this study however, it appears that more R&D intensive communications firms in California were founded by scientists affiliated with a single UC campus, Berkeley, than by those with Stanford affiliations.

Table 4. California R&D-Intensive Communications Companies – Comparison of UC Berkeley versus Stanford as a Source of Founders

Institutional Affiliation of Founder(s)	*Number of Companies*
University of California, Berkeley	33
Stanford University	30
Both UC, Berkeley and Stanford	(3)
Subtotal	60
Total Companies With Known Founder Affiliations	181

Altogether, 60 companies in the cohort reported founders affiliated with one or both of these

institutions. As Table 4 illustrates, 33 of these companies have founders who are UC Berkeley alumni, postdocs or faculty, compared to 31 companies with founders similarly affiliated with Stanford. There are four cases in which companies have founders with links to both institutions.

Executive Leadership

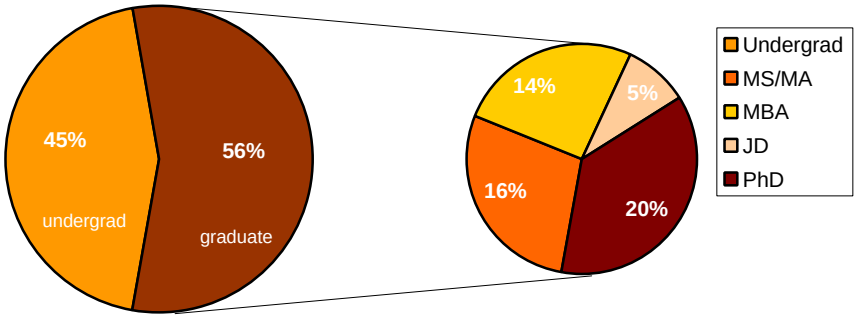
Talented executives play an essential role the success of any business, but such leadership is of critical importance for start-up companies, particularly those engaged in the high risk research and development of innovative new technologies.

The UC contribution to R&D intensive communications firms is particularly evident among key executives employed by these companies. Fifty seven percent of the 268 companies in this cohort that report the academic background of their key executives employ UC alumni, postdocs and faculty in these important leadership positions. Altogether, 253 UC alumni, postdocs and faculty have been identified as playing leading executive roles at 153 (57%) R&D-intensive communications companies in California. This number includes those who serve as Chairmen of the Board.

An additional 26 UC alumni and faculty serve as technical advisors (6) and corporate board members (20). A list of positions held by all UC alumni, postdocs, research scientists and faculty can be found in Appendix C. As most companies in this cohort are young, it is not surprising that the founders are often directly involved in the operation as executives. The study population includes 65 UC scientists who are both founders and executives of cohort companies.

These data certainly understate the number of UC alumni, postdocs and faculty serving as executives, because they reflect only the 268 companies (72% of the total) in the cohort that provide information on the educational backgrounds and faculty appointments of executives. The relevance of graduate education at UC

Figure 4. Of the 253 Executives at R&D-intensive Communications Companies with UC Degrees, 56% have UC Graduate Degrees
n=236 people at 153 companies



Note: Only the highest UC degree each person earned is reflected here, so that people with multiple UC degrees are counted once.

to these companies is clear, though, as 131 of the individuals identified hold PhD, masters, and/or business or law degrees from UC.

As can be seen in Figure 4, which depicts the percentage of these executives by the highest UC degree earned, the PhD is the largest single category of graduate degree (20%), followed by masters in science and engineering (16%). There is almost no overlap between UC graduate degrees in science and engineering, and the professional degrees in business (MBA) or law (JD); only two people in the study reported holding both. There were five instances of people with UC MBAs reporting UC undergraduate degrees in engineering. It should be noted that since this analysis focuses solely on UC degrees, it does not reflect any graduate study these UC alumni may have undertaken elsewhere. In addition, this set of executives includes twelve current and former UC faculty members, of whom 6 also hold UC degrees.

Not surprisingly, electrical engineering and computer science degrees are the most common among the members of this group, especially among those with PhD and masters degrees. As Table 5 illustrates, this is also the discipline from which UC faculty who serve as executives to companies in this cohort have been drawn. While there is more variety among the disciplines in which people earned undergraduate degrees, 120 of 157 UC undergraduate degrees reported (77%) were in engineering or closely related fields. The social sciences and humanities group includes 15 undergraduate degrees in economics, six in history and two in English, as well as one each in political science, sociology, and psychology.

Table 5. Academic Discipline of UC degrees held by Executives of California R&D-Intensive Communications Firms

	Degree					
Academic Discipline	TOTAL	Under grad	MBA/JD	MA/MS	PhD	Faculty
Electrical Engineering/Computer Science	172	73		49	39	11
Business Administration/Law	59	11	48			
Physics/Math/Other Engineering fields	58	43		10	4	1
Social Sciences/Humanities	27	26		1		
Biological sciences	5	4			1	
Grand Total	321	157	48	60	44	10

Eight UC campuses are sources of California R&D-intensive communications firms' leaders

The 279 UC scientists and engineers identified in this study have been drawn from eight of the ten UC campuses, and two of the UC-managed National Laboratories. The two campuses not represented in the academic backgrounds of the founders and executives of the companies in this cohort are UCSF, which is dedicated solely to graduate and professional study in the health sciences, and the newest campus, UC Merced, which will open in 2004. The distribution of linkages across UC campuses and laboratories is shown in Table 6, in which

these institutions are ranked by the number of people who are founders and/or executives of companies in the cohort, who have degrees and/or faculty or research appointments from that institution. The total number of links shown, 289, exceeds the total number of individuals, 279, because some people have earned degrees and/or held faculty appointments at more than one campus. Because this analysis focuses on people, not companies, a person who has participated in multiple firms is counted only once.

Berkeley is the leading campus source of both founders and executives, but Los Angeles, Santa Barbara, and San Diego are also strongly represented. Some insight into the relative distribution can be gained by considering the age and size of the Engineering schools or programs at each campus, although this view is limited because reflects all fields of engineering because comparable communications-specific data was not available. As can be seen in Table 7, Berkeley has the oldest and largest Engineering school, followed by Los Angeles.

Table 6. UC Campus Source of California R&D-Intensive Communications Firms' Founders and Executives

Campus/Lab	*# of People/Institution Links*
Berkeley	132
Los Angeles	59
Santa Barbara	31
San Diego	23
Davis	19
Santa Cruz	9
Irvine	8
Riverside	1
Unspecified Campus	5
Lawrence Berkeley*	1
Lawrence Livermore*	1
Grand Total	289

**UC-managed National Laboratories*

Two of the younger campuses are particularly noteworthy. The strong performance of the UC San Diego campus, despite the relatively recent launch of its engineering school, is a reflection of the exceptional efforts the campus leadership has made to enhance the role the campus plays as a driver on the local R&D-intensive economy. Leaders at the Santa Cruz campus, which has the newest Engineering school, also have taken an aggressive approach to strengthening the linkages to R&D-intensive industry development.

Table 7. UC Engineering Schools/Programs

Campus	Year Established	*2002 Enrollment*	
		Undergrad	Graduate
Berkeley	1942	2610	1400
Los Angeles	1945	2707	1166
Santa Barbara	1961	1000	500
Davis	1962	3313	800
Irvine	1965	2000	400
San Diego	1982	3855	853
Riverside	1989	1600	200
Santa Cruz	1997	1075	160

Conclusions

The communications sector of the economy has experienced dramatic changes over the past five years. Currently, in the winter of 2002-03, telecommunications service providers and equipment manufacturers are suffering severe losses stemming from a combination of over-investment in transmission capacity, and opportunistic accounting practices designed to hide the resulting losses from investors. Unlike the services and bulk manufacturing segments, however, the R&D-intensive segment of the communications industry has remained relatively strong, and is a source of continuing innovation that is likely to contribute to future economic development.

In this study, we examined the set of such firms located in California, and assessed the importance of University of California scientists and engineers in the formation of firms, and in their ongoing operations. We found that UC alumni and faculty have been key contributors to this economic sector, both in founding new companies and in providing leadership as executives. While more work remains to be done on examining campus linkages in greater detail, and in characterizing more completely the career paths of these entrepreneurial UC scientists, it is very clear that the University of California has played an essential role in the emergence and growth of this sector. This study provides a snapshot of the industry as of March 2002, and annual updates will allow us to track and analyze changes over time.

End Notes

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Appendix A. Methodology

California-based communications companies were screened to identify those that provide communications-related equipment and software and engage in research and development activities. It was determined that SIC/NAICS codes are not meaningful criteria to use in filtering. The U.S. Department of Commerce, in its U.S. Industry & Trade Outlook 2000 publication, for example, includes only companies with SIC codes 3661 (telephone and telegraph apparatus) and 3663 (radio and television broadcasting and communications equipment) in its definition of telecommunications and navigation equipment. A related cluster analysis conducted by the San Diego workforce development agency includes, in addition, SIC codes 3669 (communications equipment), 4812 (radiotelephone communications), 4813 (telephone communications), 4899 (communications services), 8711 (engineering services), and 8731 (commercial physical research) in its definition of the communications industry.[i]

Data Sources

Company names were gathered from the following sources:

- Private sponsors of Communications Research (CoRe) IUCRP projects;
- California-based members of the Telecommunications Industry Association;
- Members of the San Diego Telecom Council;
- California companies listed as having received venture funding in the PriceWaterhouseCoopers MoneyTree survey of venture funding for quarters Q3 1999 through Q3 2000; and
- Companies listed by Hoover's Online in the following four classifications: Hoovers: Computer Hardware – Networking & Communication Devices; Hoovers: Computer Software - Network and Connectivity; Hoovers: Telecom – Switching and Transmission Equipment; and Hoovers: Telecom – Wireless, Satellite and Microwave.

Information on companies was gathered through publicly-available sources, including Securities and Exchange Commission filings, company web sites, business information web sites, such as Hoover's Online and CorpTech, news articles, and press releases.

Screening Criteria

Companies were screened to ensure that they are California based, engaged in research and development, and focus on the communications industry.

<u>California based</u>
Companies must have a California headquarters, research and development, or manufacturing facility.

<u>Research and development focus</u>
Companies must have research and development activities. This was screened based on a variety of information, which could include whether there were research positions at the company, whether the company developed proprietary or patented technology or had research and development facilities, and the share of research and development expenditures of total expenditures.

<u>Closeness of tie to communications industry</u>
As many large companies engage in some communications related business, companies were screened to identify those that primarily engage in business related to communications. This was assessed based on the share of a company's business that was derived from communications

activities and/or a company's stated ambition to focus on the communications industry. For diversified companies, business units that focus on communications were screened.

Meet sector criteria

Companies were screened to identify those that provide hardware and/or software that can be used for communication. Notably, companies that provide "commoditized" products (passive hardware and consumer software) and services, such as voice-only telephone service, internet access, web hosting, and telephone handsets, were excluded. Online services, such as search engines and/or **content** sites and online training were excluded, as they were not understood to be part of the communications infrastructure. Included were companies that perform the following functions on behalf of communication services providers, households, or enterprises:

- Design, manufacture, and/or test hardware that can be used for the Internet, including network and telecommunications equipment (network interface cards, hubs, repeaters, trancievers, switches, routers, modems, etc.) that is upstream of Internet appliances;
- Provide backbone or satellite communication services; and
- Provide software that improves network efficiency and enables Internet and wireless communication activities.

Appendix B. Communications Industry Trade Associations and Related Groups

American Electronics Association (AEA)
CDMA Development Group (CDG)
Cellular Telecommunications & Internet Association (CTIA)
Competitive Telecommunications Association (CompTel)
Institute of Electrical and Electronics Engineers (IEEE)
Internet Engineering Task Force (IETF)
Internet Society
MMTA (now part of TIA)
National Cable & Telecommunications Association (NCTA)
North American Network Operators' Group (NANOG)
Pacific Telecommunications Council
San Diego Telecom Council (SDTC)
Telecommunications Industry Association (TIA)
United States Telephone Association
Wireless Communications Alliance
Wireless Communications Association International (WCA)

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[i] San Diego Workforce Partnership, Inc., page 24. August 2001.

Appendix C. Executive Positions held by UC Alumni, Faculty and Research Scientist At California R&D-Intensive Communications Firms†.

Category	*Position*	*Total*
Founder	Founder	71
President/CEO/COO	President & CEO	26
	President	10
	Chief Executive Officer	7
	Chief Operating Officer	5
	Chairman & CEO	1
CSO/CTO	Chief Technical Officer	38
	Chief Scientist	3
R&D	Vice President, Engineering	32
	Vice President, Product Development	6
	Vice President, Research & Development	3
	Vice President, Technology	3
	Vice President, Network Science	1
	Vice President, Software	1
	Vice President, Strategy	1
	Vice President, Systems Development & Integration	1
	Director of Product Development	1
	Director, Engineering	1
	Director, Operations	1
	Director, Software Development	1
	Director, Test, Yield, and Reliability	1
	Principal Engineer	1
Advisors	Technical Advisory Board	5
	Consultant	1
Corporate Board	Corporate Board	25
	Chairman of the Board	15
	Corporate Secretary	5
Executives	Vice President	19
	Senior Vice President	15
	Executive Vice President	8
	Vice President, Operations	7
	General Manager	5
	General Manager, Communications Business Group	2
	Chief Development Officer	1
	General Manager, Access Products Division	1
	General Manager, Networking Division	1

	General Manager, Transport Division	1
Business Development	Vice President, Business Development	4
	Vice President, Corporate Development	4
	Senior Vice President, Business Development	2
Finance	Chief Financial Officer	18
	Vice President, Finance	7
	Controller	5
	Vice President, Finance and Administration	2
	Director of Finance	1
Human Resources	Vice President, Human Resources	5
	Director of Human Resources	1
Information Technology	Chief Information Officer	1
	Vice President, Information Systems	1
	Vice President, Infrastructure	1
Legal Affairs	General Counsel	12
	Vice President, General Counsel	2
	Vice President, Legal Affairs	1
Manufacturing	Vice President, Manufacturing	2
Sales and Marketing	Vice President, Marketing	13
	Vice President, Worldwide Sales	5
	Vice President, Sales	3
	Director of Marketing	2
	Senior Vice President, Sales	1
	Sales Manager	1
	Director, Sales	1
	Senior Scientist	1
Grand Total		**422**

†Each position held is counted separately; a total of 279 UC alumni, postdocs, research scientists and faculty are represented in this table.

Appendix D. All communications-related companies considered for inclusion in the California R&D-Intensive Communications companies 2002 cohort.

@Road Inc.
2Wire, Inc.
3Com Corporation
3G Cellular, Inc.
3GCom Wireless
3ParData Inc.
A&R Telecom Inc.
Accelerated Networks, Inc.
Accenture
AccessLan Communications, Inc.
Accordion Networks
Actelis Networks, Inc.
Action Consulting
Adaptec, Inc.
Adaptive Broadband Corporation
Adicom Wireless, Inc.
ADTRAN
Advanced Fibre Communications, Inc.
Advanced Remote Communications Solutions, Inc.
AdventNet Inc.
Aeris.net
Aerocast
Agilent Technologies
Agility Communications, Inc.
AIMetrix Inc.
AirFiber, Inc.
AirPrime Inc.
Alexis Communications Inc.
Alidian Networks
All Optical Networks, Inc.
Allegro Networks
Allen Tel Products
Alliance Fiber Optic Products, Inc.
Alloptic
Allot Communications, Inc.
Aloha Networks
Alps Electric (USA) Inc.
Alteon WebSystems, Inc. (subsidiary of Nortel Networks)
Altium Technologies, Inc.
Alvarion, Inc.
Alvesta
Alysida Solutions
Amber Networks
AMCC (Applied Micro Circuits Corporation)
America's Network
AML Communications, Inc.
Anda Networks
Anritsu Company
Aperto Networks
Arca Technologies
ArrayComm, Inc.
Arroyo Opotics
Asante Technologies, Inc.
ASAP Telecommunications Services
Asita Technologies
Asquare Communications
Astroterra Corp.
Astute Networks
AT&T Corp
AT&T Wireless Services Inc.
Atoga Systems
Atreus Systems
Aurora Networks
Avanex Corporation
Avistar Communications Corporation
Axiom Technology, Inc.
Axon Photonics Inc.
Azanda Network Devices Inc.
B2C2 Inc.
Badger Technology, Inc.
Bandwidth Place
Bandwidth9 Inc.
Bang Networks
Bay Microsystems Inc.
Be Vocal Inc.
BEA Systems, Inc.
BeamReach Networks, Inc.
BeeLine Networks Inc.
Benner-Nawman, Inc.
Big Bear Networks
Blaze Network Products
BP Solar Inc.
Brecis Communications
BridgeWave Communications Inc
BrightCom Technologies, Inc.
Brightlink Networks Inc.
Broadband Innovations, Inc.
Broadcom Corporation
Broadlink Communications Inc.
BroadLogic Inc
Broadxent, Inc.
Brocade Communications Systems, Inc.
Business Connectivity Company (subsidiary of 3Com)
Business Networks Company (subsidiary of 3Com)
CacheFlow Inc.
Cadtel Systems, Inc.
Calient Networks, Inc.
California Amplifier, Inc.
Calix
Calmar Optcom
CALY Networks
Campio Communications (now Corona Networks)
Candle Corporation
Canesta Inc.
Canoga Perkins Corp.
Carlson Wireless Technologies, Inc.
Carrier Access Corporation
Casio Phonemate, Inc. (now Casio Communications, Inc.)
Caspian Networks
Castelle
Castle Access
Catapult Communications Corp.
Catena Networks
CDMA Development Group
Cell-Loc Inc.
Cellular Networking Perspectives
Cemip Networks, Inc.
Centerpoint Broadband Technologies
Centillium Communications, Inc.
Ceon Corporation
Certicom Corp.
Channell
Chip2chip
Chromisys Inc
Cidco Incorporated
CIENA Corporation
Cierra Photonics
Cinta Networks Corporation
Cisco Systems, Inc.
Coactive Networks
COLO.COM

Com Dev Wireless
Com21, Inc.
Communications Manufacturing Co.
CommWorks Corporation (subsidiary of 3Com)
Compliance International
Composite Optics Inc
Computer Telephony Institute
Comstellar Technologies, Inc.
Concio Telecom Business Unit
Conductus, Inc.
Conexant Systems, Inc.
Continuous Computing Corp.
CON-X Corporation
Copper Mountain Networks, Inc.
CopperCom
Cordell Inc.
Correlant Communications
Corrigent Systems
Corvia Networks, Inc.
CoSine Communications, Inc.
CoWave Networks Inc.
Cox Communications, Inc.
CP Technologies
Cplane, Inc.
CSI Telecommunications
CTLINK, LLC
Cubic Communications, Inc.
Cubic Corporation
CyberDog Communication Inc.
Cyberlane Inc.
Cyfuse
Cygent, Inc.
Cyras Systems Inc.
Dashbit Incorporated
Data Connection Corp.
MetaSwitch
Datron World Communications
Davidson Consultants
DCM Industries, Inc.
Denso International America, Inc.
Derivation Systems Inc.
Diablo Research Inc.
Digital Archway Inc.
DMC Stratex Networks, Inc.
Dokoni, Inc.
Dot Wireless, Inc.
DPS Telecom
D-Star Technologies Inc.
Dynarc, Inc.
E20 Communications, Inc.
Echelon Corporation
Ecom2Ecom
Element 14 Inc.
Ellipsis Digital Systems
Empowertel Networks
Emulex Corporation
Endwave Corporation
Energy Science Laboratories, Inc.
EngineX Networks Inc.
Ensemble Communications, Inc.
Entrada Networks, Inc.
Entropic Communications
Enuvis Inc.
Epic Cycle
Epoch Internet (formerly Epoch Networks)
Equinix Inc.
Ericsson
Ericsson Wireless Communications
ESRI Inc.
Excelsus Technologies, Inc.
Excess Bandwidth Corporation
eXchange Colocation, LLC
Express Touch Inc.
Extreme Networks, Inc.
FARTECH, Inc.
Fiber Network Engineering
FiberYard
Filanet Corp.
Finisar Corporation
First Virtual Communications, Inc.
Flextronics
Force10Networks Inc.
Fortel Inc.
Foundry Networks, Inc.
Foxconn
FTR&D LLC
Fujant, Inc.
Fuji Electric Co., Ltd.
FunCaster.com
GA eXpress
Gadzoox Networks, Inc.
GarrettCom
General Atomics
Geneva Business Research Corp.
Genoa Inc.
Geoworks Corporation
Glimmerglass Networks Inc.
Global Atmospherics, Inc.
Global Locate
Globalstar
Globe Wireless LLC
Gluon Networks, Inc.
GM Corporation
GNP Computers
GoDigital Networks Corporation
GoSMS.com, Inc.
GraphOn Corporation
Graviton, Inc
GTRAN Inc.
GuardDog Communications
Halfdome Systems, Inc.
Hankin Investment Banking
Harmonic Inc.
Harris Corporation
Hendry Telephone Products
hereUare Communications
Hewlett-Packard
Highlander Engineering, Inc.
Hill & Knowlton
Holocom Networks
HomeRelay Communications, Inc.
Hughes Network Systems
Hybrid Networks, Inc.
iAsiaWorks (formerly AUNET Corporation)
IBM Wireless Solutions
ICC
Iconn Wireless Inc.
ICS Advent
Ideal Industries, Inc.
IMC Networks
Incode Telecom Group, Inc.
indiCast.com
InfoPrise
InfraSwitch Inc
Ingram Micro Corporation
Inktomi Corporation
Innomedia
Instant InfoSystems
Integrated Micromachines Inc.
Integrated Telecom Express Inc
Intel Corporation
Intelligent Fiber Optic Systems
Interactive Telesis, Inc.
Intergraph
Interon Networks, Inc.
Interoperable Wireless
Intersil Corp.
Intira Corporation
IP Unity
IP Wireless
iPass Inc. (formerly i-Pass Alliance Inc.)
ipVerse
iSeeTV

Ishoni Networks Inc. (formerly HiQ)
iVMG Inc.
IXIA Communications
Jabra Corporation
Jarna Inc.
Jasmine Networks, Inc.
JAYCOR
JDS Uniphase Corporation
JetStream Communications Inc.
JNI Corporation
Juniper Networks, Inc.
K2Optronics
Kagoor Networks Inc.
Kasenna
Kawajiri & Associates
Kendin Communications
Kenwood Communications Corp.
Kestrel Solutions Inc.
Knurr
KRON
Kyocera America Inc.
Kyocera DDI Institute of Future Telecommunications
Kyocera Wireless Corporation
Lantelligence, Inc.
Lantern Communications Inc.
Lantronix, Inc.
Larscom Incorporated
Laser Power Corp.
Latitude Communications, Inc.
Leap Wireless
Legato Systems, Inc.
LG InfoComm U.S.A., Inc.
LGC Wireless Inc.
Light Connect Inc.
Lightcross Inc.
LightLogic
LightPointe
Lightwave Microsystems Corp.
Linksys Group, Inc.
Littlefeet, Inc.
Logic Innovations Inc.
LongBoard, Inc.
LSI Logic
LTK Cable Technology, Inc.
Lucent Technologies
Lumenare Networks
Luminent, Inc.
Luminous Networks
Lumos Technologies Inc.
Luxcom, Inc.
LuxN, Inc.
LynuxWorks, Inc.
Lynx Photonic Networks
magic4
Magis Networks, Inc.
Mahi Networks
Malibu Networks
Maple Optical Systems
Mariner Networks, Inc.
Marvell Technology Group Ltd.
Matsushita Electric Works, R&D Ltd.
Maxima Corporation
Mayan Networks
mDiversity Inc.
MediaQ
MegaSys Computer Technologies
Merge Technologies Group Inc.
Merlin Systems (now Redback Networks)
Metric Equipment Sales
Metro Tel Corp.
Metro-Optix
Micro Linear Corporation
Micromuse Inc.
Microtest, Inc.
Minerva Networks
Mitsubishi Wireless - MCTC
Mobera Systems Inc.
MobileID Inc
MobileSys Inc.
Mobilygen Corp.
Mockingbird Networks
ModeTek Inc.
Morphics Technology
Motorola Broadband Communications Sector
MRV Communications, Inc.
MS Technology
National Technical Systems (NTS)
NeoPoint, Inc.
Net Connection Corp.
net.com
NETCENTREX
NetContinuum Inc.
Netergy Microelectronics
NETGEAR Inc.
NetManage, Inc.
Netopia, Inc.
Netro Corporation
NeTrue Communications, Inc.
NetScreen Technologies, Inc.
Network Alchemy
Network Associates, Inc.
Network Equipment Technologies, Inc.
New Focus, Inc.
New Horizons Computer Learning Ctrs
New Tone Communication Corp.
Newmar
Newport Communications Inc.
Nexsi Corporation
Next Level Communications, Inc.
Nextel Communications
Nightfire
Nishan Systems, Inc.
Nokia Mobile Phones
Nokia Research Center
Nortel Networks, Ltd.
Novalux
Novatel Wireless, Inc.
Nuera Communications, Inc.
NxtWave Communications
Occam Networks, Inc.
Oluma, Inc.
OMM, Inc.
OmniSky Corporation
Omnitron Systems Technology, Inc.
Ondax Inc.
ONI Systems Corp.
Onix Microsystems Inc.
OnPrem Networks Corp.
Open Systems Consulting
Open Telephone Networks
Openwave Systems Inc.
Oplink Communications, Inc.
Opthos Inc.
Optibase Inc.
Optical Coating Laboratory, Inc.
Optical Communication Products, Inc.
Optical Micro-Machines
Optical River Systems, Incorporated
OptiMight Communications Inc.
Optobahn
OpVista
Orincon Corp.
Orincon Technologies, Inc.
Ormet Corp.
OSE Systems, Inc.
OTELNET
Pacific Bell
Pacific Blue Micro

Packet Design, Inc.
Packet Machine
PacketAir Networks
Packetcom Inc.
Packeteer, Inc.
PacketLight Networks Inc.
PacketVideo Corporation
Pagoo Inc.
Palomar Technologies
Paradigm Wireless Systems Inc.
Path 1 Network Technologies Inc
Patriot Scientific Corporation (PTSC)
Patton & Associates, Inc.
P-Com, Inc.
P-Cube
Peerless Systems Corporation
Pentech Solutions, Inc.
Peregrine Semiconductor
PerkinElmer Optoelectronics
Personal Telecommunications Tech
PhatPipe
Philips Semiconductors
PhiloMetron
Photon Research Assoc., Inc.
Pioneer Magnetics, Inc.
PlaceWare, Inc.
Platforms Wireless international
Pluris, Inc.
Polaris Networks, Inc.
Polexis, Inc.
Polycom, Inc.
Power Acumen, Inc.
PowerWare Corp Small Systems Group
Powerwave Technologies, Inc.
Praja, Inc.
Praxon
Primex Manufacturing LTD.
Proxim, Inc.
Pulse~LINK, Inc.
Q Microwave
QLogic Corporation
QThink
Quake Global, Inc.
Qualcomm, Inc.
Quality Power Systems
Quantum Magnetics, Inc.
Quasar
QUEST
Quick Eagle Networks Inc
QuickSilver Technology Inc.
Racal Instruments Inc.
Radian Heatsinks, a division of Intricast Co., Inc.
Radio Local Area Networks Inc. (RadioLAN)
Radix Technologies, Inc.
RADLAN Inc.
RAM Laboratories, Inc.
RangeStar Wireless
Rapid5 Networks Inc.
RC Networks, Inc.
Redback Networks Inc. (fka Merlin Systems)
RedWire Broadband
REGAL Electronics, Inc.
REMEC CSH (Subsidiary of REMEC, Inc.)
REMEC Magnum (Subsidiary of REMEC, Inc.)
REMEC Wireless (Subsidiary of REMEC, Inc.)
REMEC, Inc.
Repeater Technologies, Inc.
Reversi Networks
RF Industries, Ltd.
RF Magic
Rhapsody Networks Inc.
RHK Inc.
RIFOCS Corporation
Riverstone Networks, Inc.
Rohm LSI Systems
Sage Instruments, Inc.
Sage Systems, Inc.
Salira Optical Network Systems
San Diego Data Processing Corporation
San Valley
Sanyo Fisher Company
Satellite Security Systems of North America, LLC
SBE, Inc.
SBS Communications Group
SBS Technologies, Inc.
SchlumbergerSema
Science Applications International Corporation (SAIC)
SCS Corp.
Seiko Instruments USA, Inc.
Sempra Communications
Sensoria Corporation
Sentica Corporation
Shoreline Teleworks
Siemens Corporation
Siemens Information & Communication Mobile LLC
Sigma Networks Inc
Signia Technologies
Silicon Automation Systems Inc.
Silicon Wave, Inc.
Simulation Magic
SiRF Technology Inc.
SIWAVE Inc.
SkyDesk
SkyRiver Communications, Inc.
SkyStream Networks Inc.
SL Corporation
SmartPipes, Inc.
SnapTrack a Qualcomm Co.
Socket Communications, Inc.
Solus Micro Technologies Inc.
SonicWALL, Inc.
Sonik Technologies Corporation
Sonoma Systems
SONY WTD
Sorrento Networks Corporation
Sorrento Telecom Inc.
Sound Advantage, LLC
Southampton Photonics
Space Electronics Inc.
Sparkolor Corporation
Special Order Systems
SpectraSwitch Inc.
Spectrian Corporation
Spraylat Corporation
Sprint Business
SS8 Networks, Inc.
SSE Telecom, Inc.
ST Microelectronics
Stanford Microdevices Inc.
StarVox Corporation
Stellcom, Inc.
STM Wireless, Inc.
StoragePoint Corp.
StorageWay
Strix Systems Inc.
Success Capital Partners
Sunrise Telecom, Inc.
Superconductor Technologies Inc.
Sylantro Systems Corp.
Symbian Inc.
Symmetry Communications Sys.
Synaxia Networks Inc.

Syndeo Corporation
Synopsys Inc.
Tacan Corp
TAHOE Networks
Talarian Corporation
Tao
Tarantella, Inc.
TCI International, Inc.
TCSI Corporation
Technoland, Inc.
Technology Marketing Partners
Technology Trends, Inc.
Tekelec
TekInsight.com, Inc.
TelcoBuy.com
Telcom Data, Inc.
Telecompetition, Inc.
Telefonix
Telenetics Corporation
Telenor Wireless
Telera Communications (Formerly CallNet Communications)
Telesys Software Inc.
Telewise Communications, Inc.
Tellus Technology
TELMEX USA, L.L.C.
Telseon
Tempo
Teraburst Networks, Inc.
TeraGlobal
Teraoptic Networks Inc.
Terawave Communications
Terayon Communication Systems, Inc.
Test Mart
Tetra Tech Data Systems
Texas Instruments
The McKenna Group
The Primas Group
Thunder River Technologies Inc
Thunderbird Executive Education
Tiara Networks
TIBCO Software Inc.
Time Domain Corporation
Titan Wireless, Inc.
Tollbridge Technologies
Tombolo Mobile Communications
Tone Software
Torrey Science & Technology Corp.
Toshiba America Information Systems
Total Media Technologies, Inc.
Tourmaline Networks, Inc.
Transparent Optical
Traxsis
TrellisWare Technologies, Inc.
Trillium Digital Systems, Inc.
Trimble Navigation Limited
Trinagy, Inc.
Troika Networks Inc.
Trompeter Electronics
TROY Group, Wireless and Connectivity Division
TrueSpectra
TRW Avionics Systems Division
TRW Satellite Communications Division
TRW Space & Electronics Group
TRW Systems and Information Technology
Turin Networks
Turnstone Systems, Inc.
Tut Systems, Inc.
TUV Telecom Services, Inc.
U.S. Telefone
UltraBand Fiber Optics
Unicom Electric, Inc.
URS Corporation
UTStarcom, Inc.
Valiant Networks, Inc.
Vari-Tronics Company Inc.
Vega Vista Inc.
V-ENABLE, Inc.
Verance Corporation
Verilink Corporation
Verizon
Versatile Optical Networks
Vertel
Vertical Networks Inc.
Verticom Inc.
ViaSat, Inc.
Vibro-Acoustic Sciences Inc.
Vicom Systems Inc.
VINA Technologies, Inc.
Virata
Visicom Laboratories, Inc.
Vitesse Semiconductor
Vitria Technology
Vivace Networks, Inc.
Voice Access Technologies Inc
Voicepro
Volex Inc.
Vpacket Communications, Inc.
VSR - Voice Systems Research
Vyyo Inc.
Wavecom Inc.
WaveSplitter Technologies, Inc.
WaveWare Communications
Web Basis, Inc.
Western Multiplex Corporation
Western Telematic, Inc.
Westwave Communcations, Inc.
Wheat International Communications
Widcomm Inc.
WilllowBrook Technologies LLC
Wind River Systems, Inc.
Wireless Facilities, Inc.
Wireless Inc.
Wireless Online Inc.
Wyle Laboratories, Inc.
X:drive
XO Communications
Xpeed
Xsilogy, Inc.
Xstream Logic Inc.
Xtera Communications
Zaffire
Zarak Systems Corporation
Zeus Communications
Zhone Technologies, Inc.
ZNYX Networks
Zoxsoft
ZTE San Diego
Zucotto Wireless, Inc.
Zyray Wireless