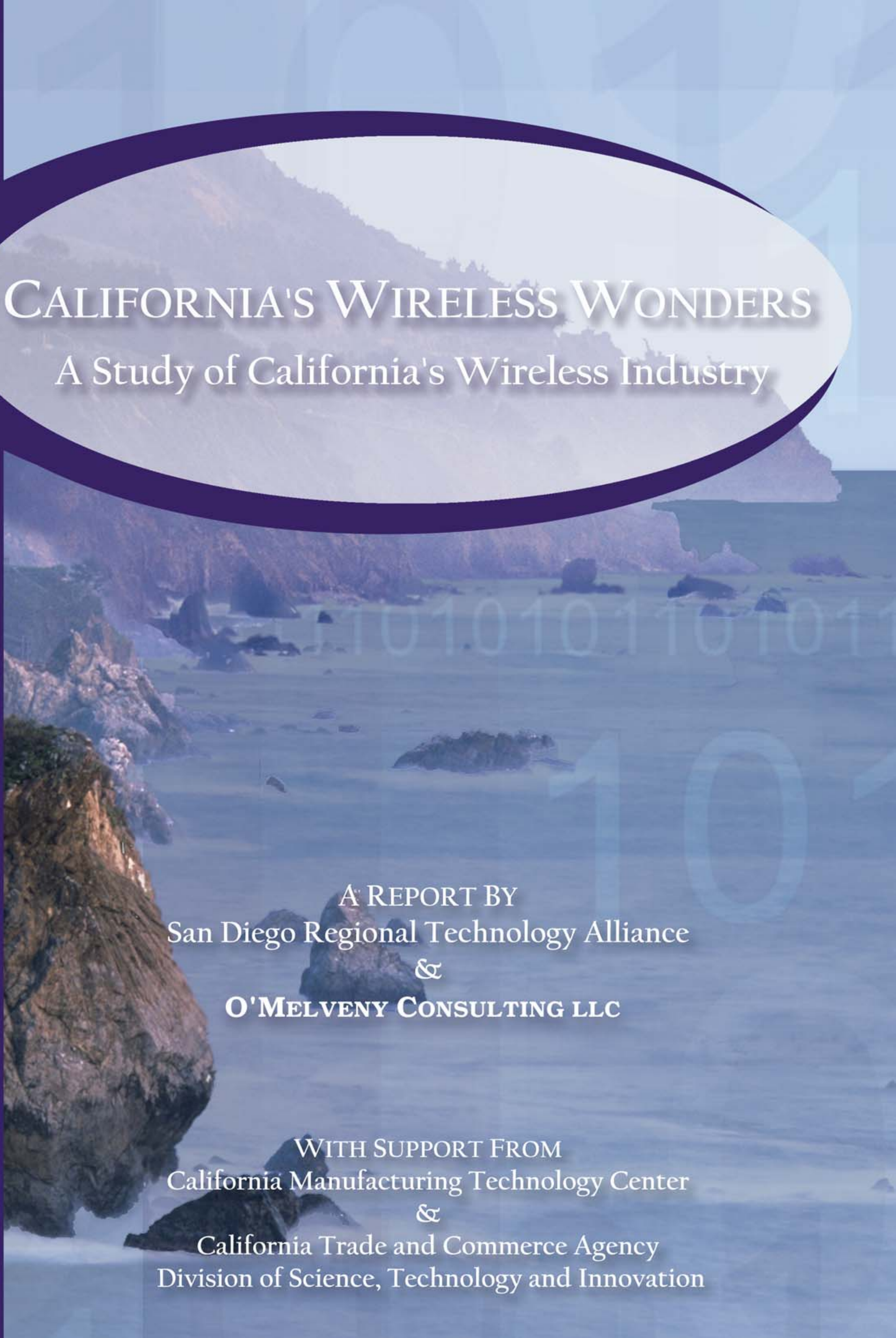

CALIFORNIA'S WIRELESS WONDERS

A Study of California's Wireless Industry

A REPORT BY
San Diego Regional Technology Alliance
&
O'MELVENY CONSULTING LLC

WITH SUPPORT FROM
California Manufacturing Technology Center
&
California Trade and Commerce Agency
Division of Science, Technology and Innovation

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THE SAN DIEGO REGIONAL TECHNOLOGY ALLIANCE
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FOREWORD

This report was conducted by the San Diego Regional Technology Alliance (RTA) and O'Melveny Consulting (OMC), in partnership with the California Manufacturing Technology Center (CMTC) to assist the State of California in understanding the dimensions and issues facing California's wireless sector.

The report was written and researched by Cliff Numark, Managing Director of Operations at OMC with additional research assistance provided by OMC analyst Ron Nandi and OMC associate Nicole Huntington. RTA research manager Christine Ang assisted in research and in directing the report. Tyler Orion, CEO of the RTA, provided direction and detailed editing. Lorri Aiello, of CMTC, provided advice and direction on the implementation of the wireless company survey, along with CMTC Vice President Leila Mozaffari.

This report was conducted using primary and secondary market research, including research on existing sources; interviews with numerous experts from venture capital, the public sector, leading companies and academic sources; and an original survey conducted by CMTC.

EXECUTIVE SUMMARY

As wireless technology changes the face of modern communications, California stands poised to lead the nation in its development and implementation. In aggregate numbers, California employs the most wireless employees, hosts the most wireless companies, and has the largest wireless payroll of any state. And in two regions, the Bay Area and the San Diego Area, wireless technology has exhibited tremendous growth.

California's leadership in the wireless sector lies in the underlying technology, in innovative start up companies, and in established technology companies who have developed products for the wireless market. As the innovator behind Code Division Multiple Access (CDMA), which is expected to be a part of all 3G technology, Qualcomm represents a fundamental force in the wireless industry. Qualcomm's leadership – and technology – has extended to numerous subsectors of the wireless area, as it has invested, spun off or sold technologies in the wireless software standards, enterprise solutions, carrier, handsets, and data networks industries.

At the same time, California's traditional strengths, in the defense industry and in the semiconductor industry of Silicon Valley, make the state a powerhouse in satellites and the integrated circuits that are fundamental to all wireless components. In fact, the number of Silicon Valley wireless start-ups funded by venture capital dwarfs other regions. Overall, then, California is a leader not just in aggregate numbers but also in particular subsectors of the wireless industry, such as satellites, Bluetooth, wireless software, free space optics, fixed wireless and mobile devices.

The specific results of this report found:

- California headquarters the most public wireless firms, representing 28 percent of the nation's wireless companies.

- California employs more than 60,000 people in the wireless sector, nearly double the 34,000 employed in Texas. However, California's wireless employment is not as concentrated as Maryland, Massachusetts, New Jersey and Virginia. California has 177 wireless employees per 100,000 residents, compared to 288 for Maryland and 266 for Massachusetts.

- California hosts more than 2,000 wireless firms, nearly double the 1,100 located in Texas. California is second in concentration, after Florida. The number of California wireless firms has increased by 156 percent over 1993 levels.

- California's total payroll for wireless employees exceeds $3.5 billion, more than twice that of Texas, at $1.5 billion. On a per capita basis, California ranks fifth among major states. Total payroll for California wireless firms has increased by 135 percent over 1993 levels.

- The greater Los Angeles area has the greatest number of wireless firms and employees (just edging the Bay Area in both indicators) at 800 firms and 22,500 employees.

- The Bay Area is more concentrated in number of firms and payroll. The Bay Area also has significantly more wireless venture capital funding, with nearly four times as much venture capital funding as San Diego and Los Angeles combined.

- The San Diego region is the most concentrated wireless area in California, with 484 wireless employees per 100,000 residents. San Diego has also experienced the fastest growth among California regions, with employment increasing 257 percent and payroll by 371 percent.

- California has a number of significant innovation sources, including the recently launched California Institute for Telecommunications and Information Technology, the Lee Center at the California Institute of Technology, and Wireless Communications Research Group at Stanford University.

- Although California hosts companies in the wireless carrier industry (such as Leap Wireless), wireless data networks, wireless handsets (such as Kyocera's United States presence), and wireless base stations and other overall equipment, the state is not a major leader in these subsectors; many of the leaders are located either in Europe, particularly Scandinavia, or in the Midwest or East Coast.

- California is a leader in the satellite industry, with Hughes' DirecTV and ViaSat originating in California.

- California is a leader in the integrated circuits area, through such firms as Conexant, Broadcom, Qualcomm, Atheros, Maxim and Intersil.

- California is a leader in the Bluetooth area, home to companies such as SOHO Wireless, Widcomm, and Silicon Wave. California is also a leader in wireless local area networking, with such companies as BOINGO, Nomadix and 3Com.

- California is a leader in mobile devices, home to personal digital assistant companies Palm and Handspring.

- California is home to a number of companies that subcontract to major equipment vendors, in areas such as smart antennas and wireless modems.

- California is a leader in the potentially new wireless software standard, as the two standards in North America, Brew and Java2ME, originate from California companies Qualcomm and Sun Microsystems.

- California has a number of companies in wireless software and has particular leadership in streaming video (from San Diego-based PacketVideo) and telematics (through Wingcast, a joint venture between Qualcomm and Ford).

- California is a leader in fixed wireless and free space optics, as the technologies of three leading companies – Optical Access, AirFiber and LightPointe Communications – are located in San Diego and a number of fixed wireless equipment companies, such as the Bay Area's Vyyo, WJ Communications, and Western Multiplex.

- According to a survey of wireless firms conducted in February 2002 by the California Manufacturing Technology Center (CMTC), many are bullish on prospects for the year, with 68 percent expecting an increase in revenues, 53 percent planning to expand into a new product line, and 48 percent expanding into a new geographic market.

- The top concerns of California firms were reducing operating costs, hiring qualified employees and increasing productivity.

- The wireless industry faces a number of policy issues, including spectrum allocation, health and safety regulations, cell phone safety and E911 which can influence the development of the industry. Cell phone radiation, in particular, is of particular concern to the industry.

- For California to promote the industry, it can embark on a number of strategies, including policies and practices that encourage the development of broadband wireless infrastructure for underrepresented areas (such as the rural San Joaquin Valley and areas north of Sacramento), support for continued innovation to promote both new company development and research that sparks new companies and products, and marketing the state as a wireless center.

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I. INTRODUCTION

California has long led the country, and the world, in the area of technological innovation. The state receives the most venture capital in the nation, has the greatest number of technology employees, and is home to some of the world's greatest technology companies.

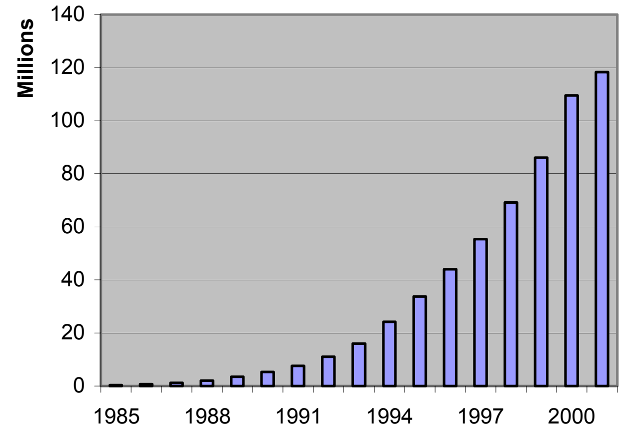
This report focuses on California's leadership in a specific sector of the technology industry, the wireless sector, documenting and analyzing California's strength, relative to other states, and in the particular subsectors of the wireless industry.

Like the Internet, this multi-faceted industry has altered the way individuals conduct business, socialize, and interact. This technological wonder – the ability to communicate in ways that most likened to science fiction 20 years ago – has led the industry to grow significantly in a short period of time, with total US subscribers increasing more than tenfold in a 10 year period. This rapid expansion is paralleled worldwide, with total subscribers increasing from 16 million in 1991 to more than **1 billion** in 2001.[1] (See Figures 1 and 2).

And this growth in subscribers worldwide brings an increased demand for wireless infrastructure, hardware, software and content – especially as the Internet converges with wireless technology.

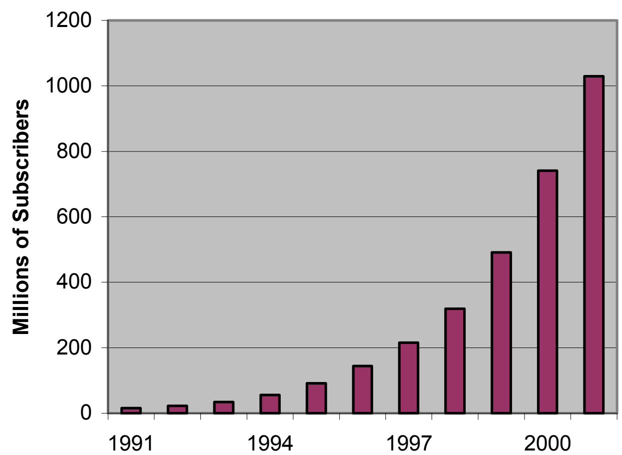
Although there are technical and business barriers today, the potential – and what has been accomplished today – is remarkable. In 2000, *four* times as many mobile phones as personal computers were sold worldwide, about 400 million mobile phones, compared to little more than 100 million desktops and laptops. The number of Internet-capable phones nearly equaled the number of personal computers.[2]

Figure 1. US Wireless Subscribers (1985-2001)



Source: Cellular Telecommunications and Internet Association

Figure 2. World Wide Cellular Subscribers



Source: International Telecommuniations Union

Indeed, market research firm Ovum predicts that by 2003 there will be twice as many Internet-capable handsets as PCs with web browsers.[3] As the Economist writes, "[C]learly a great deal is at stake. Some say it is all just wishful thinking. But in many parts of the world – not only in Japan – millions of people are even now using phones and other handheld devices to communicate on the move. All over the globe, the foundations for the shift to more advanced services are already in place."[4]

California is a major driver of this industry. Like all sectors, it suffered during the 2001 recession, with wireless employers laying off tens of thousands.[5] But as the home to many major wireless infrastructure companies, including Qualcomm, Intersil, WJ Communications, ViaSat and Sun – in addition to the mobile communication divisions of Nokia, Ericsson and Siemens – California is well-positioned to impact this industry in infrastructure and services.

Indeed, the wireless industry represents a significant sector in California, far outpacing other states nationwide in employment, establishments and payroll. Furthermore, California's intellectual capital – from its world-class universities to special research organizations like the state-sponsored California Institute for Telecommunications and Information Technology (CalIT^2) – continues to provide a base for expansion and growth.

This report provides an overview of California's industry, documenting the strength of California companies. Specifically, the report will first define the industry and provide a perspective on the wireless industry in the context of other technology developments. Then, the report will document how California is positioned relative to other states nationwide, in terms of employment, establishments and total payroll.

From there, the report will focus on the key regions in California, comparing the composition of these regions. This will serve as a launching point for outlining the various components of the wireless industry and documenting total potential markets, key California companies, key technology issues and business concerns in these sectors. Finally, the report will discuss regulatory issues impacting the industry as well as report the results of a survey of California wireless firms, reporting on policy and business issues of concern.

II. WIRELESS INDUSTRY DEFINED

According to the National Telecommunications and Information Administration (NTIA), telecommunications refers to communications by wire, radio, optical or other electromagnetic systems.[6] The wireless industry focuses on those systems that are not land-based, which includes cellular and PCS carriers, fixed wireless solutions, satellite equipment and services, wireless devices and infrastructure equipment, and other related applications.[7]

Three Standard Industrial Classification (SIC) codes were selected in this report to compare California to other states and to compare regions within the state.[8] Three Standard Industrial Classification codes come closest to reporting information from relevant companies:

3663 Radio and TV Communication Equipment
4812 Radio/Telephone Communications
4899 Communications Services

These three codes cover a significant portion of the wireless industry, such as satellite equipment, wireless carrier services, global positioning systems and cell phone manufacturing. The industries covered in these codes are included in Appendix 2. Admittedly, there are problems with using these codes as the sole basis for assessing California's wireless industry;[9] therefore, the SIC code data is supplemented by market data, examining particular market figures for subsectors of the wireless industry.

III. CALIFORNIA'S WIRELESS STRENGTH AND CALIFORNIA'S WIRELESS REGIONS

A. California's Strength

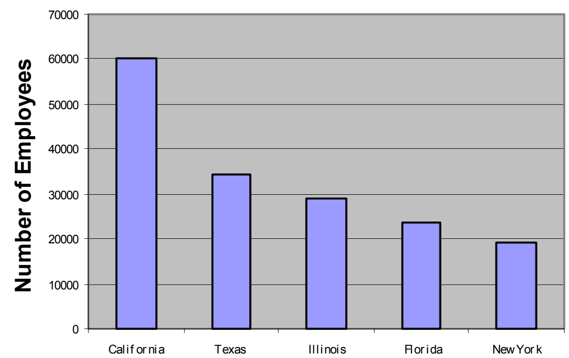
A number of states could claim to be a wireless center – Texas, Illinois and Florida all have a significant number of wireless employees and establishments. Yet California is the leading state in the wireless industry. Among all states, California has the greatest number of wireless employees and establishments and the greatest wireless payroll.

Not only is California's wireless sector large in aggregate numbers but it has also experienced rapid growth. Certain areas, such as San Diego, have increased wireless employment rapidly in the past 10 years, becoming wireless centers.

By employment, California far exceeds its closest rival, Texas, with nearly double that state's employment. California employs more than 60,000 people in its wireless sector, nearly double the 34,000 employed in Texas. Because of California's large population, it is not as concentrated as some leading states, such as Virginia (home to Nextel), Massachusetts, Maryland, New Jersey (home to Lucent) and Illinois (home to Motorola's 147,000 employees); California had 177 wireless employees per 100,000 residents, compared to 288 Maryland and 266 for Massachusetts.

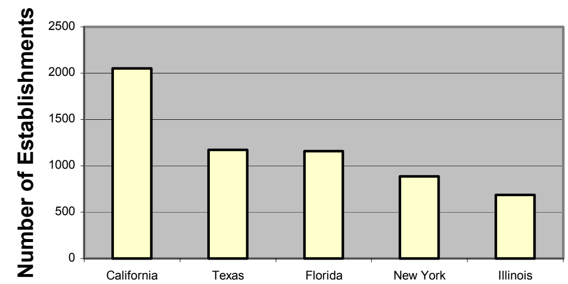
By establishment, California had almost twice its nearest rival – Texas – in the number of wireless firms; a total of 2,000 wireless firms operated in California, compared with 1,100 in Texas. Despite its populous size, California is second to Florida in the concentration of wireless firms, with New Jersey, Texas, and Illinois ranking below the state. Indeed, consistent with this, California represents 28% of the nation's public wireless firms, whereas no other state even approaches the double digits. See Appendix 3 for a list of the firms.

Figure 3. Total Wireless Employment



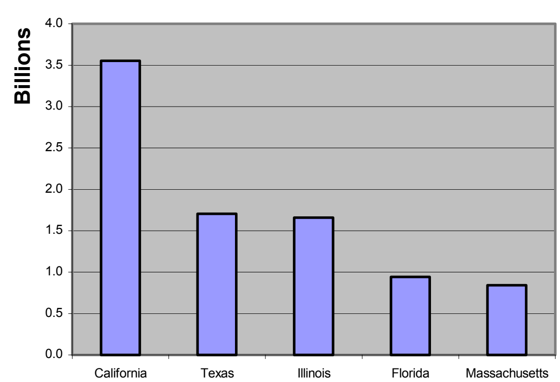
Source: County Business Patterns (reporting data from 1999, the most recently available information), O'Melveny Consulting Analysis.

Figure 4. Total Wireless Establishments



Source: County Business Patterns (reporting data from 1999, the most recently available information), O'Melveny Consulting Analysis

Figure 5. Total Wireless Payroll



Source: County Business Patterns (reporting data from 1999, the most recently available information), O'Melveny Consulting Analysis

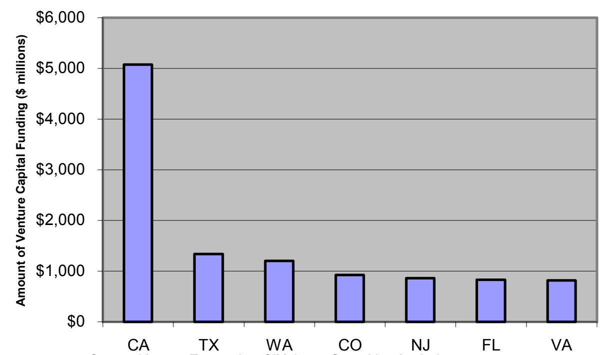
By payroll, California again exceeds its nearest rival, Texas, by more than a factor of two, netting more than $3.5 billion to the state, compared to $1.5 billion to Texas. On a per capita basis, California's wireless payroll is not as concentrated – but still ranks fifth among major states, behind Washington with $105 of wireless payroll per resident.

Furthermore, as a mark of its innovative efforts, California significantly exceeds all other states in the number of wireless firms funded by venture capital investors. In the period from 1993 – 2001, California received more than $5 billion in venture capital funding for wireless companies and had more than 180 deals done during that time. Compared to other states, California had four times as many venture capital deals, and received four times as much venture capital funding. On a per capita basis among these top states, California ranked second in the number of deals (behind Massachusetts) and third in the amount of funding (behind Washington and Colorado).

Not only does California exceed other states, its growth has been significant as well, doubling the establishments, payroll and nearly doubling the number of employees since 1993.

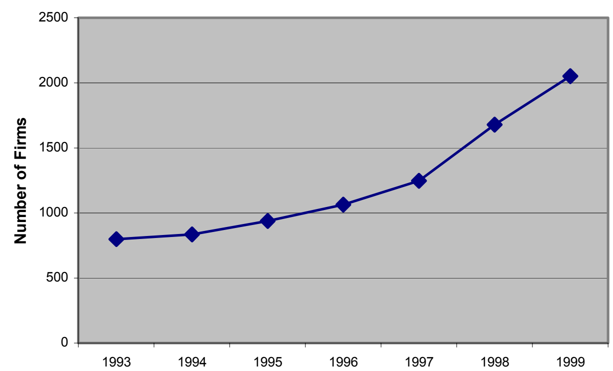
As seen from Figure 9, the number of California wireless companies increased rapidly, rising 156

Figure 7. Venture Capital Funding, 1993-2001



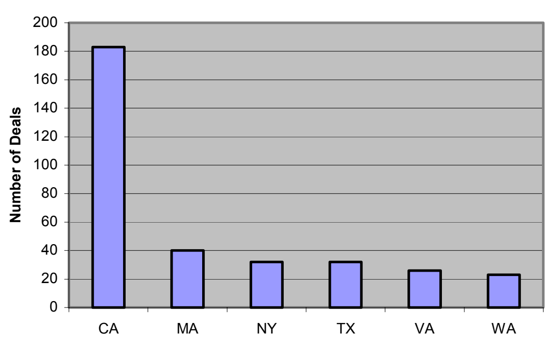
Source: Venture Economics, O'Melveny Consulting Analysis

Figure 8. California Wireless Firm Growth



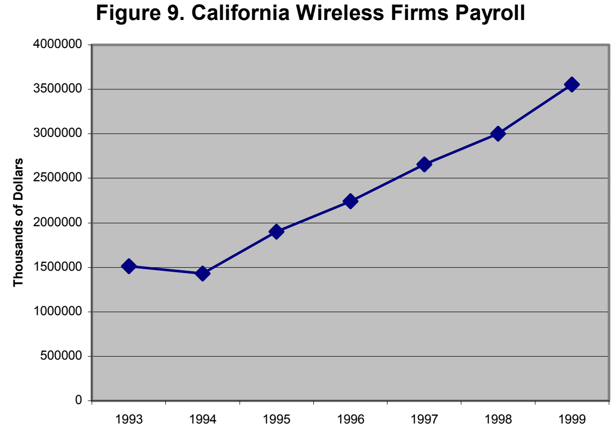
Source: County Business Patterns, O'Melveny Consulting Analysis

Figure 6. Venture Capital Deals, 1993-2001



Source: Venture Economics, O'Melveny Consulting Analysis

Figure 9. California Wireless Firms Payroll

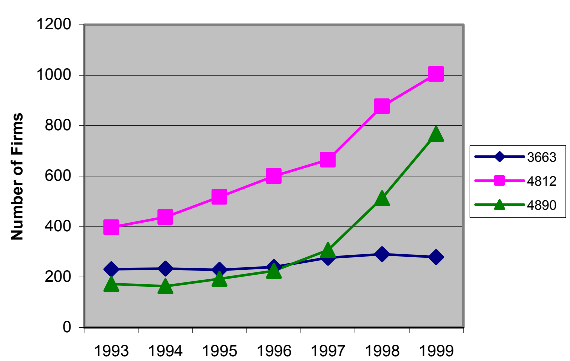


Source: County Business Patterns, O'Melveny Consulting Analysis percent over 1993 levels and growing at an average annual rate of 17 percent per year. The significant growth in firms occurred in radio/telephone communications services (which includes wireless retailers) and other wireless services (such as satellite carriers and tracking systems).

The growth by payroll followed the same pattern. State wireless payroll increased by 135 percent since 1993, growing at an average annual rate of 16 percent, with the greatest growth occurring in the wireless services area. That area has grown by more than 215 percent since 1993. Although the equipment manufacturers, represented in SIC 3663 did not increase greatly in numbers (as seen in Figure 11), they did increase greatly in payroll – signaling that the number of firms remained constant and simply increased their employees. The other two subsectors, on the other hand, had growth in employees and payroll that was tied to growth in the number of firms.

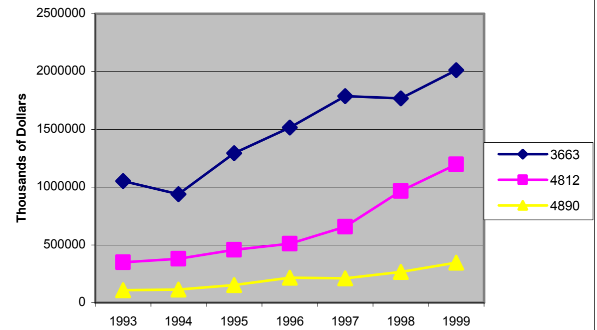
California's wireless employment has increased 70 percent since 1993. Although this represented significant growth, California wireless employment growth was about half of payroll growth. The average annual increase was just shy of 10 percent with the services area leading the employment growth.

Figure 10. CA Wireless Subsectors Number of Firms Over Time



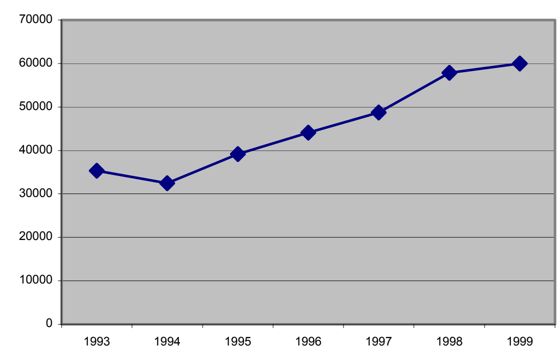
Source: County Business Patterns, O'Melveny Consulting Analysis

Figure 11. California Subsector Payroll



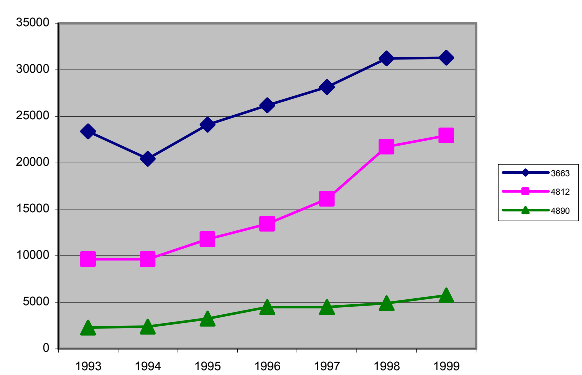
Source: County Business Patterns, O'Melveny Consulting Analysis

Figure 12. California Wireless Employment



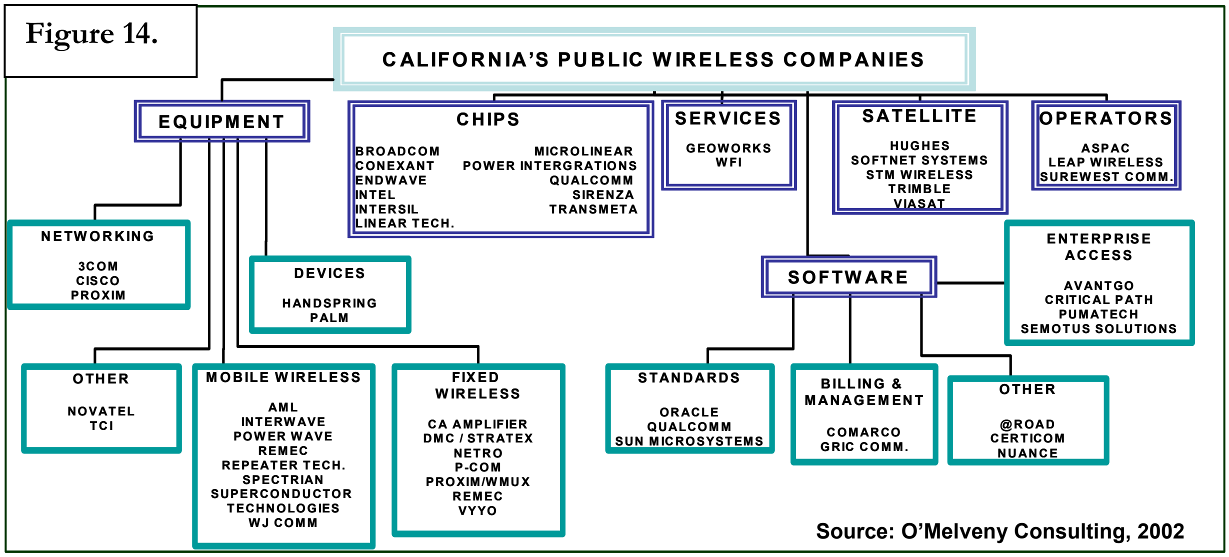
Source: County Business Patterns, O'Melveny Consulting Analysis

Figure 13. California Wireless Subsectors Number of Employees Over Time



Source: County Business Patterns, O'Melveny Consulting Analysis

Figure 14.



Source: O'Melveny Consulting, 2002

Despite the above statistics, California's leadership in the wireless sector may seem, at first, odd. Not one major national wireless carrier is headquartered in California. Similarly, the large data-focused carriers, such as Motient, and Bell South Mobitex are housed in the South – Virginia and Georgia. And the major infrastructure manufacturers – the companies that make the base stations and handsets are either international – such as Ericsson, Nokia, Siemens, and Nortel – or located on the East Coast (Lucent) or the Midwest (Motorola).

California's strength in the wireless sector lies at both the center, as a support for the core infrastructure, and in software and services. As shown later in this report, California's leadership has been buoyed by Qualcomm. As detailed later in the report, Qualcomm's pioneering CDMA technology is poised to become the standard for all advanced wireless communication that occurs in the next five years as the technology is incorporated into 3G systems.

But more than rely on CDMA, Qualcomm through its development or spinoffs, is associated with a number of other technologies that surround the development of the wireless sector, including BREW (one of two leading software standards for downloading files to wireless devices), Wingcast (a joint venture with Ford in telematics), Wireless Knowledge (a joint venture with Microsoft to enable downloading of enterprise applications, such as email), Leap Wireless (a Qualcomm spinoff that is one of the most innovative wireless carriers and has experienced some of the industry's most rapid growth), Kyocera (a Japanese company that acquired Qualcomm's CDMA consumer wireless phone business, which remains based in San Diego), and Omnitracs and Globalstar – a data network service and a satellite system. "Qualcomm has been critical to putting California on the map in the wireless space," said Joel Balbien, General Partner of Los Angeles-based Smart Technology Ventures. "Qualcomm has been a major catalyst."[10]

However, California is far more than Qualcomm. California, home to Silicon Valley, has a preponderance of talent and companies in the area of integrated circuits – the chips that power the cellular phones and base stations. For example, California hosts such Los Angeles area companies as Intersil, Conexant, Broadcom, and Bay Area companies such as Maxim, National Semiconductor and others who design and manufacture the variety of application-specific integrated circuits. Of course, California has leadership in devices with the prominence of Palm and Handspring, the two leading firms located in Silicon Valley.

In some areas, California continues to maintain its market dominance but is shifting into the new wireless sector as established firms add wireless business units: Los Angeles-based Hughes Electronics (sold to Colorado's Echostar, pending regulatory approval) and San Diego-based ViaSat represent California's old strength in satellite and space technology are headquartered in California. Similarly, Oracle (developing OracleMobile) and SUN Microsystems (innovating another wireless software standard, J2ME) represent two established Silicon Valley companies that are nimbly positioning their products for the wireless future. And in software, California has significant leadership in the complicated process of downloading web and enterprise information to mobile phones through the actions of such companies as San Francisco-based Neomar.

And in areas of significant technological innovation on the cusp of becoming major markets, California is leading the charge. For example, in streaming mobile video standards and delivery, San Diego-based PacketVideo represents one of the world's leaders. In free space optics, the potential for using lasers to communicate data, three San Diego-based companies – LightPointe, AirFiber and Optical Access are national leaders.

B. Wireless in California's Regions

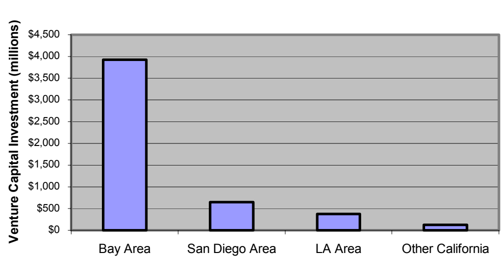
Reflective of this analysis, much of California's wireless growth has occurred in the Silicon Valley area, the world's most concentrated technology area, and San Diego, home of CDMA. Although large in aggregate numbers, the Los Angeles area did not experience as much growth.

As demonstrated in the charts below, on an aggregate basis, California's wireless technology strength – in both employment and payroll lies in the Los Angeles area[11] and the Bay Area. There are more than 600 wireless firms in the Bay Area, nearly 800 in the Los Angeles area and nearly 200 in the San Diego area. From an employment standpoint, the Bay Area and the Los Angeles area are nearly equal with approximately 22,500 employees, with San Diego at approximately 14,000 employees.

However, on a per capita basis,[12] San Diego is the most concentrated region, with 484 wireless employees per 100,000 residents, compared to the Bay Area (375 per 100,000) and the Los Angeles area (141 per 100,000).

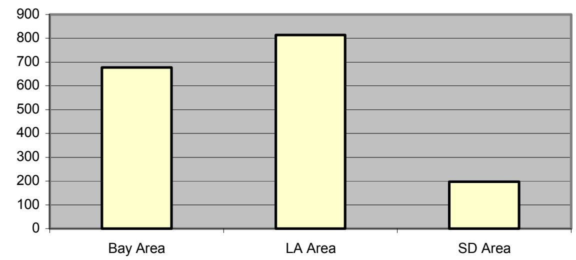
Furthermore, San Diego has experienced the fastest growth overall, since 1993 increasing employment by 257 percent, payroll by 371 percent and firms by 150 percent. Only in establishment growth was it exceeded – by both the Bay Area and the Los Angeles area, which increased the number of wireless establishments by 181 percent and 156 percent. In addition, the Bay Area had four times as much venture capital as other California areas combined.

Figure 15. Venture Capital Funding by Region, 1993-2001



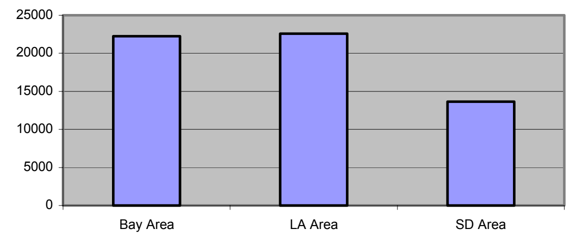
Source: Venture Economics, O'Melveny Consulting Analysis

Figure 16. Wireless Firms in California



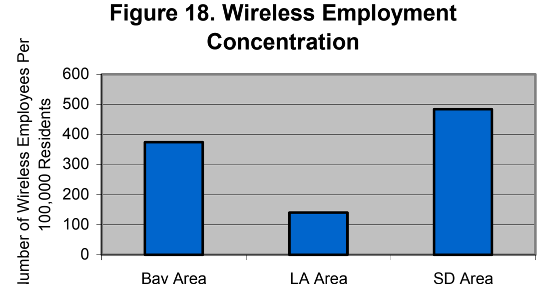
Source: County Business Patterns 1999.

Figure 17. Wireless Employment in California Regions



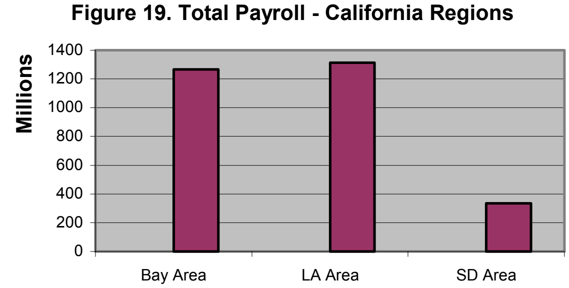
Source: County Business Patterns 1999. Includes Qualcomm.

Figure 18. Wireless Employment Concentration

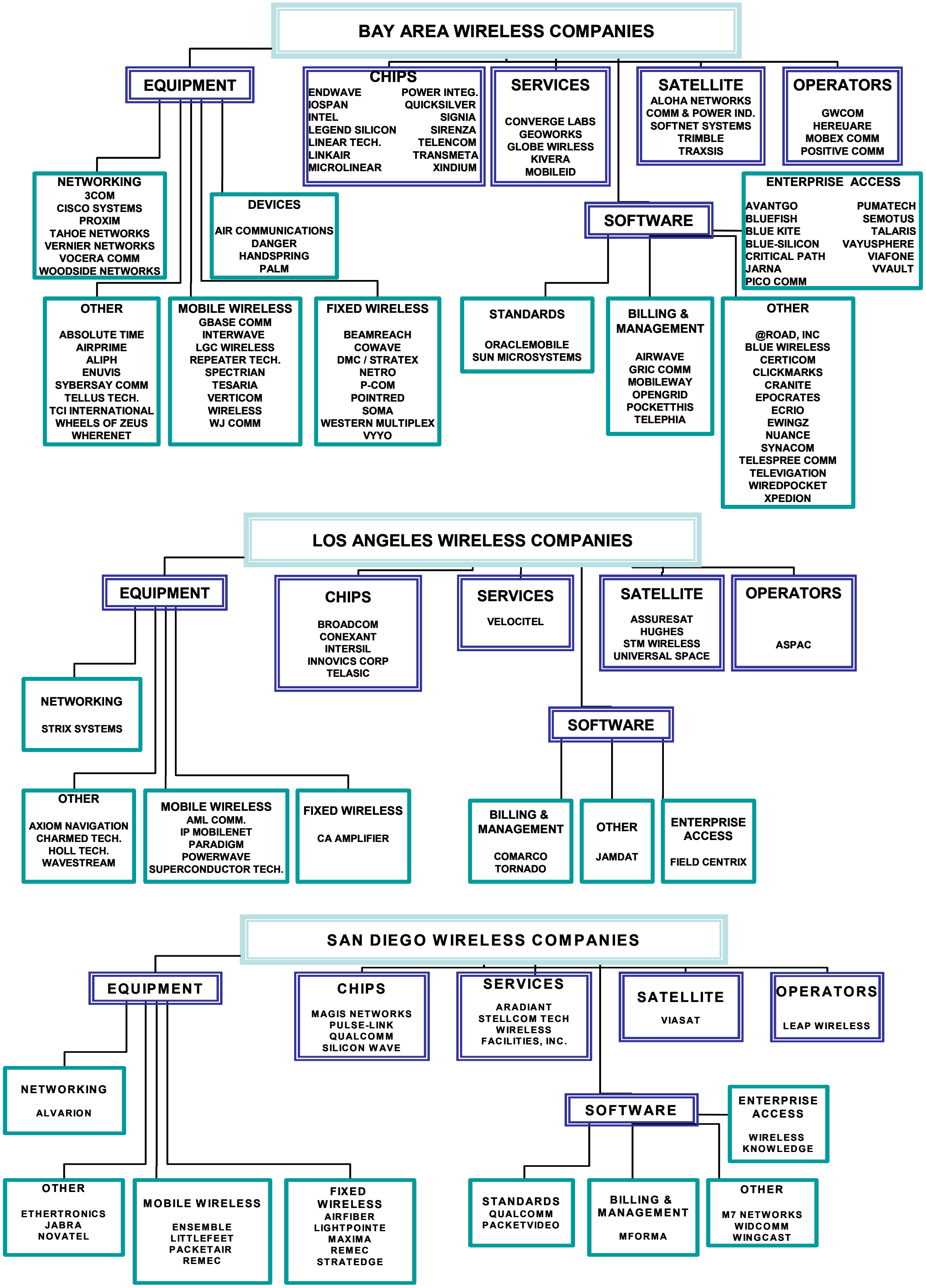


Source: County Business Patterns 1999. Includes Qualcomm. O'Melveny Consulting Analysis

Figure 19. Total Payroll - California Regions



Source: County Business Patterns 1999



Source: O'Melveny Consulting, 2002

Figure 20.

1. The Bay Area

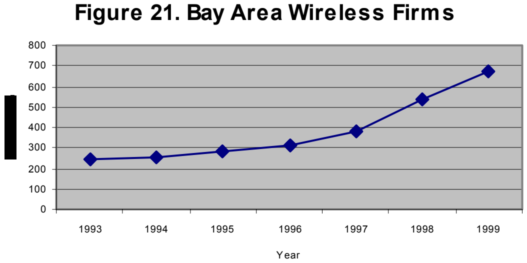
The Bay Area's wireless strength rests in its concentration as the world's greatest technology area – established technology players like Sun, Oracle, Intel and 3Com, as well as venture-backed startup companies, have developed wireless applications to move with the market.

Like most of California and Silicon Valley, the roots of the Bay Area's wireless sector ultimately lie in the defense sector. As noted in one of the works on Silicon Valley's development, *Regional Advantage*, Fairchild semiconductor (which spawned a number of Silicon Valley companies including Intel) and a number of other firms all had a significant business from the defense industry.

Now, the wireless community of the Bay Area covers a spectrum of software, hardware, and support services. Indeed, the Wireless Communications Alliance, an organization that was formed as an outgrowth of Joint Venture Silicon Valley and hosts monthly meetings on wireless topics, interacts with more than 350 companies in the wireless area.

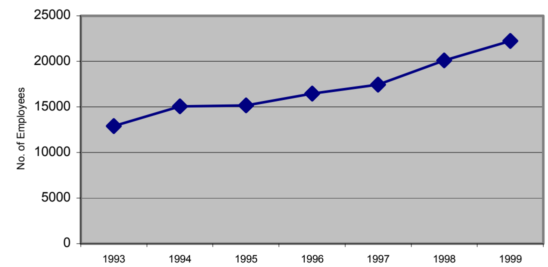
The diversity of the Bay Area's wireless sector includes chip companies like Atheros (a venture-backed company leading development of 802.11a chips) and Intel, base station chip companies like WJ Communications, device manufacturers like Palm and Handspring, and mobile internet providers like Avantgo. The full description of Bay Area firms can be found in Appendix 5 and throughout the next sections. A graphic overview sampling the diversity of the Bay Area's firms can be viewed at right.

Figure 21. Bay Area Wireless Firms



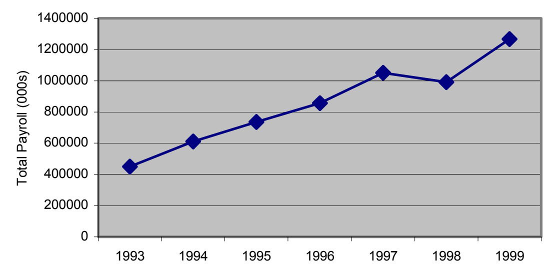
Source: County Business Patterns 1999. O'Melveny Consulting

Figure 22. Bay Area Wireless Employment



Source: County Business Patterns 1999. O'Melveny Consulting Analysis

Figure 23. Bay Area Wireless Firms Payroll



Source: County Business Patterns 1999. O'Melveny Consulting Analysis

Table 1. Sample Bay Area Wireless Firms

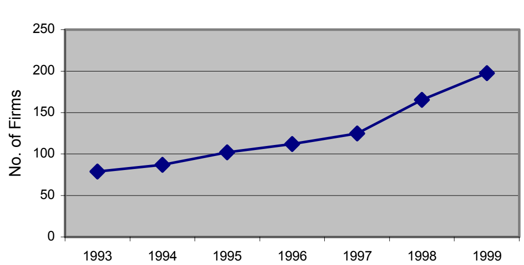
FIRM	DESCRIPTION
AIRPRIME	Venture-backed firm provides high-speed, CDMA wireless data and voice products to the OEM.
AVANTGO, INC.	Public software developer runs enterprise software on PDAs.
DMC STRATEX NETWORKS, INC.	Public firm manufactures digital microwave radios for fixed wireless.
ENDWAVE CORP.	Products include radio-frequency modules, transceivers, and antennas.
GRIC COMMUNICATIONS	Makes software products that enable ISPs to cooperate in Internet roaming.
NUANCE	Develops voice interface; clients include brokerages, airlines, telecom carriers, and retailers.
PROXIM, INC.	Wireless networking cards.
REPEATER TECHNOLOGIES, INC	Builds wireless network repeaters that receive, amplify, and retransmit signals between wireless customers and cellular base stations.
SOFTNET SYSTEMS, INC.	Provides two-way satellite-based Internet access for ISPs, telecom carriers, schools, and business clients.
SPECTRIAN CORP.	Produces linear power amplifiers. Used by wireless communication providers to (1) carry an increased no. of calls on a single frequency, (2) to boost radio signal quality. Products include multicarrier amplifiers and single-carrier amplifiers.
VERTICOM	Oscillators and converters for broadband wireless and satellite.

2. The San Diego Area

San Diego's wireless industry is also rooted in the defense industry – but has spiraled out significantly since those early days. San Diegans trace the beginning of the industry to Linkabit, a venture started by UCSD professors in 1968, which later spun off Qualcomm in the 1980s. From the Linkabit roots, a number of other companies have arisen in San Diego; in fact, much of San Diego's wireless sector can be directly tied to some association with Linkabit or Linkabit spinoffs, as shown in the attached graphic for the period 1968-1997.[13]

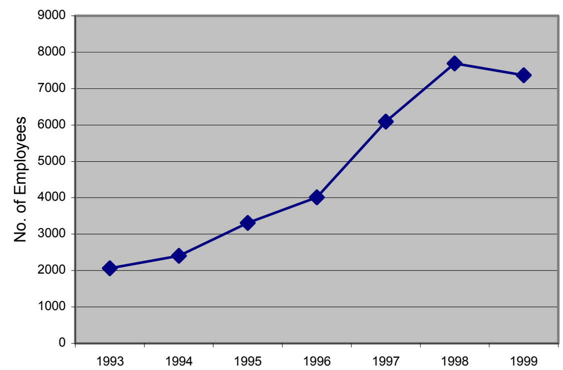
In addition to those firms, a number of startups and larger companies since 1997 have emerged in the San Diego area, attracted by the concentration of RF chip designers with a knowledge of CDMA. These include larger companies, like Siemens, which located their mobile phone divisions in the area, as well as innovative companies such as Graviton (machine-to-machine communication tools), Littlefeet (small base stations), M7 Networks (mobile infrastructure hosting company), Peregrine Semiconductor (manufacturer of integrated circuits for fixed wireless and CDMA digital cellular), JABRA (manufacturer of earpieces for cellular phones), Stellcom (system integrators for wireless industry), Cubic (defense-based company that has developed RF and DSP-based equipment), and Ensemble Communications (which connects cellular systems to fiber optic systems).

Figure 24. San Diego Wireless Firms



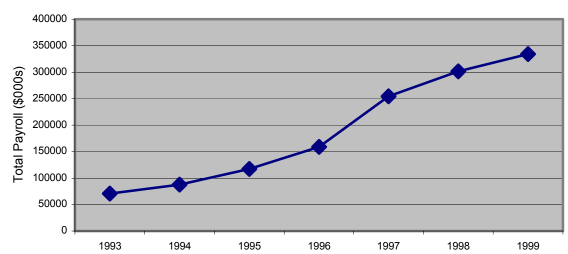
Source: County Business Patterns 1999.

Figure 25. San Diego Wireless Employment



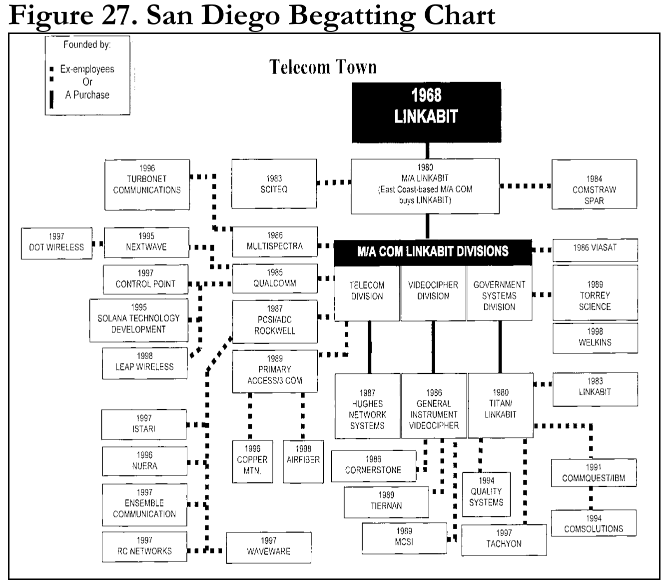
Source: County Business Patterns 1999.

Figure 26. SD Wireless Firms Payroll



Source: County Business Patterns 1999.

Figure 27. San Diego Begatting Chart



Source: Martha Dennis, Windward Ventures

3. The Los Angeles Area

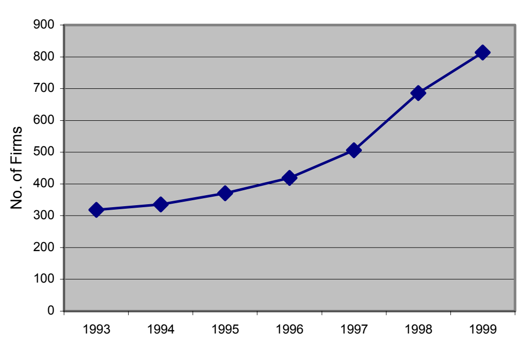
Los Angeles' wireless strength is mostly due to equipment and satellites, reflecting the region's defense industry background.

Like San Diego, some of the leading companies in the Los Angeles wireless sector are rooted in the aerospace industry, most notably Hughes Electronics (which will be merged with Colorado Echo Star, subject to regulatory approval). A recently funded company, TelAsic, spun out of Raytheon, is a fabless integrated circuit company focused on providing products for base stations.

At the same time, the greater Los Angeles area (including Orange County) has also developed a significant presence in integrated circuits for 802.11 chips and for transceivers in cell phones. Conexant and Broadcom are two examples, as well as Intersil.

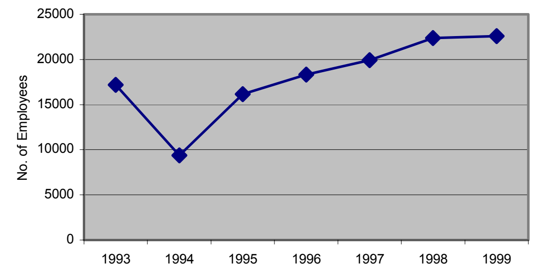
Like the Bay Area and the San Diego area, the greater Los Angeles region also has its share of spin-outs from universities: InnoVics, focused on solving the "diversity" problem and ensuring strong signals, was started by a UCLA professor and Broadcom was started by a UCLA professor. Another area of strength is in amplifiers and transceivers, with companies such as California Amplifier and AML located in the region.

Figure 28. LA Wireless Firms - Over Time



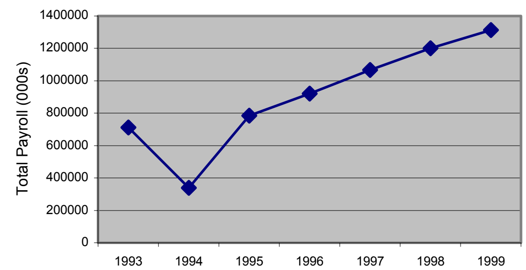
Source: County Business Patterns 1999.

Figure 29. LA Area Wireless Employment



Source: County Business Patterns 1999. O'Melveny Consulting Analysis

Figure 30. LA Wireless Firms Payroll



Source: County Business Patterns 1999.

Table 2. Sample Los Angeles Firms

FIRM	DESCRIPTION
AMERICAN MICROWAVE TECHNOLOGY (A.K.A.: AMT)	Manufactures custom radio frequency and microwave power amplifiers
AML COMMUNICATIONS,	Provides amplifiers for wireless communications.
ASSURESAT, INC.	Provide GEO satellite operators with temporary satellite replacements in the event of a launch or satellite failure.
CALIFORNIA AMPLIFIER, INC.	Products include antennas, amplifiers, and transceivers
COMARCO, INC.	Provides testing equipment and billing system software for PCS operators.
FIELD CENTRIX, INC.	Develops enterprise software to automate mobile field-service operations
HOLL TECHNOLOGIES	Develops electronic components and electromagnetic composites
INCOM COMMUNICATIONS	Provides 200 MHz narrowband SMR (specialized mobile radio) services
IP MOBILENET INC	Manufactures and distributes IP radios, base stations, amplifiers, controllers.
POWERWAVE TECHNOLOGIES	Makes radio-frequency power amplifiers used in base stations of cellular and (PCS) networks
STM WIRELESS, INC.	Builds networks for transmitting voice and data using satellite terminals.

C. Centers of Innovation[14]

Wireless innovations originate from a variety of sources – from the line engineers working in venture-backed companies to the professors and graduate students at California universities.

Indeed, California is home to a variety of research institutes, some of which are conducting ground-breaking research in wireless technologies. The scope and scale of the research is as varied as California's wireless industry – covering innovations in such areas as integrated circuits, detection, security, fixed wireless, and integration with the Internet.

Table 3. Examples of Innovation Sources

INSTITUTION	RESEARCH AREAS
California Institute of Technology - Lee Center	Full integration of worldwide web on wireless platform
California Institute of Telecommunications and Information Technology	New materials, network infrastructure, and software solutions Active testbed for new technologies
Stanford University - Wireless Communications Research Group	Algorithms to improve data rates Methods to reduce power consumption
University of California Berkeley – Wireless Research Center	CMOS implementations
University of California Los Angeles – Wireless Integration Research Group	Application-Specific Integrated Circuits
University of California San Diego – Center for Wireless Communications	Broadband wireless access, including integrated circuits, smart antennas, spectral efficiency and call traffic management strategies

The California Institute of Telecommunications and Information Technology – Cal-(IT) ²

Established as a result of Governor Gray Davis' California Institutes for Science and Innovation initiative, the goal of Cal- (IT) ² is dedicated to extending the reach of the current information infrastructure throughout the physical world. The $240 million institute is funded by more than $140 million in private funds and $100 million in public funds.

As a whole, Cal-(IT) ² focuses on four major application areas – environment and civil infrastructure, intelligent transportation, digitally enabled genomic medicine and new media arts. But in zeroing in on those applications, the institute develops technologies related to the base layer – materials and devices – which have provided the foundation for improving wireless communications; networked infrastructure, interfaces and software systems.

The Institute has assembled a team from UCSD's Center for Wireless Communications (CWC) (see below), Center for Magnetic Recording Research (CMRR), San Diego Supercomputer Center (SDSC), and UCI's Center for Pervasive Communications and Embedded Systems Research Center. The Institute has dozens of industry partners, ranging from large companies such as Intersil and Compaq to venture capital firms.

Some highlight projects of the Institute include:

- "Living Laboratory," enabling undergraduates to use PDAs and access a 802.11 campus-wide infrastructure; and
- Testbed for Qualcomm's High Data Rate technology, enabling significantly increased data speeds of up to 2.4 Mbps.

Current projects at Cal (IT) ² include the integration of portable networked embedded system devices; the improvement of RF transceivers, radio modems, wireless link controls, cellular and Internet protocols, audio and video processing, and security mechanisms; and developing ubiquitous access to the Internet from handheld wireless terminals and sensors.

California Institute of Technology - Lee Center for Advanced Networking

The Lee Center is focused on enabling wireless devices to seamlessly access the Internet and the worldwide web. Some of the wireless web projects being developed at the Lee Center include:

- the development of enabling technologies for handheld devices that feature high-bandwidth communications;

- the creation of efficient algorithms and protocols for fast access to the Internet by a large number of clients; and
- implications of offering wireless web access to thousands of customers.

To embark on this research, the center focuses on areas related to scheduling protocols (to optimize overall quality of service); development of environmental testbeds to evaluate performance; development of tiny integrated circuit transceivers, and self-configuring antenna arrays for millimeter-wave networks.

Stanford University - Wireless Communications Research (WCR) Group
Wireless research at Stanford University takes place at the Wireless Communications Research (WCR) Group, a division started by the school's electrical engineering department in October 1993.

Initiated by Professor Donald C. Cox, a former Executive Director of Radio Research at Bellcore, the center focuses on exploring new wireless access techniques, new signal processing techniques for implementing access technologies and new mobility management techniques for large scale networks.

On the product development level, the Wireless Communications Research (WCR) Group is exploring opportunities in:

- Wireless access to new networks (e.g. ATM), and
- Wireless local area data networks, cellular mobile radios, and new low-power low-tier personal communications systems.

In its research, the center is exploring the relationships between the complexity of signal processing algorithms and circuit architectures as a possible solution to minimizing power consumption while maximizing performance.

University of California San Diego - Center for Wireless Communications
The main focus of the Center for Wireless Communications at the University of California, San Diego is Broadband Wireless Access. This will allow for the execution of multimedia applications for all mobile users.

Consequently, areas of research include low-power radio frequency devices, including power amplifiers, linear amplifiers, and signal processors; "smart" antennas; methods to improve spectral utilization efficiency and multiple access strategies for sharing available spectrum among multiple users; traffic management strategies to ensure a low rate of dropped calls as users roam; and multi-media applications.

University of California Los Angeles - Wireless Integrated Systems Research Group (WISR)
Established in January 1997, the Wireless Integrated Systems Research group exists as a division within the UCLA Electrical Engineering Department.

The group is dually affiliated with the Integrated Circuits and Systems Laboratory (ICSL) as well as the Communication Systems Laboratory. The WISR focuses on the following three areas of research:

1. Wireless Communication System Design
2. Very Large Scale Integration (VLSI) Application-Specific Integrated Circuits (ASICs) for wireless data communications
3. Test-bed development and field trials of end-to-end wireless links

Current projects at the WISR include:

- Beam-forming ASIC for application in broadband fixed wireless access systems
- Reconfigurable Signal Processing ASIC for High Speed Data Communications
- Smart antenna array processor

University of California Berkeley – Wireless Research Center
The wireless research center is a research unit operating as a part of the Electronics Research Laboratory in conjunction with the Department of Electrical Engineering and Computer Science at the University of California, Berkeley. The focus is on the development of highly integrated complementary metal-oxide semiconductor (CMOS) implementations – an attractive option given the fact that they have the lowest possible energy consumption while using advanced communication algorithms.

Areas of research include:

- Design of CMOS wireless transceivers and analog RF front ends. Researchers at the university hope that the development of these radios will support transport of several different data types, including low bandwidth control, voice, and text messaging.
- Low power digital computation, with high sample rates and complex algorithms for low energy consumption.

In addition to these highlighted university research centers, there is a collection of wireless research taking place at other universities, such as the University of California Santa Barbara and the University of Southern California, and research institutes, such as Rockwell Scientific, HRL and the national labs.

D. Consolidation in the Industry

In the past two years, wireless companies have continued to build influence on a national and international level through alliances, joint ventures, mergers and acquisitions. The most significant are discussed below. Appendix 4 contains a detailed list of mergers and acquisitions nationwide.

3Com/Aether Systems Inc. – In July 1999, 3Com and Aether Systems created a joint venture called OpenSky to offer wireless data services to corporations and consumers. Aether is a mobile computing applications development tool provider. The newly created firm extends web-clipping technology implemented in Palm VII and Palm.Net to devices other than Palm VII, including competitive Windows CE. This technology allows PDAs, pagers, and other devices to access ERP, CRM, messaging, and Internet e-mail applications.

3Com/Nomadic Technologies, Inc. – In November 2000, 3Com acquired Nomadic Technologies, Inc., an expert in the development of specialized wireless networking devices. The acquisition strengthened 3Com's foothold in wireless LAN solutions for PCs by enabling connectivity for a wide variety of Ethernet-ready devices, such as Internet access appliances, printers, and other non-PC devices. 3Com acquired Nomadic for $33 million in cash.

Conexant/Alpha - Alpha Industries Inc. and Conexant Systems Inc. will merge their operations. Conexant will combine its gallium-arsenide products with Alpha's power amplifier products, forming a $3 billion radio-frequency competitor that will focus on 2.5- and third-generation products and CDMA and GSM air interfaces. Conexant, headquartered in Newport Beach, Calif., will spin off its wireless business, including a GaAs wafer fabrication facility in Newbury Park, Calif., and merge that business with the Woburn, Mass.-based Alpha.

Handspring Inc./Bluelark Systems, Inc. – In January 2001, Handspring acquired Bluelark Systems, a move that gave the acquiring firm the ability to provide its customers with faster wireless Internet access. Bluelark Systems, Inc., was a developer of technology that enables the delivery of Web content to a variety of wireless devices. Bluelark's most well known products were its Blazer and BlueSky, a Palm OS Web browser and proxy server that enabled fast, seamless Internet access from handheld devices.

LM Ericsson/Sony Corp. – In May 2001, Sony Corp. and LM Ericsson merged their mobile phone divisions with hopes of revitalizing their struggling handset businesses. The new company, Sony Ericsson Mobile Communications, is a 50-50 partnership located in London, England that employs about 3,500 people worldwide. The company creates its own brand of products, the majority of which are smartphones and communicators that are distinct from the parent companies.

Palm, Inc./WeSync – In January 2001, Palm, Inc. acquired WeSync, a provider of group-information sharing for handheld devices. The acquisition enabled Palm to move beyond syncing information between a user's handheld and their PC. This freed users from being dependent on their PCS. Furthermore, the combined technologies allow its users to share information among peers via the Web, mobile phones, and servers behind a corporate firewall.

QUALCOMM Inc./SnapTrack Inc. – In January 2000, QUALCOMM Inc. acquired SnapTrack Inc., a provider of wireless positioning location technology. The combined technologies place both companies at the center of the wireless position location market. With the acquisition, the two firms envisioned the production of location-enabled mobile phones using Wireless Assisted GPS technology in the future. This technology enables enhanced service availability and performance in all terrain, inside and outside, via smart phones, PDAs and pagers. For corporate customers, the technology provides location-specific services either directly to the user or via wireless Internet applications and services.

IV. WIRELESS SUBSECTORS

A. Overview

Although the wireless sector has a number of applications, core technologies enable the transmission of voice and data. The core technologies have evolved since the first analog phones in 1979. Furthermore, the core technologies will permit more data to be transmitted wirelessly.

The first generation cellular system was Advanced Mobile Phone System which transmitted data at 9.6 kilobits per second and served as an analog cellular system, forcing each call to occupy a specific frequency. To enable more calls to be placed over each frequency, digital transmission technology was developed, which became known as 2G technologies. The core 2G technologies are Time Division Multiple Access (TDMA), Global Systems for Mobile Communications (GSM), and Code Division Multiple Access (CDMA).[15]

TDMA

TDMA is a system that assigns each signal a separate time slot for transmission, with each time slot containing digitally encoded data. TDMA represents a broad class of standards, including GSM, IS-136 (common in the United States) and PDC (the standard in Japan).

GSM

GSM represents the common standard adopted by Europe and to a lesser extent, the United States. One of the novelties of the GSM system is its interchangeability: because each subscriber has a subscriber identity module (SIM), travelers can plug their SIMs into any GSM phone, wherever they find the appropriate billing and mobile application system. Furthermore, GSM phones are generally cheaper and smaller than other phones.

CDMA

CDMA is the alternative standard pioneered by Qualcomm, originally designed for military applications. Unlike TDMA which assigns multiple time slots per frequency, CDMA uses codes to identify different calls. These codes resemble encryption – and both the base station and the receiver know the codes. Although CDMA is more complicated and requires more filtering, it makes far greater use of the spectrum.[16]

Each cellular operator chooses one of the above standards (in the US), and the cellular phones correspond to those standards (which is why a phone on one subscribers' network cannot work on another's network). Table 4 outlines the various penetration rates of digital technologies:[17]

Table 4. Worldwide Subscribers

Technology	Number of Subscribers (millions)
GSM	564.6
CDMA	99.8
PDC (Japan)	54.7
US TDMA	81.3
Analog	59.4

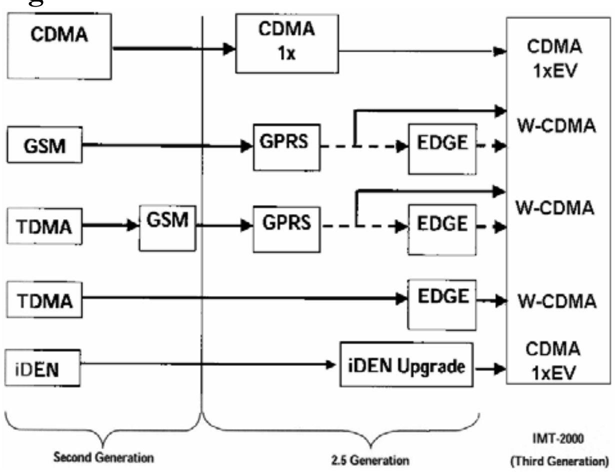
Source: EMC World Cellular Database via GSM World, July 2001

These 2G technologies, however are limited in the speed in which they transmit data. Therefore, the network operators are improving their systems to become 2.5G and then, eventually, 3G networks. Although exact definitions do vary, 2.5G is generally considered to enable 64 -144 kbps data speeds and 3G networks enable 384 kbps to 2Mbps, a significant upgrade.[18] 3G has created much excitement based on the data possibilities with enhanced networks, including more video applications, larger interactive files, and applications such as location-based services.[19]

The path to 3G from present networks will require the interim 2.5G, principally implementing CDMA 20001x for CDMA systems (expected to increase data rates to 144 kbps) or GPRS (expected to increase data rates from 25 to 144 kbps). Verizon Wireless and

Sprint PCS will deploy CDMA 2000 1x en route to cdma2000 1xEV, while AT&T Wireless, VoiceStream (a subsidiary of Deutsche Telekom) and Cingular Wireless will implement GPRS en route to WCDMA.[20] The path to 3G is demonstrated in the graphic below.

Figure 31. Evolution to 3G



Source: Morgan Stanley

Despite the hype of the wireless Internet, most analysts have predicted that 3G technologies will not be implemented until 2003 at the earliest. And even the first company in the world, NTT DoCoMo, to implement 3G has experienced difficulties, replacing 1,500 3G handsets because of a software glitch that erased data and froze phones.[21] See Table 5 below.

Despite this delay, analysts ultimately predict significant penetration – as much as 50% —in the mid-term.[22] In fact, in the beginning of 2002, Verizon launched its new data services, featuring pricing based on data rather than time.

The 3G delay can be attributed to a number of factors – technical, business, and operational in nature. Technically, the difficulty of integrating CDMA technology and converting GSM-based technologies is substantial. From a business perspective, the operators must develop business models that enhance the development of creative applications – to the extent that the application developers do not benefit from the upside of application use, fewer applications will

Table 5. 3G Network Migration Schedule[23]

Carrier	Network	Estimated Deployment	Users (mills)	Major Network Infrastructure Vendors
Verizon	CDMA 1x	Nationwide 2002	28.7	Lucent, Nortel, Motorola
	CDMA 1xEV	Following 1x rollout		
Sprint PCS	CDMA 1x	Commercial nationwide mid-2002	14.4	Lucent, Nortel, Motorola, Samsung
	CDMA 1xEV-DO (data only)	2003		
	CDMA 1xEV DV (data & voice)	2003-2005		
Cingular	GSM/GPRS overlay on TDMA markets	Begin year end 2001; completion early 2004	21.3	Ericsson, Nokia, Siemens for GSM/GPRS/ EDGE; Lucent for TDMA; Nortel for core
	EDGE overlay on GPRS/GSM markets	Begin late 2002		
AT&T	GSM/GPRS overlay	Conclude year-end 2002	17.1	Ericsson and Nokia for GSM/GPRS/ EDGE; Lucent of TDMA; Nortel for core
	Begin upgrade to EDGE	Mid-2002		
	Begin upgrade to UMTS (w-CDMA)	Early 2003		
Nextel	Data compression to boost data rates to 60-70 kbps	First half 2002	9.6	Motorola
	iDEN upgrades to double capacity	2003		
Voice Stream	Launch GPRS	Late 2001	6.3	Nortel, Ericsson, Nokia
	Begin upgrade to EDGE			

Source: Wireless Week

likely result and there will be less demand for 3G. Finally, as indicated in the above chart, there will be significant equipment upgrades required to move to CDMA technology. For example, more than $8.5 billion was spent in 2000 on W-CDMA technology; Cingular alone will pay about $3 billion to transition the company to 3G data rates.[24,25] Nevertheless, implementing 3G technologies will likely benefit Qualcomm. As one analyst reported, Qualcomm will eventually be a winner because "all 3G is based on some form of CDMA."[26]

Even as 3G is being developed, researchers are already developing the technology for 4G. These technologies focus on varying the modulation method to further increase the amount of data that can be transmitted over a given frequency. These techniques vary from Orthogonal Frequency Division Multiplexing (digital transmissions using analog signals) to Frequency Shift Keying and Phase Shift Keying (systems used in Bluetooth and 802.11). 4G will also be enhanced by the development of "smart antennas" that can further segment radio waves through their positioning. California company ArrayComm, located in the Bay Area, is developing a smart antenna, along with a number of other companies.[27]

B. Network Operators

1. Cellular/PCS Networks

The companies in the accompanying figure represent the nation's largest network operators. With California's population, all of these companies have a significant presence in the state but none are headquartered here. Indeed, with the exception of Leap Wireless, none of the nation's top 25 mobile telephone operators are headquartered in California.

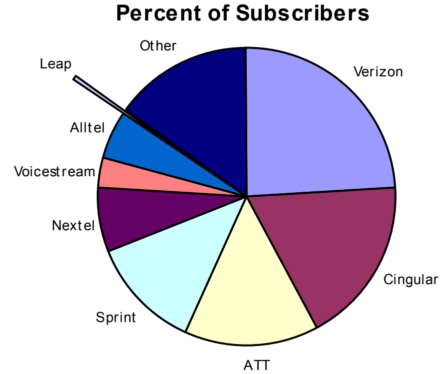
Leap Wireless is a 1998 spinoff of Qualcomm. The company was spun off to provide carrier services using CDMA technology as well as running fixed and mobile wireless solutions in South America; Leap owns a significant stake in Pegaso, the mobile phone service in Mexico. In the United States, Leap quickly attained market presence – more than 724,000 subscribers in October 2001 in more than 25 US markets – and exceeded 1.1 million by the end of 2001. Nevertheless, as shown in the accompanying figure, it represents a small fraction of the total subscriber market.

The rapid growth of Cricket, Leap's branded service, is a reflection of the company's market-focused approach to cellular services. With Cricket, the company offers unlimited local phone service, with no roaming, for $29.95 per month. The company carefully targeted mid-sized markets, such as Phoenix, Tucson, Boise, Spokane, Memphis and Chattanooga, to avoid significant competitive threats. And Cricket's offering was market driven, not technology driven – focusing on the needs of stay-at-home parents and students who wanted the convenience of a cellular phone but did not travel outside the area.

Ultimately, the offering, to a certain extent, ate into the wireline subscriber base.[28] Analysts have praised the approach for carving out a new market and providing real differentiation from national wireless carriers. In fact, 60% of its customers rely on Leap's system as their primary form of telecommunications – and 70% are first-time mobile-phone users[29]

Leap has complemented its successful Cricket service with additional content services, through the Telephone Entertainment Network and the Slice channel, to further serve customers. Leap acquired Backwire, a company that develops customized email newsletters and content; the

Figure 32. North American Carrier Market Percent of Subscribers



Source: Gartner, Wireless Week, CTIA. N = 118 million subscribers intellectual property of Spotcast Communications, which delivers wireless data content by voice and text; and myAladdin.com, which has geo-referenced wireless data for restaurants, movie theatre locations, and traffic impacts. The service enables customers to access data through voice-activated commands and would "push" advertisements to the users.[30]

Despite its success with its Cricket service, Leap's approach may be hampered by a number of factors – competitors, questionable product offerings, and the recent FCC policy change regarding spectrum cap limits. First, although Leap efficiently delivers services through Cricket, it will need to continue innovating to retain customers and expand its subscriber base in its targeted cities as new competitors, such as Alltel, adopt Leap's pricing strategies.

Furthermore, with part of Leap's target market as youths, Leap may face competition – or collaboration – with mobile virtual network operators (MVNO) such as Virgin, which has considered selling mobile services in the United States.[31] Finally, the spectrum cap policy change by the FCC (discussed in later sections) may significantly impact Leap. As a smaller player that owns spectrum, Leap may be a takeover candidate for larger carriers seeking to expand spectrum to implement 3G strategies.[32]

2. **Data Networks**

The above carriers and other companies have established data only networks for purposes ranging from email to fleet carrier information. The major data-only providers are Motient (which recently filed for Chapter 11 but is still expanding), Cingular Interactive (using Mobitex), Aerie networks (which bought Metricom's Ricochet), Verizon and AT&T's CDPD Internet access, all of which offer two-way messaging. Two-way paging is offered by SkyTel, Arch and Weblink Wireless; both Arch and Weblink have recently filed for bankruptcy. These systems use either cellular-like topology to communicate data or satellite technology.

Of these carriers, only Qualcomm's Omnitracs system is headquartered in California.[33] Omnitracs is a data system that focuses on the trucking market, enabling transportation companies to efficiently manage logistics. More than 400,000 Omnitracs systems have been shipped and Qualcomm recently formed an agreement with Eutalstat to bring EutelTRACS to Europe's fleet managers.[34]

In a related approach, some companies use the networks of data carriers as wireless internet service providers – essentially resellers of the data networks. The more compelling companies in this space are GoAmerica, Omnisky/Earthlink, and YadaYada. These companies provide the services for PDA users to access email and the web. A total of 370,000 individuals accessed data wirelessly in 2000, with 100,000 accessing data via GoAmerica and Omnisky (which was based in the Bay Area).[35] But because the data market has not progressed as quickly as anticipated, these services have been troubled.[36] With OmniSky falling (the company sold its assets to EarthLink through its Chapter 11 filing in December 2001),[37] competitors like GoAmerica, most prominently, are well-positioned.

C. Satellites

Satellites represent another significant segment of data communication, communicating information ranging from television services to broadband. California has a significant presence in the satellite services and equipment markets.

Satellite Services

The global market for satellite services exceeds $39 billion and is projected to grow to $115 billion by 2007.[38] Of this, broadcasting represents the highest amount, encompassing 57 percent of the revenue.[39] The two major corporations in the direct broadcasting satellite area are Echostar Communications and Hughes Electronics Corp., which recently sold its

DirecTV subsidiary to Echostar for $25.8 billion, giving the company access to 16 million North American subscribers.

The other growing area for satellite services is broadband to the home – consumer broadband satellite services. Currently, in the U.S. there are fewer than 100,000 customers, a small fraction of the 7.6 million US broadband subscribers and 16 million US satellite TV subscribers.[40] Nevertheless, the market is significant: sources have estimated that 20 -26 million consumers will not have DSL broadband or cable options for five years or more.[41] Furthermore, Merrill Lynch estimates that 15 percent of business and 30 percent of households will only be able to access the Internet and video services via satellite, representing a market opportunity for this industry.[42]

Revenues from this system are predicted to climb from less than $250 million to $2 billion by 2006.[43] The two major companies in this space are Los Angeles-based Hughes and Starband. WorldCom announced that it will also offer Internet satellite service in 2002.[44] Other providers in this space include Interpacket and Loral CyberStar, ImpSat in Latin America, NetSat Express in Europe and Asia, DeTeSat covering Europe, IP Planet covering Middle East and Eastern Europe, and Intellicom and San Diego-based Tachyon covering the United States.

To date, the market for mobile services via satellite has fallen far short of hopes – and the marketplace is littered with the companies who could not produce the subscriber base to make the economics work. Struggling Iridium and Globalstar are among the California firms in this group. Nevertheless, as new Ka-band services are launched, analysts predict more users will flock to broadband satellite, especially as 30 percent of the US population cannot access either DSL or cable for high speed internet service.[45] [46]

Satellite Equipment Manufacturers

Both Hughes and Gilat are significant companies in the equipment market for satellite broadband, with Hughes Network Systems (in San Diego and Maryland) supplying the equipment. San Diego-based ViaSat, which produces satellite equipment for commercial and defense applications, is also a major player, providing the service to Echostar-owned Wildblue, an Internet service to be launched in 2002. Skystream is also a major satellite manufacturer, located in Sunnyvale. Other companies who manufacture this equipment include Norsat and Nera. Overall, the worldwide market for satellite manufacturing exceeds $20 billion.[47]

New Developments

Two technology and business innovations that are developing in the satellite area are videophones and XM radio. XM radio and Sirius are two companies offering satellite radio that greatly expand listeners' options: for $10 per month for XM Satellite or $13 per month for Sirius (with no commercials); both services offer various music and news channels and require a $400 set up fee for the equipment.[48] Analysts expect the satellite radio industry will reach 8.4 million subscribers by 2005 and ramp to 26 million subscribers by 2010, driven by increased penetration from automakers and consumer installation of new radios through the aftermarket.[49]

With the help of four Inmarsat satellites, satellite videophones are becoming more commonplace as a result of the Sept. 11 terrorist incident; indeed, with equipment prices at $7,500, compared to the $50,000 previously, satellite communications are possible in the fields of journalism, offshore oil drilling, and telemedicine.[50]

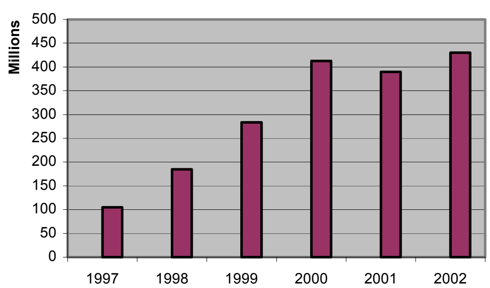
D. Hardware and Infrastructure

1. Handsets

In 2001, global handset sales declined from 2000 levels, although predictions for 2002 show an increase. The major handset manufacturers are all headquartered outside of California.

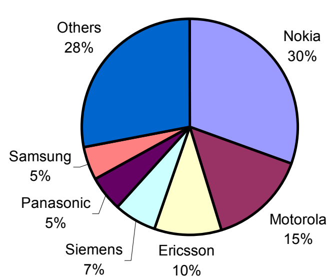
However, some companies maintain a mobile phone presence in the state; Siemens, for example, has its North American mobile phone headquarters in San Diego. The following figures show the growth and leveling off of the handset market, as well as market share distribution.[51] Reflecting the slow-down, Kyocera Wireless laid off more than 700 jobs in the San Diego/Tijuana area.[52]

Figure 33. Global Handset Sales



Source: The Economist, Merrill Lynch. 2002 aggregate forecast.

Figure 34. Worldwide Handset Shares 2000



Source: Gartner Dataquest

2. Devices

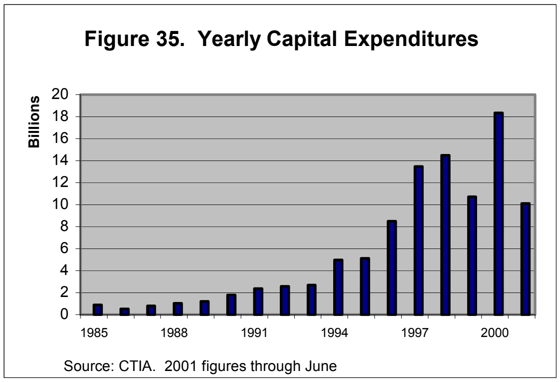
Complementing traditional mobile handsets are personal digital assistants that, using service providers such as GoAmerica, can access the Internet. There are three major categories of Internet-enabled wireless devices: those that use the Palm operating system (such as Handspring and Palm) with a wireless modem, those that use the Pocket PC operating system with a wireless modem, and Internet-enabled devices such as Research In Motion's Blackberry device.[53] More than thirteen million PDAs were sold worldwide during 2001.[54] In third quarter 2001, Compaq's iPAQ made up 7.3 percent of all PDA sales, Handspring composed 13.9 percent, Palm made up 29.7 percent, and Casio made up 5.6 percent.[55]

Converged devices are developing to function as both PDAs and communicators – to a certain extent, Research In Motion, provides this functionality, as its BlackBerry devices enables enterprise users to efficiently access email, and reducing the cost to enterprises from $9,700 to a laptop to $2,000 for a Blackberry. The company has partnered with SAP, Siebel and Peoplesoft to leverage its enterprise application.[56]

By the same token, devices that combine the functionality of PDAs and phones are emerging. Kyocera, with its US headquarters in San Diego, in 2001 introduced its smartphone, using the Palm Operating system, and Handspring unveiled its Treo, a communicator that effectively serves as both a phone and organizer.[57]

3. Infrastructure Equipment

Seven companies provide the bulk of equipment to assist carriers in building wireless networks: Ericsson, Nokia, Motorola, Nortel, Lucent, Alcatel, and Siemens. Of these, Ericsson, Nokia, and Siemens have a significant presence in California.



Despite layoffs by many of these firms (see Table 4 below), some analysts have predicted an uptick in their revenues as new equipment is required by wireless carriers to upgrade their infrastructures, eventually to 3G. For example, the Yankee Group expects mobile infrastructure spending to rise from $99.4 billion this year to $120.2 billion in 2004, falling to $114 billion in 2006. The increase is still consistent in the trend in equipment purchases as demonstrated in the above figure.[58]

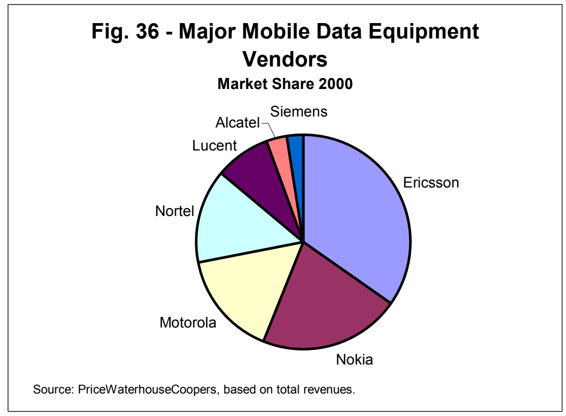
For those that will upgrade to 3G via EDGE, the upgrade costs will be significant and may be a boon to Ericsson, Nokia, Lucent, Nortel and Motorola. In fact, North American equipment manufacturers may face competitive pressures from the Europeans as Cingular and AT&T Wireless move to GSM conversions, while the market for European systems, already on GSM, is not as great.[59]

Table 6. Announced Layoffs by Major Manufacturers in 2001

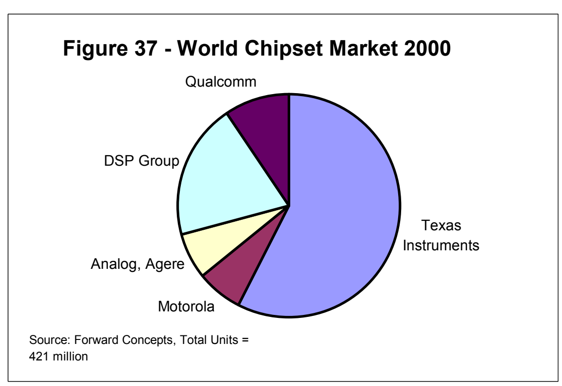
Company	2000 Employees	Announced Layoffs
Alcatel	131,598	23,000
Ericsson	105,129	15,000
Nokia	60,289	3,100
Siemens	113,000	14,000
Lucent	126,000	44,000
Motorola	147,000	37,000
Nortel	94,500	40,000

Source: Goldman Sachs, Wireless Week

The equipment market breakdown for 2000 is indicated in the figure below.[60] Ericsson has continued to gain market share, increasing its percentage since 1999.



At the more microlevel, powerful chips underpin the cell phone systems. California-based Qualcomm holds 75 to 80 percent of the CDMA chip market, and approximately 10 percent of the overall chip market for wireless phones.[61] The overall market leader is Texas Instruments, which holds approximately 58 percent of the total market, followed by Silicon Valley-based DSP Group, which holds almost 20 percent of the market.[62] DSP licenses its technology to a number of leading manufacturers, including National Semiconductor, Samsung and Sony.[63] Other companies supplying chips for cell phones and/or base stations include Orange County-based Conexant, Intersil, and the Bay Area Sirenza. Telasic, a new startup, spun out of Raytheon, is developing new base station chips.



4. 802.11 and Bluetooth

802.11 and Bluetooth are two standards that enable wireless communication to occur in unregulated spectrum – 2.4 GHz to 5 GHz. The same device can use both standards – and in fact, it is likely that 802.11 and Bluetooth will be complementary, with Bluetooth providing cable replacement and on-demand connectivity and 802.11 providing wireless local area network access and extensions.

802.11

The Institute of Electrical and Electronics Engineers, Inc. (IEEE), a non-profit, technical professional association, set the standard for 802.11 in 1997.[64] 802.11 operates either in the unlicensed Instrument, Scientific, and Medical (ISM) or National Information Infrastructure (NII) radio frequency bands (901 MHz to 928 MHz, 2.4 GHz to 2.5 GHz, and 5GHz bands) or in an infrared medium. [65] Since its inception, the 802.11 standard has branched out into a variety of standards including 802.11a, 802.11b, and 802.11g. [66]

The IEEE 802.11b specification allows for the wireless transmission of approximately 11 Mbps of raw data at distances from several dozen to several hundred feet over the 2.4 GHz unlicensed band.[67] The distance depends on impediments, materials, and line of sight. This specification started to appear in commercial form in mid-1999, with Apple Computer's introduction of its AirPort components, manufactured in conjunction with Lucent's WaveLAN division.[68]

802.11a is the second-generation IEEE wireless LAN standard that applies to the 5 GHz Unlicensed National Information Infrastructure (UNII) band. This standard specifies the use of Orthogonal Frequency Division Multiplexing (OFDM) for data transmission at rates up to 54 Mbps.[69] IEEE's 802.11g is being developed to speed raw data rates up to 54 Mbps in the 2.4 GHz ISM band. IEEE 802.11g is an extension of IEEE 802.11 and will be backward compatible to existing 802.11b systems.

Bluetooth

Bluetooth (BT) is a de facto standard established by a group of manufacturers. It was named after the 10th century Viking king, Harald Bluetooth who united his kingdoms of Denmark and Norway. In February 1998, the Bluetooth Special Interest Group (BT-SIG) was designed to complement, not compete with, IEEE 802.11b. BT enables laptops, PDAs, cellular phones, and other devices to exchange data in a close-range (10 meters maximum) ad-hoc network. Bluetooth is intended to be a replacement for Infrared and cables.

Since both Bluetooth and IEEE 802.11b operate in the same 2.4 GHz band, there can be interference between systems operating simultaneously and in close proximity. Typically, this interference will result in slower performance of the affected systems.

Table 7. Bluetooth v. 802.11

	Bluetooth	**802.11**
Range	10 meters	100 meters
Coverage type	Point-of-demand access	Local-area network access
Best devices	Notebooks, PDAs, Cell Phones, Headsets, Printers, etc.	Notebook, PDA Add-ons
Best Applications	Cable Replacement and On-Demand Connectivity	Wireless LAN Access & Extension

Source: Steve Parker, 3Com, Presentation to CTIA Conference 2001

Overall, the Wireless Local Area Network (WLAN) is a fast growing market driven by demand for high-speed wireless connectivity and increasing availability of cost-effective, standards-based and interoperable products.

WLAN applications range from: 1) the extension of the wired Ethernet to wireless mobile devices within the corporation, 2) the seamless connectivity of networks inside the home for broadband internet and multimedia content sharing, and 3) the increasing deployment of wireless accesses in the public areas such as airports and hotels. Furthermore, the core technology also has applications in the fixed wireless space enabling cost-effective wireless broadband network between buildings and into the homes.

802.11b has become the only standard deployed for public short-range networks, such as those found at airports, hotels, conference centers, and coffee shops and restaurants. Several companies currently offer paid hourly, session-based, or unlimited monthly access via their deployed networks around the U.S. and internationally. [70]

In fact, a Los Angeles company, BOINGO, founded by Earthlink founder Sky Dayton, is partnering with those companies to provide a one-stop site for wireless LAN access; BOINGO is also partnering with Nomadix, a Los Angeles company, for billing and management solutions for gateway devices. BOINGO has also worked with Agere for network cards and HP.[71]

Overall, the wireless LAN market is experiencing explosive growth with the current momentum behind the 2.4GHz 802.11b products, and the market is forecasted to grow in excess of $4.6B by 2004. The market opportunity for Bluetooth-enabled products is expected to exceed 1 billion units by 2005. [72]

A number of California companies have developed 802.11 and Bluetooth technologies and devices:

> *SOHO Wireless*, a company based in Silicon Valley, enables small business or home owners to extend their internet access (through DSL or some other means) via its 802.11b device. LANRoamer Gateway, enables all "SOHO Affiliates" (for which there is no charge) to connect to the Internet for a $20 fee. This charge provides high-speed Internet access on the affiliate's backhaul Internet circuit.

> *WIDCOMM*, which stands for "Wireless Internet and Data/Voice Communications", is a private company located in San Diego that supplies Bluetooth software and systems to semiconductor, communications, and computing device OEMs. WIDCOMM also provides a family of network access solutions with Bluetooth wireless technology, called BlueGate - the first available server-independent Bluetooth wireless access points to integrate point-to-multipoint and extended receiver range capabilities.[73] WIDCOMM has been backed by significant investors, including Enterprise Partners, Comerica Bank, Sienna Holdings, Alcatel Ventures, Conexant, Philips, and Texas Instruments. [74[]

> *Silicon Wave* is another Bluetooth company based in San Diego that designs and produces radio frequency systems-on-chip for wireless and broadband communications. Due to the high level of systems integration, Silicon Wave enables OEMs to design reliable, high-performance products with very low power consumption, fewer components and in a smaller space.[75] Silicon Wave chips are used in battery operated devices, mobile phones, notebook PCs, printers, PDAs, set-top boxes and cable modems.

In addition, a number of Los Angeles and Bay Area companies are developing chipsets for the 802.11 market. These include Atheros, one of the leaders in developing the 802.11a chipsets, Intel, and Orange County-based Intersil and Broadcom. California also is home to a number of companies who manufacture network interface cards and network access points, such as Proxim, 3com, Gtran, Cisco, SMC, and Intel.[76]

5. Other Equipment

In addition, there are a number of other equipment manufacturers related to the wireless industry. For example, Arraycomm, a Silicon

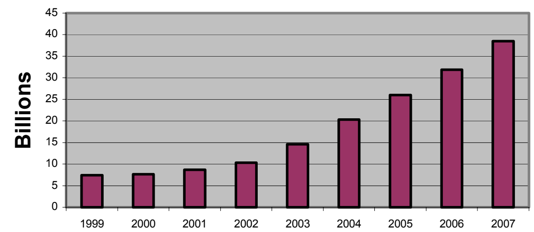
Valley company, manufactures "smart" antennas. Its IntelliCell technology, which is licensed for use in W-CDMA, GSM, and other networks, has near-term opportunities as carriers attempt to fit more calls within a given spectrum as the antenna directs signals toward appropriate receivers and enables multiple signals to be sent at the same time.[77] Other companies in this area include Santa Clara-based Wireless Online, funded by Mayfield, which is striking deals with Mexico and China-based telecommunication firms.[78]

Novatel Wireless Inc., a San Diego based wireless Internet solutions provider, designs wireless LAN modems that allow users to access the Internet. The company's customers include manufacturers, telecommunications service providers, and wireless service providers. Novatel's wireless LAN modem product line enable wireless access to the Internet, email, and corporate LANs. Furthermore, the modems provide enabling technology for wide-area networking.

E. Software Applications and Services

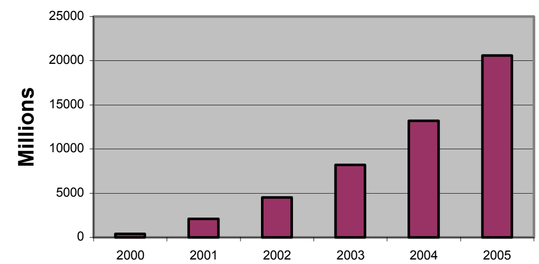
The potential – and the significance – of mobile services lie in the ability to transmit data. Indeed the data market is expected to grow significantly, both overall and at the enterprise level, as indicated in the following figures.[79] To realize this potential, however, standards must be agreed to, business models must be developed, software platforms must be introduced, and applications must be created. The following sections articulate these issues.

Figure 38. US Wireless Data Market



Source: Salomon Smith Barney, The US Mobile Data Report. Projected Figures

Figure 39. US Wireless Enterprise Market



Source: Goldman Sachs, 2001 - 2005 are forecast

1. Wireless Standards

The primary existing applications to communicate data via cellular phones are Short-Messaging Service (SMS) and Wireless Application Protocol (WAP). Two additional potential standards, J2ME and BREW, will enable mobile users to download files and applications quickly. These applications, though different, are not competitive – in fact, multiple applications can be used to access data.

SMS enables text messages of up to 160 characters to be sent through mobile phones. Initially, it was solely used in GSM networks, but it is now accessible to TDMA and CDMA networks. Unlike one-way paging, users can send and receive messages.[80] SMS has had a significant impact in Europe and Japan, via i-Mode, with more than 20 billion messages per month in the European Union in December 2001, compared to fewer than 5 billion in North America.[81] SMS has failed to attract significant attention in North America for a number of reasons. These reasons include the large number of car commuters (as opposed to public transportation in Europe and Japan) and the calling party pays system in Europe – which prevents receivers of SMS messages from being charged for incoming communication.

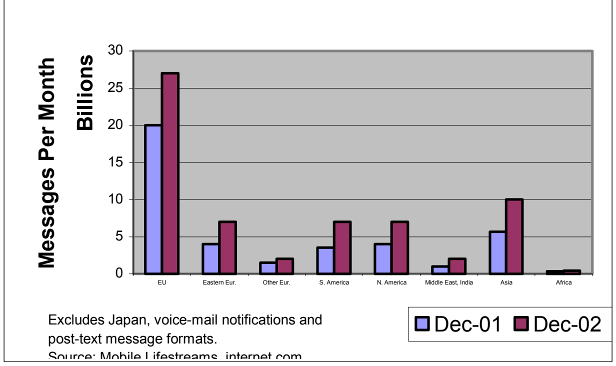


Fig 40. Worldwide SMS Use - 2001, 2002 Projected

Similarly, wireless application protocol (WAP) enables mobile phones and devices to connect to an Internet gateway, permitting access to web content. WAP has failed to make a significant impact in Europe and the US because of an inability to standardize the offering and because neither the Europeans nor the Americans developed a business model which encouraged content developers to develop WAP-related information.

Although WAP failed to attract significant attention to the wireless web in Europe and the US, the next wave squares two California companies against each other to develop the platform for downloadable applications: Qualcomm and Sun. The standard that triumphs could become to "wireless devices what Windows is to the PC: a universal standard for software developers."[82]

Qualcomm's BREW is the newer player, unveiling the system in February 2001 and structuring the platform in a way that can produce designated revenue streams. BREW vets the applications, ensuring they are suitable for phones. They also assist in the payment, serving as the middleman for distributing applications to carriers and paying developers.[83] Overall, BREW adds value to developers by providing a standardized format, adds value to device manufacturers by lowering integration costs, and adds value to carriers by certifying applications. Verizon and a number of other carriers have endorsed BREW, along with Kyocera, Toshiba and other manufacturers.

Sun's Java 2 MicroEdition (J2ME) takes a less controlled approach. It is based on the java standard and can be used for both PDAs and wireless phones to enable those devices to download content. Research in Motion, Motorola, Nokia and Siemens support J2ME as a platform.[84] J2ME relies on the network of 2.5 million JAVA programmers to develop applications, requiring that the carrier police the technical suitability of those applications. For example, Nextel and Motorola announced a certification program for J2ME developers, using a third party – a system that would not be required under BREW because Qualcomm certifies the developers.[85]

The differences between BREW and J2ME are outlined in the table below.

Table 8. BREW vs. J2ME

	BREW	J2ME
Payment/Certification	Performed by Qualcomm	Must be arranged by Carrier/Developer
Wireless Technology	CDMA initially, now any	Any technology

Sun is pursuing the same open source business model that it developed in JAVA (obtaining revenue through documentation, courses, integration and support) while Qualcomm seeks to leverage the open source nature of BREW with the additional revenue potential of a transaction fee for certifying applications and centralizing payment.

NTT DoCoMo's i-Mode is the model of what the American data market can become. In

Japan, 50 percent of DoCoMo phone users access train schedules, 56 percent of users access email and 35 percent of users access banking and stock market services – these numbers are substantially higher than the data access services in North America. i-Mode's growth is impressive: it took NTT 18 months to achieve 10 million subscribers, while AOL needed five *years* to achieve that subscription base.[86] Today, for just one network operator, NTT DoCoMo, 26 million Japanese subscribe to data services, compared to 5 million subscribers *total* in the US today.[87]

The i-Mode success relates to a number of factors. Most importantly, NTT developed a business model in which the content developers were paid for content that was accessed, rather than the "walled garden" approach of the Europeans and North Americans in which the network operator/carrier controlled the content. The "walled garden" strategy fails to incentivize developers to deliver applications because they do not share in the profits. Under the NTT model, the company was paid a fee for providing the service, approximately 9 percent, and receives all of the delivery revenue; content developers receive 91% of the revenue from their service.[88]

Other factors to NTT's success include cultural factors, such as the high wireless penetration rate in Japan, the preponderance of public transportation (necessitating train schedules), and the frequent use of electronic funds transfers, not checks, to conduct financial transactions. Finally, NTT's interface is very easy to use, especially compared to some WAP applications.

2. Software Platforms

The process of communicating data wirelessly is complicated, especially when it integrates with enterprise applications such as email, and accessing company databases behind the firewall. A number of companies, at various levels, provide this platform on which additional applications can reside.

One of the leading companies providing access to email and personal information management is Research in Motion's Blackberry device, which enables data to travel from a blackberry device through Cingular's network to a blackberry gateway to the Internet and then into a respondent's email box. To access email, the communicator draws information from behind the firewall and through the blackberry gateway to deliver the messages.

A number of companies, including many from California, compete in this market space. For example, San Diego-based Wireless Knowledge, a joint venture between Qualcomm and Microsoft, has an Echo platform that resides on a company's web server, taking the request from an employee's mobile device and translating the Internet's HTML into the appropriate language for the device (such as HTML for Palm OS devices, HTML for Pocket PCs, or WML or HDML for phones).[89] San Francisco-based Neomar provides the same functionality, as does Mountain View based Visto.com, Brisbane-based Viafone, and San Jose-based Everypath.

Other companies focus on delivering web content and other services to customers and partners, such San Mateo-based Avantgo. One of the greatest competitors outside of California, which formerly focused on the financial services industry but is now moving toward the platform area, is Aether Systems in Maryland. Still other companies have developed more enterprise-specific applications, such as Silicon Valley-based Oraclemobile.com and iAnywhere.

3. Software Products

A number of software products relate to the mobile area – and many of these companies are located in California. These products range from mobile games to wireless security to telematics.

One of the leading companies that is developing a standard for streaming video is San Diego-based Packet Video. Funded by leading corporate investors, including GE, Time Warner, Qualcomm and Sun, the company delivers streaming video and audio content over existing and next-generation wireless networks to PDAs, smartphones and laptops. In 2001, the company received an additional $100 million round of investment as it seeks to become the standard for mobile video. Its chief direct competition is Emblaze, an Israeli-based company, and it faces potential competition from Microsoft and RealNetworks, both of which seek to port their Internet-based video players to the mobile environment. A key lingering question is whether the video market, predicated on the development of 3G networks, will materialize in a way that will enable PacketVideo and its network of developers to derive sufficient revenue.[90]

Because Americans spend significant time in their autos (10% of the total business day, on average), a number of companies are examining potential mobile applications to maximize this time.[91] The potential applications include basic telematics (voice communication, navigation, emergency/safety) available from OnStar (on GM vehicles), and more advanced services such as location-based commerce services, mobile commerce transactions, fleet management, and mobile workforce support. Analyst predictions on the marketplace vary widely, from $13 - $100 billion by 2010.[92]

A number of barriers exist in any telematics system, including the threat of additional regulations, a lack of uniform standards and choice of potential technologies (ranging from G3 to 802.11), and long product development cycle for autos. A key concern: do consumers have the willingness to pay for basic safety at $240 per year (cost of OnStar)?

Many of the firms in the telematics area have significant automotive ties, with competitors including CellPort Labs, Delphi Automotive, ATX Technologies, LoJack, and Visteon. OnStar is clearly the dominant player today, providing service for General Motors cars using voice, and commanding 75 percent of the market of 2.3 million telematics subscribers. Ford and Qualcomm formed San Diego's Wingcast in 2000 to compete with the OnStar system.

F. Fixed Wireless and Free Space Optics

Fixed wireless solutions use microwaves to communicate information, substituting for fiber laid along in the street. Fixed wireless solutions were often championed during 2000 by competitive local exchange carriers, who sought to use the technology to quickly compete against the regional bell operating companies in offering both high-speed internet access and voice communications.

There are three basic fixed wireless systems: (1) Multi-channel multipoint distribution services (MMDS) which run over short distances (requiring line of sight) and employ vector orthogonal frequency division multiplexing (VOFDM) technology; (2) Local multi-point distribution services (LMDS) which operate at higher frequencies and have superior data speeds; and (3) the unlicensed national information infrastructure bands that Bluetooth and 802.11 run on.

Given the tumbling public markets and the speed at which fixed wireless providers needed to provide solutions, a number of the proponents – including Teligent and Winstar – are now bankrupt. Nevertheless, existing carriers are including the systems as a back-up to their networks. Moreover, analysts have recently predicted that fixed wireless subscribers will rise from 210,000 worldwide today to 2.1 million by 2005; service provider revenues from fixed wireless will grow to more than $3 billion, according to these reports.[93] Two California companies, WJ Communications and Western Multiplex, manufacture fixed wireless products.[94]

California is especially strong in a developing area that may compete with MMDS and LMDS systems – free space optics. This technology uses lasers to communicate broadband data, solving the "last mile" problem, in which telecommunications companies cannot bring broadband to the home or office because it is too far from the network operations center. The system uses lasers at distances from 500 to 2,000 meters but it can be impaired by fog or other weather.

Three leading companies – OpticalAccess, AirFiber, and LightPointe Communications – are based in San Diego;[95] a major competitor, Terabeam, is based in Washington. This September, Qwest announced that it was using LightPointe's service to avoid the time it takes to gain permits and rights of way to run fiber.[96] The cost is $8,000 per link, a fraction of the $100,000 to $300,000 of bringing fiber to the home.[97] The Strategis Group estimates that the technology will grow into a $2 billion market in the next five years.[98]

V. LOOKING FORWARD – PROSPECTS FOR 2002 AND POLICY MEASURES

Despite the 2001 economic slowdown, the prospects for California's wireless companies are promising. According to a February 2002 survey of California wireless firms conducted by the California Manufacturing Technology Center (CMTC) for this report,[99] more than half plan to increase revenues and employees during this year. A number of policy measures – from spectrum usage to cell phone siting – will impact the industry, and the major policy concern is cell phone radiation. In addition, a number of policy measures can further strengthen the state's industry, including encouraging California's existing innovation centers and innovative start up activity, as well as establishing a better wireless infrastructure and promoting the state as a wireless center.

A. The Prospects for 2002

CMTC conducted the survey to assess the temperature of California's wireless firms, analyzing their critical issues, challenges and policy measures.

Overall, California's wireless firms were bullish on their prospects for 2002, with 68 percent seeing an increase in revenues, 53 percent expanding into a new product line, 51 percent increasing employees, and 48 percent expanding into a new geographic market. Fewer than 15 percent reported that revenues would decrease. In fact, the firms predicted that their revenues would increase by an average of 24 percent, with a median increase of 10 percent, and employees would increase by an average of 50 percent, with a median increase of 20 percent.

The firms did identify barriers to their success – but these were principally in areas associated with growing companies. The top issue that the firms faced was reducing operating costs, followed by hiring qualified employees and increasing productivity. Consistent with this, companies identified as potential barriers to

Figure 41. Prospects for 2002

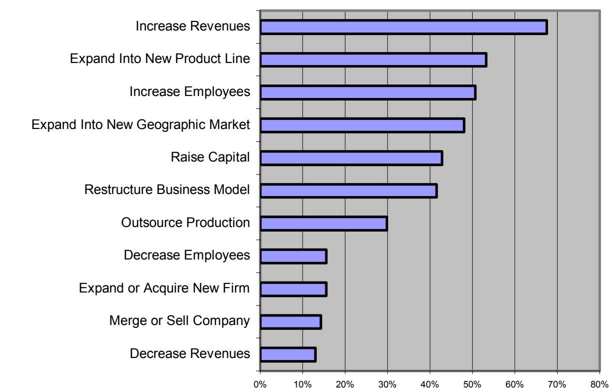
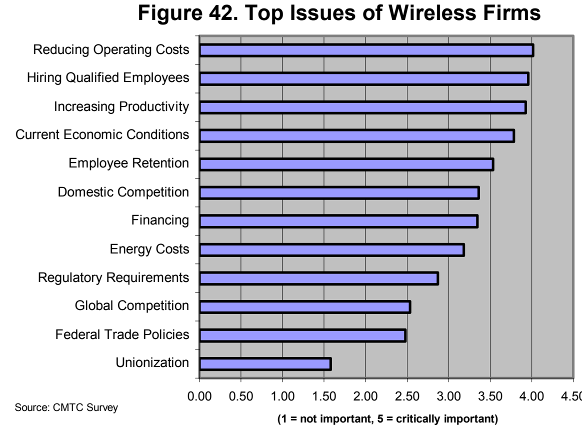
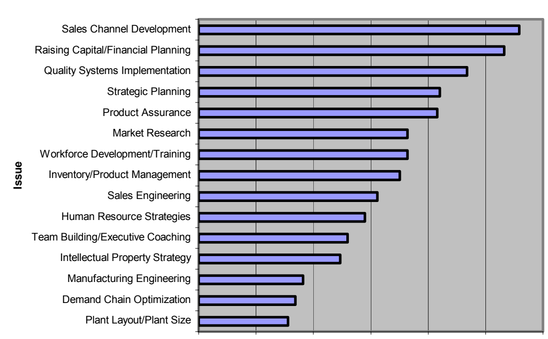


Figure 42. Top Issues of Wireless Firms



Source: CMTC Survey

Figure 43. Potential Barriers to Success



their success sales channel strategies, capital raising, and product-related issues, such as quality systems implementation and product assurance, as well as strategic planning.
On the whole, California companies seem rooted in the state – with 34 percent saying nothing would cause them to leave California; 24 percent said they would leave if taxes increased and 18 percent said they would leave if costs increased, according to qualitative responses.[100]

A number of policy issues affect the wireless industry, with the majority of these issues occurring at either the federal or local level. Principally, the policy issues can be divided into federal regulatory issues related to allocation of spectrum, safety issues related to radiation, state issues related to driving while speaking on cell phones, and public safety issues.

B. Spectrum Allocation

The Federal Communications Commission, under the act that created the agency in 1934, has the power to regulate issues related to radio, satellite and other areas of the public spectrum. A division within the agency, the Wireless Telecom Bureau, regulates all issues relative to the wireless industry, except satellite. Overall, the bureau and the commission seek to foster competition, provide universal service, maximize the efficiency of the spectrum, promote small business, enforce its rules and protect consumers.[101]

The FCC allocates spectrum based on auctions that it holds – an evolution of the process for distributing spectrum. In the past, the agency distributed spectrum through competitive hearings or lotteries. Now, the policy of auctioning spectrum is clearly entrenched, and in fact, spectrum costs can significantly exceed infrastructure costs for building a wireless system.[102]

The FCC reached two major decisions during 2001 that will significantly impact the composition of the wireless carrier industry, and therefore, the wireless equipment industry. First, the FCC negotiated with bankrupt carrier NextWave Telecom to sell its spectrum into major markets, opening up the door for carriers to purchase additional spectrum. However, an appeals court determined that the FCC violated bankruptcy laws by re-auctioning the spectrum that had been licensed to NextWave, and the US Supreme Court has decided to hear FCC's appeal – effectively delaying other carriers from using the spectrum until the court rules, which could take a year.[103]

At the same time, the FCC removed the spectrum cap which limited the amount of spectrum that one carrier could own. This spectrum cap policy had encouraged a number of smaller regional wireless carriers to develop, such as Leap Wireless. With the spectrum cap removed – under a policy of enabling carriers to realize further economies of scale, provide lower cost services and more offerings – the major carriers will likely buy out smaller carriers, as some, like AT&T Wireless are running out of spectrum.[104]

For some time, the industry has lobbied for increased spectrum to make 3G services available and had sought to obtain spectrum that the military reserves in the United States but is available commercially in Europe and Japan. With the September 11 terrorist attacks, it was unlikely that military spectrum would yield to commercial services; in fact, the FCC and the military are studying issues associated with distributing spectrum in the military band.[105]

Nevertheless, the industry has resumed its push for increased spectrum – which may be necessary for 3G to be implemented. Tom Wheeler, president of the Cellular Telecommunications & Internet Association (CTIA), called on the FCC to release more spectrum for commercial services; the National Telecommunications and Information Administration is currently conducting a study of potentially available spectrum and its use.[106]

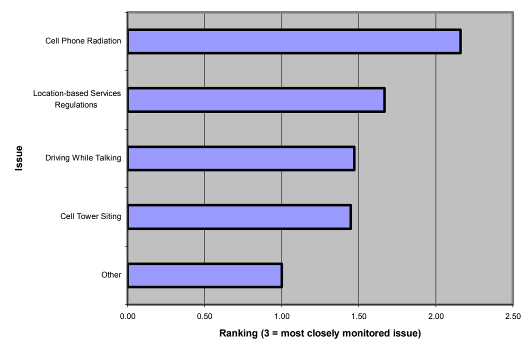
Similarly, two technology advocacy groups, TechNet and the Computer Systems Policy Project, have called for a national broadband policy to focus on regulations that would offer incentives for deployment of high-speed landlines and for making 120 MHz of additional spectrum available in 2004 and another 80 MHz available in 2010. This would harmonize the US standards with those of other countries.[107] The overall goal would enable 80 percent of US homes to have access to broadband services with data transfer rates of at least 1.5 Mbps by the end of 2003 and 50 percent of homes have 6 Mbps lines.[108]

C. Health Impacts

Health and safety advocates have long been suspicious of the radiation emitted from cell phones – and other electromagnetic devices, such as electricity towers. Although many have questioned the possibility that cell phones may emit radiation that could cause cancer, no studies have definitively confirmed suspicions that handsets' RF radiation causes cancer.[109]

By the same token, no studies have demonstrated handsets' safety either; a United States General Accounting Office study investigating the issue concluded in May that not enough data is available to clearly prove that mobile phones pose no health risks.[110] The Cellular Telecommunications and Information Association and the Food and Drug Administration are jointly conducting research to determine the connection between wireless phone use and cancer.[111]

Figure 44. Top Public Policy Issues



In fact, recent evidence from a Dutch study found that wireless phones do not pose health hazards, but the study called for further research.[112]

The FCC already enforces safety measures regarding radiation levels: the FCC limit for public exposure from cellular telephones is an specific absorption rate (SAR) level of 1.6 watts per kilogram.[113]

However, the final judgment may be decided in court. A number of plaintiffs are suing carriers and handset manufacturers to receive damages related to brain tumors and other ailments. In fall 2001, a judicial panel consolidated separate state court lawsuits in Louisiana, Maryland, New York and Pennsylvania into one federal court.[114] Other separate suits, however, have been filed since the consolidation.[115]

As the magazine Wireless Week stated on cell phone radiation, "[T]his year is expected to be a pivotal one both in the courts and in the court of public opinion."[116] Indeed, cell phone radiation ranked as the most-watched policy issue in CMTC's survey.

D. Safety While Driving

In two years, nine localities and the state of New York have banned talking on cell phones while driving in an attempt to curb accidents that result from distracted drivers. A number of studies have been conducted, with no conclusive results. Indeed, forty states have considered such a measure, and given localities' actions, there threatens to be a patchwork of rules between various states and local governments.

A total of five states have already enacted cell phone laws, including California, which now requires that rental cars come with cell phones to include information about how to use the phones safely. In addition to New York, other states with cell phone laws include Florida, which bars motorists from using cell phone headsets that cover both ears, and Massachusetts, which prohibits using cell phones while driving a school bus and requires motorists to always keep one hand on the wheel.[117]

Last year, Assemblymember George Nakano carried AB 770, signed by the Governor, which directs the California Highway Patrol to conduct a study of cell phone-related accidents in the state; Nakano's motivation for this bill stems from the fact that he himself was hit by a driver who was using a cell phone while driving.[118] In 2002, Assemblymember Joe Simitian of the Bay Area sought to replicate New York's ban, proposing a bar on all drivers from using handheld phones, with the exception of law enforcement and public safety officials; the bill did not pass out of the Assembly Transportation Committee in January 2002.[119] According to the bill, violators would have been subject to a fine of $40 for the first offense and $50 for subsequent offenses.[120]

To prevent this regulatory chaos of different rules between states and local governments, Representatives Gary Ackerman from New York and Senator Jon Corzine from New Jersey have introduced legislation to curb talking on phones while driving.[121] If enacted, the United States would follow the path of two dozen countries that have restricted drivers from using cell phones.[122]

The general population clearly supports a ban: in a recent poll, 75 percent of adults said they favored eliminating cell phone use while driving.[123] This sentiment is bolstered by recent studies, such as a British study, which found that talking on the phone was worse than driving drunk.[124]

This research is countered by the belief of many industry officials: drivers are distracted by many issues – radios, talking with passengers, and eating.[125] In fact, a study in NeuroImage found that performing two tasks simultaneously – language comprehension tasks and visual rotation tasks – led to reduced brain activity, i.e., an inability to concentrate on either.[126] But this study found that *anytime* two activities were conducted at once – regardless of the activity – the brain would be less alert.

Meanwhile, another earlier study released by the American Automobile Association, concluded that cell phones are less likely to cause an accident than are other distractions, such as talking with passengers or eating. Moreover, according to another study conducted by the University of North Carolina Highway Safety Research Center, only 1.5 percent of drivers involved in 5,000 accidents between 1995 and 1999 reported being distracted by cell phones.

E. E-911

This fall, the FCC approved the enhanced 911 plans for five nationwide carriers, Nextel, Sprint, Verizon, and the GSM properties of AT&T Wireless and Cingular Wireless. E911 enables carriers to pinpoint cell phone users using global positioning satellite technology, enabling emergency personnel to quickly identify the location of individuals needing assistance.[127]

E911 can serve public policy goals, enabling victims or potential victims to be located – a service highlighted by the September 11 terrorist attacks. Nevertheless, some privacy concerns remain, as the GPS chips will enable carriers to track fairly precisely the location of cell phone users.[128] The biggest concern for industry, however, is the potential cost (estimated by some analysts at $1 billion per carrier) – and the significant possibility that the technology implemented for E-911 could become quickly outdated.[129]

In addition to these pointed policy measures,[130] there are some overarching policy measures that can be considered, principally involving access to broadband.

F. Testbed/Infrastructure

California companies and communities are interested in a vibrant infrastructure for individual users – to connect communities for economic development and other purposes – and to serve as a testbed for developing new technologies.

As indicated earlier, technology executives and others have advocated a goal to enable "access to all" for broadband service, which would include both wired and wireless solutions. This issue is especially relevant outside the major metropolitan areas of California – especially in the Central Valley, the upper north of California, and the desert area of California.

As a 2000 report from the U.S. Department of Commerce National Telecommunication and Information found, "rural areas are currently lagging far behind urban areas in broadband availability." In rural areas, cable and DSL service, combined, is available to just 50 – 60 percent of homes.[131] Programs such as the federal E-Rate program, which enable rural health care providers and schools and libraries to access discounted high-speed communication services, help support this access by subsidizing the installation of DSL, cable or satellite service.[132] In fact, as indicated earlier, satellite service, offered by Hughes Network Systems and EchoStar's Starband Communications is an effective mechanism to deploy broadband to rural areas.[133]

In addition to these economic development concerns, technology development concerns exist. For example, executives in the wireless industry have commented on the lack of infrastructure in California, compared to other countries. In fact, the California Institute of Telecommunications and Information Technology (CalIT^2) has embarked on this approach through its "Active Campus" program.

The University of California at San Diego and the University of California at Irvine are "living laboratories" where issues of security, wireless networking, and scalability are currently being tested. For example, hundreds of freshmen at UCSD received PDAs that enable them to communicate wirelessly, testing an 802.11b infrastructure. In addition, Qualcomm's new High Data Rate (HDR) system, which can operate at peak rates of 2.4 Mbps on a 1.25 MHz channel are being tested.

G. Encouraging Innovation and Marketing the State

In the technology world, California has brand name recognition. CMTC's survey and interviews with wireless leaders indicated that California should work to continue maintaining its edge, by supporting innovation in the state, as well as building California's brand as a wireless center.

As noted earlier in this study, California leads the nation in wireless startups funded by venture capital. In interviews conducted with wireless leaders, policies that continue to encourage innovative activity were encouraged. These measures could include the continued support of innovative institutions, such as research programs at UCSD, UCLA and UC Berkeley.

These measures also include programs to encourage businesses and startup companies, such as the Regional Technology Alliance program (nonprofit organizations dedicated to assisting early stage technology companies) that are funded in part by the Technology Trade & Commerce Agency; the California

Manufacturing Technology Center (a state-supported organization to assist California manufacturers); the California Technology Investment Partnership (CalTIP) program which provides commercialization funds for companies innovating technologies that originate from universities and other sources; other nonprofit organizations such as Joint Venture Silicon Valley and UCSD CONNECT; and economic development programs that encourage wireless companies to locate in the state. In fact, in qualitative responses of CMTC's survey, policy measures to assist enterprises ranked among the topmost concerns.

In addition to these initiatives, expanding the California brand internationally was advocated by a number of wireless executives. With the compelling companies that exist in California, the state can rightfully brand itself as a major player in the wireless industry.

VI. CONCLUSION

California's wireless sector represents a significant technology area for California. Employing more than 600,000 in the state, California has the most wireless employees, the most wireless companies and the highest total wireless payroll of any other state.

This report has documented the status of California's wireless industry, finding that California not only leads other states but has witnessed substantial growth since 1993, more than doubling the payroll and number of firms. Two areas of California, in particular, appear to be driving the wireless growth – San Diego, home to Qualcomm, and the Bay Area, home to a number of firms, such as SUN Microsystems Oracle, Intel, Atheros and a number of firms in the integrated circuit area. Overall, 28 percent of the nation's public wireless firms are headquartered in California.

Even though the state is not a leader in handset manufacturing or national wireless carriers, the state hosts companies who are making significant innovations in the satellite industry, mobile devices, free space optics, and specific software areas, such as wireless software standards and streaming video. The policy issues facing these California companies are not unique to California. Indeed, they reflect the basic issues – regulations from the FCC governing spectrum and health and safety – which impact wireless companies throughout the country.

Like many technology sectors, California makes a significant mark on the wireless industry. The state could move even further by assisting areas without broadband internet access and encouraging a wireless infrastructure that can serve as a testbed for new technologies. The state could also promote the significant base that exists in the region – a powerhouse akin to the technological development of Scandinavia or Japan. Finally, for the state to maintain its leadership, it must continue encouraging technological innovations that match the growth in this new area of communications.

Appendix 1

Table of Public California Wireless Companies

Company	Employees	Revenues 2001	Market Category	Region
3Com	8,165	2,820.90	Hardware - Networking	Bay Area
@Road, Inc.	315	10.6	Software	Bay Area
Aml Communications, Inc.	61	5.1	Equipment - amplifiers	LA Area
Aspac Communications, Inc.	17	0	Fixed wireless - equipment	LA Area
Avantgo, Inc.	342	16.3	Software/Content	Bay Area
Broadcom	2,824	961.80	Semiconductors	LA Area
California Amplifier, Inc.	363	125	Equipment	LA Area
Certicom Corp.	319	12	Software - security	Bay Area
Cisco Systems	38,000	22,293	Hardware - Networking	Bay Area
Comarco, Inc.	230	39.2	Software and Services, equipment	LA Area
Conexant	6,400	1,062.60	Semiconductors	LA Area
Critical Path, Inc.	1,041	135.7	Software - ASP	Bay Area
Dmc Stratex Networks, Inc.	1184	417.7	Equipment - Digital Microwave Radios	Bay Area
Endwave Corp.	535	41.2	Hardware - RF modules, transceivers, antennas	Bay Area
Geoworks	158	12.1	Software	Bay Area
Gric Communications, Inc.	217	29.5	Software - connection to Internet via 802.11	Bay Area
Handspring	425	101.9	Equipment	Bay Area
Hughes Electronics	9000	7288	Satellite	LA Area
Intel	83,400	$26,539	Semiconductors	Bay Area
Intersil	2,036	$481.10	Semiconductors	LA Area
Interwave	393	$26.50	Satellites	Bay Area
Kana Software	1,181	119.2	Software	Bay Area

Leap Wireless International, Inc.	860	50.3	Carrier	San Diego
Linear Technology	3,193	427.50	Semiconductors	Bay Area
Micro Linear	107	22.10	Semiconductors	Bay Area
Netro Corp.	281	68.5	Equipment	Bay Area
New Focus, Inc.	1622	80.4	Equipment	Bay Area
Novatel Wireless, Inc.	286	61.2	Equipment - wireless modems	San Diego
Nuance	469	51.8	Software - speech recognition	Bay Area
Oraclemobile.Com	42,927	10,130.1	Software	Bay Area
Palm, Inc.	1,311	1,057.60	Equipment, operating system	Bay Area
P-Com Inc.	891	234.4	Fixed wireless - equipment	Bay Area
Powerwave Technologies, Inc.	1295	447.4	Equipment	LA Area
Proxim, Inc.	347	107.5	Equipment - wireless networking components (modems, ethernet bridges)	Bay Area
Puma Technology, Inc.	223	30.8	Software	Bay Area
Qualcomm Inc.	6300	3,196.80	Technology, Equipment	San Diego
Remec, Inc.	3167	189.2	Equipment	San Diego
Repeater Technologies, Inc.	103	17	Equipment - antennas, repeaters	Bay Area
Semotus Solutions, Inc.	105	5.5	Software - wireless application service provider	Bay Area
Sirenza	95	$19.80	Semiconductors	Bay Area
Softnet Systems, Inc.	552	9.9	Satellite	Bay Area
Spectrian Corp.	318	163.6	Equipment	Bay Area
Sse Telecom, Inc.	103	14.8	Satellite	Bay Area
Stm Wireless, Inc.	112	17.1	Equipment	LA Area
Sun Microsystems, Inc.	43,700	15,721	Software	Bay Area
Superconductor Technologies, Inc.	178	10	Equipment	Other

Surewest Communications	731	143.3	Carrier	Other
Tci International Inc.	118	30.6	Equipment - antennas	Bay Area
Transmeta Corp.	418	16.2	Equipment - chips	Bay Area
Trimble Navigation Ltd.	2306	369.8	Software, equipment - GPS	Bay Area
US Wireless Corporation	67	0.2	Equipment – tracking system	Bay Area
ViaSat, Inc.	796	75.9	Satellite	San Diego
Vyyo Inc.	241	15.4	Equipment - free space optics	Bay Area
Western Multiplex Corp.	232	105.5	Equipment	Bay Area
Wireless Facilities Inc.	1,486	$207.20	Misc. Services	San Diego
WJ Comm	243	62.20	Switching Equipment	Bay Area

Appendix 2

Breakdown of Wireless Standard Industrial Classification Codes

3663- Radio and Television Communication Equipment
Broadcast equipment (including studio), for radio and television, manufacturing
Cable decoders manufacturing
Cable television transmission and receiving equipment manufacturing
Cameras, television, manufacturing
CB (citizens band) radios manufacturing
Cellular telephones manufacturing
Closed circuit television equipment manufacturing
Communications equipment, mobile and microwave, manufacturing
Earth station communications equipment manufacturing
Global positioning system (GPS) equipment manufacturing
Marine radio communications equipment manufacturing
Microwave communications equipment manufacturing
Mobile communications equipment manufacturing
Pagers manufacturing
Radio transmitting antennas and ground equipment manufacturing
Receiver-transmitter units (i.e., transceivers) manufacturing
Satellite communications equipment manufacturing
Space satellites, communications, manufacturing
Studio equipment, radio and television broadcasting, manufacturing
Telephones, cellular, manufacturing
Television transmitting antennas and ground equipment manufacturing
Television, closed-circuit equipment, manufacturing
Transceivers (i.e., transmitter-receiver units) manufacturing

4812- Radio/Telephone Communications
Beeper (i.e., radio pager) communication carriers
Cellular telephone communication carriers
Cellular telephone services
Mobile telephone communication carriers
Paging services
Personal communication services (PCS) (i.e., communication carriers)
Radio communications (paging and cellular resellers)
Radio paging services communication carriers
Radiotelephone communications (cellular carriers)
Radiotelephone communications (paging carriers)
Telephone communications carriers, wireless (except satellite)
Two-way paging communication carriers
Wireless data communication carriers (except satellite)
Wireless telecommunication resellers (except satellite)
Wireless telephone communications carriers (except satellite)

4899- Communication Services
Communications services, NEC (ship-to-shore broadcasting)

Communications services, NEC (satellite communications)
Communications services, NEC (except radio dispatch, ship-to-shore, and satellite communications)
Ship-to-shore broadcasting communication carriers (except satellite)
Earth stations for satellite communication carriers
Satellite telecommunication carriers
Earth stations (except satellite telecommunication carriers)
Radar station operations
Satellite telemetry operations on a contract or fee basis
Satellite tracking stations on a contract or fee basis
Telemetry and tracking system operations on a contract or fee basis

Appendix 3

Description of Public California Wireless Companies[134]

3COM
Founded in 1979, 3Com manufactures networking hardware and software. Its target markets include the enterprise and service provider markets. The company is structured into three operations: the Business Networks Company (BNC), Business Connectivity Company (BCC), and the CommWorks Corporation. The Business Networks Company provides network infrastructure equipment for large and small businesses. The Business Connectivity Company supplies products that allow computing devices to access computer networks. Finally, The CommWorks Corporation enables Internet Protocol (IP)-based access and infrastructure platforms for the telecommunications service provider market. Notable customers include AOL Time Warner and AT&T.

@ROAD
Using its patented LocationSmart wireless Internet technology, @Road provides its customers with a mobile positioning system that offers two-way messaging, vehicle location information, and dispatch communications. Customers include truckers, distributors, couriers, and school bus operators. Founded in 1996, @road also has an Internet-based Mobile Resource Management (MRM) Solution as well as an open platform Application Program Interface (API) to address mobile commerce industry partners wanting to use @road's technology. In addition, having established agreements with wireless network operators such as AT&T Wireless, Cingular Wireless, Nextel, and Verizon, @road uses the Global Positioning System (GPS) to fix a vehicle's position. This data is then transmitted to a service center and then made available to customers via the Web.

AML COMMUNICATIONS
AML Communications, Inc. is a producer of low noise and power amplifiers for wireless communications companies. Designed to improve the performance of cellular phone systems and satellite communication systems, the firm's products send out and receive multiple signals with minimum interference. Furthermore, not only can AML handle product volume and design complexity that exceeds industry standards, it is also a fully certified ISO firm. Currently, the company is looking to expand its customer base by targeting OEMs, in addition to its traditional wireless service provider markets. Clients include Transcept and AT&T Wireless.

ASPAC COMMUNICATIONS
In collaboration with YeeYoo.Net, ASPAC Communications, Inc. is developing a wireless broadband interactive communication system and online services for China. In addition to having a joint venture with YeeYoo Network Information Technology, a Beijing Sino-tech Science and Technology Development Center, ASPAC has also formed ties with the China Education and Research Network (CERNET), a firm that currently operates the second largest network in China. Using the combination of CERNET and SINOTECH, ASPAC hopes to capitalize on the access to over 20 kilometers of nationwide fiber backbone and operation services that both Chinese firms provide. If ASPAC ultimately has its way, the company will soon be the leading provider of high-speed Internet access to schools and businesses throughout the People's Republic of China.

AVANTGO
Avantgo, Inc., a leading provider of mobile enterprise software, offers applications that allow PDAs to receive content from over a thousand channels, among them the Wall Street Journal, Yahoo!, and other Internet sites. The company currently services 28 of the Fortune 100 and over 2500 companies in 50 countries. AvantGo's software can be used to run business processes and improve the exchange of information between companies and their employees and customers. The firm's solutions include customer relationship management (CRM), supply chain management (SCM), and personal information management (PIM) mobile business applications.

BROADCOM
The company manufactures broadband communications chips for use in cable set-top boxes, cable modems, high-speed local, metropolitan, wide area and optical networks, home networking, Voice over Internet Protocol (VoIP), carrier access, residential broadband gateways, direct broadcast satellite and terrestrial digital broadcast systems. The firm also builds integrated circuits for digital subscriber line (DSL), carrier access, and wireless communications equipment. Corporate clients include Motorola, which accounts for 18% of sales, 3Com, Cisco Systems, and IBM. The company's products are built on four primary technology foundations: proprietary communications systems algorithms and protocols; digital signal processing hardware architectures; silicon compiler design methodologies and cell library development for standard cell and full-custom IC design; and analog and mixed-signal circuit design using industry standard CMOS processes

CALIFORNIA AMPLIFIER
Founded in 1981, California Amplifier produces a wide variety of amplifiers, downconverters, antennas, and integrated microwave fixed point solutions designed to improve reception in satellite television, wireless cable, and wireless broadband access systems. The firm is organized into two business units: the Wireless Access Products division, which focuses on broadband wireless access products for transmission of video, voice, and data services; and the Satellite Products division, which focuses on the production of outdoor radio-frequency (RF) electronics for reception of satellite signals.

CERTICOM
With an increasing demand for information security products, Certicom has positioned itself to become the industry standard with its innovative technologies. The company provides a complete line of network security products and services for wireless applications, devices, components, and networks. Firms that license Certicom's encryption technology include Motorola, Palm, and QUALCOMM. Certicom also offers consulting, integration services, and training to its customers in the use of its wireless security solutions.

CISCO SYSTEMS
The worldwide leader in networking for the Internet, Cisco Systems owns a majority of the market share for routers and switches, components used to link networks and power the Internet. Other products the firm provides include network access servers and management software. The company has also ventured into the telecommunications sector with products designed to transmit data, voice, and video traffic – a market that is fierce in competition with noted companies such as Nortel and Lucent. A company known for its aggressive acquisitions, Cisco has recently slowed this activity in response to the slowing economy.

COMARCO
COMARCO, Inc., a leading provider of wireless products, services, and application systems, allows operators of cellular and PCS networks to use their testing equipment and billing system software to design and operate their systems. Other products that COMARCO builds include wireless emergency call box systems that to date number over 18,000 units across the nation; and a 70-watt universal battery charger, called ChargeSource, that provides power and charging functionality for commonly used electronic and wireless devices.

CONEXANT
Conexant Systems manufactures integrated circuits and subsystems used in communication devices and networks such as fax machines, computer and cable modems, cordless and cellular phones, and television set-top boxes. The company delivers its semiconductor products through three separate divisions: the wireless communications division, which provides power amplifiers, radio-frequency subsystems and complete system solutions; the broadband access division, which builds digital entertainment and information networks for domestic use; and Internet infrastructure division, which develops semiconductor networking solutions that support the transmission of video and voice data. Conexant's customers include IBM, Motorola, Nokia, and Sony.

CRITICAL PATH
Critical Path provides email hosting, wireless device support, integrated calendaring, and bi-directional faxing to service providers, wireless and wireline carriers, enterprise corporations and postal authorities all over the country. Initially, the company's focus was on providing basic email services, but as the firm grew it expanded its services to include all aspects of messaging, including security, identity management, collaboration services, and wireless access. Unfortunately however, the company's recent fall in revenues forced management to lay off 40% of its workforce.

DMC STRATEX NETWORKS
As one of many firms competing in the market to offer broadband wireless access services, DMC Stratex Networks builds digital microwave radios used in wireless communications systems worldwide. The company's wireless products deliver information via high-frequency broadband, microwave and millimeter wave signals. The company's radios include its Altium (broadband); DART, SPECTRUM II, XP4 (medium-capacity); and DXR (long-haul) brands, all devices that transmit voice, video, and data through microwave frequencies. Target markets for the company include Broadband access providers, including CLECs and competitive access providers; PCS/PCN and mobile service providers; PTTs, common carriers, competitive access providers, and other service providers; private networks; and original equipment manufacturers (OEMs). DMC's customers include BellSouth, Motorola, and Siemens.

ENDWAVE
Endwave Corp., a major supplier of RF systems and parts to the wireless telecommunications infrastructure markets, offers a wide variety of products that range from amplifiers, multipliers, up/down converters, and oscillators to integrated transceivers and frequency synthesizers. Notable clients of Endwave include Nokia, Hughes Electronics, and Nortel Networks. The company itself was created as a result of a merger between Endgate and TRW Milliwave in 2000.

GEOWORKS
Giving business professionals the ability to access information and services through phones, pagers, and personal digital assistants is what Geoworks is in the business of doing. The company produces mobile data software that enables clients with mobile access to their information, and also licenses its smart phone operating system to companies such as Nokia and Toshiba. Founded in 1983, the company relies on its international presence for much of its business – non-US customers account for approximately 80% of sales.

GRIC COMMUNICATIONS
GRIC Communications, provider of Internet-based mobile office communications services, allows its customers to dial into their ISPs using local numbers, even when outside their area. GRIC's customers include ISPs, communication providers, and enterprise customers. Using its global GRIC Alliance Network, a web of more than 300 service providers, GRIC can offer Internet access through over 15,000 dialing locations in 150 countries. Products and services offered by GRIC include the GRICtraveler – Global Internet Roaming for Service Providers; the GRICtraveler – Corporate Secure Remote Access for Enterprises; and QMS (Quality Management Service).

HANDSPRING
Handspring, a provider of handheld computing products, licenses Palm's operating system and its Visor handhelds. Handspring, which competes against Palm, focuses on building products that make organization simple and that give users easy access to the Internet. Although the company's handhelds are priced similarly to Palm's product line, the Visor's springboard expansion bay includes such add-ons as modems and extra memory.

HUGHES ELECTRONICS
As the operator of DIRECTV, the largest US direct broadcast satellite (DBS) provider, it is no wonder that the current unit of General Motors was a target for acquisition by its competitors. GM has agreed to sell the company to DIRECTV's main US rival, EchoStar. Provided that the deal goes through, the merger would create one of the largest multichannel TV providers in the US. In addition to its Electronics unit, Hughes also owns satellite network operator PanAmSat and satellite equipment maker Hughes Network Systems.

INTEL
Intel has established itself as the leading manufacturer of computer chips, controlling over four-fifths of the PC microprocessor market. Among the company's largest clients includes Dell, which accounts for 14% of sales. Despite a loss of market share to AMD, Intel still maintains an extremely profitable stronghold on the market for PC computer chips. Recently, the firm has focused on supplying computer chips to foreign markets in an effort to maintain its growth.

INTERSIL
Intersil is a wireless LAN and analog semiconductor company that develops products for the communications and computing markets. The company also provides complete silicon, software and reference design solutions for new products, thus allowing for portable connectivity to its users. Companies such as Cisco, Compaq, IBM, Nokia, and Sony use Intersil's analog and mixed-signal integrated circuits in their equipment. Furthermore, the firm's power management products – used

to control the power on high-speed computer motherboards for communications and power management – are incorporated in PCs, servers, and storage networking gear.

INTERWAVE

Interwave offers compact wireless systems for voice and data communications, namely end-to-end compact cellular systems and broadband wireless data networks that deliver scalable IP, ATM broadband networks. The company's flagship products include a line of wireless base station transceivers and controllers that are used extensively by both the public and private sectors. The firm's products are sold in over 20 countries. Nortel Networks owns about 15% in the company.

KANA SOFTWARE

Formed in 2001 when enterprise communications software specialist Kana Communications bought customer relationship software maker Broadbase Software, KANA provides external eCRM solutions to businesses worldwide. The firm offers a Web-based e-business platform for managing and personalizing communications, customer information, and other services via email, phone, and other channels. The company's principle product, KANA iCare, provides a link between contact centers and marketing departments, allowing businesses to have interactions with customers at all areas of contact and throughout the company.

LEAP WIRELESS INTERNATIONAL

Leap Wireless, a wireless communications carrier, provides communications services for the mass consumer market. The company's 1,100,000 customers in over 25 US markets attest to this. Headquartered in San Diego, CA, Leap was spun off from QUALCOMM in 1998. Its marquee product, the Cricket Comfortable Wireless Service, features unlimited flat-rate local calling but no roaming. The company, which operates CDMA (code division multiple access) digital networks, plans to introduce wireless data services in the near future.

LINEAR TECHNOLOGY

Linear Technology provides a wide variety of linear integrated circuits (ICs) used in several electronics applications. Among these applications include telecommunications, cellular phones, networking products and satellite systems, laptops and desktops, computer peripherals, video/multimedia, industrial instrumentation, automotive electronics, factory automation, process control, and military and space systems. The integrated circuits produced by the firm enable the translation of analog data into digital information for use in mobile devices. To date, Linear Technology has a consumer base of over 15,000 manufacturers.

MICRO LINEAR

Micro Linear develops analog and mixed-signal integrated circuits for use in a variety of communications markets, including the consumer, SOHO, and enterprise segments. The firm sells its base-band processor and radio-frequency transceivers through a global network of distributors such as Insight Electronics. The firm's two most notable products include a 2.4GHz RF frequency hopping, spread spectrum (FHSS), transceiver chip set and a 900MHz Low IF single chip transceiver. The U.S. market accounts for over half of Micro Linear's sales.

NETRO
Netro provides Fixed Wireless Access solutions to communications service providers around the globe, using its AirStar radio equipment to deliver voice and data signals at high speeds to small and mid-size businesses customers. The AirStar system is composed of three parts: an outdoor transmission and reception unit; a hub for linking multiple units and sorting their signals; and a customer network interface device. Netro also offers AirView Link Explorer software for managing a network. The company recently acquired the product assets and team of AT&T Wireless' Fixed Wireless Division, also known as Project Angel.

NEW FOCUS
New Focus builds optical components, the purpose of which is to boost the capacity and speed of telecommunications networks. All of the company's fiber-optic products are manufactured under the Smart Optics for Networks brand. New Focus' line of products includes fiber-amplifier products, wavelength-management products, high-speed opto-electronics, tunable laser modules, telecom test-and-measurement instrumentation and advanced photonics tools. Businesses that purchase their optical components directly from New Focus include Corvis, Agilent, and Corning.

NOVATEL WIRELESS
Novatel Wireless Inc., a San Diego based wireless Internet solutions provider, designs wireless LAN modems that allow users to access the Internet from everywhere. The company's customers include manufacturers, telecom service providers, and wireless service providers. Novatel's wireless LAN modem product line can be divided into 5 product categories: the Minstrel Family of Wireless Palmtop Modems; Merlin Wireless PC cards; Sage Wireless Serial Modems; Lancer 3W Wireless 3 Watt Modems; and the Expedite Family of Wireless Embedded Modules. All wireless LAN modems in all five categories enable wireless access to the Internet, email, and corporate LANs.

NUANCE
With its innovative products and groundbreaking technologies, Nuance produces Voice Web software. The company makes voice interface software that corporations use to make their information and services accessible from any telephone. Nuance provides software that covers all major categories of Voice Web – speech recognition, voice authentication, text-to-text speech and voice browsing. Examples of Nuance's products put to use include brokerages that use the company's voice-based interface technologies for stock quotes or trading, or airlines that use the software for flight verification. Customers of Nuance include Nortel Networks, Sears, and Charles Schwab.

ORACLE
Based in Redwood City, Calif., Oracle is a leading provider of systems software. Their product listing includes database management, application development, and application server software. Companies manage everything from word documents and excel spreadsheets to XML and digital images using the Oracle9i database management software. Oracle now also provides business applications for its customers, including supply chain and human resource management applications. Consulting and support services account for over half of the firm's sales.

PALM
Owning a significant share of the market for handheld computers, Palm looks to continue this trend with a steady stream of innovative products. Its affordable, entry-level m100 competes with the base model offered by industry rival Handspring, a company which itself uses Palm's operating system. The pricier III and V series include features such as color displays and increased memory. Furthermore, the Palm VII model adds wireless Internet access to address book, email, and memo functions. In 1999, the company launched its Palm.Net wireless service, a system that provides on-the-go Internet access.

P-COM
P-Com builds Point-to-Multipoint, Point-to-Point, and Spread Spectrum radio systems for use in the telecommunications industry. This way telecommunications firms and Internet service providers can use P-Com's microwave radio transmission equipment to provide wireless access services as an alternative to laying cable. P-Com's Network Services division provides engineering, installation support, program management and maintenance support services to the telecommunications industry in the US.

POWERWAVE TECHNOLOGIES
Powerwave Technologies, a supplier of radio frequency (RF) power amplifiers, builds both single-carrier and multi-carrier ultra-linear RF power amplifiers. Powerwave's power amplifiers help wireless transmissions with a reduction in signal interference, and its single- and multiple-carrier amplifiers support a variety of digital and analog transmission protocols. The company's products are used in the base stations of cellular and personal communications service (PCS) networks. Founded in 1985, Powerwave's headquarters are located in southern California.

PROXIM
Proxim is in the wireless broadband networking business, providing wireless networking components, adapter cards, modems, and Ethernet bridges to enterprises, service providers, small businesses and homes. The company offers solutions for home and small office users, network service providers, OEMs and public and private businesses. Using Proxim's services, devices such as desktop and notebook computers, not to mention handheld data collection terminals, are all used to access wireless local-area and building-to-building networks.

PUMATECH
Pumatech manufactures software products and services that allow users to access, exchange and synchronize data stored on computers, handheld devices, personal organizers, and smart phones. The company's trademark software, called Intellisync, synchronizes handheld devices and business applications such as Microsoft Exchange and Lotus Domino. Pumatech's other products, such as its Browse-It software, converts HTML into interactive content for Palm devices. This consequently allows for users of Palm to secure access to the Web.

QUALCOMM
Qualcomm is perhaps best known for creating Code Division Multiple Access (CDMA) technology. Although CDMA was initially not without its critics, the technology's ability to squeeze more calls and data through limited airwaves, in addition to its quick evolution to high data-transmission speeds, are features that have proven beneficial to the company's reputation. CDMA technology is

now widely used in cell phones, wireless telecom equipment, and satellite equipment. The company produces CDMA chipsets and system software, components that are used extensively by telecommunications firms such as Sprint PCS. Furthermore, Qualcomm also produces the OmniTRACS global positioning system, a service that is used by the trucking industry, for one. The company also supplies satellite wireless telephone operator Globalstar with network equipment.

REMEC

In the wireless communications networks puzzle, REMEC builds the high frequency subsystems used in the transmission of integrated voice, video and data traffic component of it. Its microwave radio transmitters, amplifiers, and filters are used in weapons and satellite systems. Most of the firm's customers include businesses in the telecom manufacturing industry such as Alcatel, Motorola, and Nokia. Defense contractors such as Lockheed Martin, Northrop Grumman, and Raytheon are also included among REMEC's customers.

REPEATER TECHNOLOGIES

Repeater Technologies delivers infrastructure repeaters to mobile and personal communication service providers and base station manufacturers around the globe. Some of the products that Repeater manufactures include: antennas, used to provide both indoor and outdoor wireless connectivity; management software, used to control its equipment; battery systems, used to provide battery power; and infrastructure products designed to be compatible with networks using the CDMA wireless standard.

SEMOTUS SOLUTIONS

Semotus Solutions, formerly Datalink.net, is a wireless application service provider (ASP) that enables information to be transmitted to customers using wireless portable devices. Users are delivered such useful information as stock quotes, news, and custom alerts via pagers, mobile phones, and PDAs. The company has expanded its customized wireless and e-Commerce services by integrating with its four affiliates: Cross Communications, Inc., Five Star Advantage Inc., Simkin, Inc., and WaresonTheWeb. Markets that Semotus Solutions offers products to include businesses with field operators, home health care providers, and financial services.

SIRENZA

Formerly known as Stanford Microdevices, Sirenza designs radio-frequency (RF) integrated circuits for the wireless and wire-line telecommunications markets. The firm's products include power modules, low noise amplifiers, high-linearity gain blocks, modulators, mixers, amplifiers, drivers, and switches. Clients use these various components to enhance the performance of their wireless and broadband telecom systems. The fabless company's amplifiers, drivers, switches, and discrete devices are made from advanced materials like gallium arsenide and silicon germanium. Customers include Avnet, Minicircuits Labs, Richardson Electronics, Lucent, Hughes Network Systems, and Motorola.

SOFTNET SYSTEMS

Using proprietary wireless technology, SoftNet Systems, via its Intellicom subsidiary, provides two-way satellite-based Internet access to ISPs, schools, corporations and businesses worldwide. The company has operations in the Caribbean, Latin America, and the US. Although SoftNet has discontinued its Internet-over-cable subsidiary ISP Channel and its Aerzone business traveler assistance subsidiary, it still continues to market its cable Internet access service in China.

SPECTRIAN

By using Spectrian's linear power amplifiers, wireless communication providers can carry more calls on a single frequency and boost radio signal quality. The company's products include multicarrier amplifiers and single-carrier amplifiers. Both categories of products support analog and digital voice, advanced GPRS/EDGE voice and data, and broadband wireless applications in microcell and macrocell base stations. Electronics manufacturers such as Nortel Networks and Samsung are among those firms that purchase Spectrian's amplifiers.

SSE TELECOM

SSE Telecom Inc., builds satellite telecommunications equipment for voice, data, and video transmissions. Their products are sold to systems integrators, service providers, and businesses in over 110 countries. Founded in 1988, the company's principle product is the iP^3 Gateway, a carrier-grade integrated terminal that is made up of an indoor unit (IDU), outdoor unit (ODU) and optical antenna.

STM WIRELESS

Founded in 1982, STM Wireless provides satellite networking terminals and wireless communications systems for telecom providers worldwide. Networks are built for transmitting data using STM's DAMA hardware and software. The data from the networks in turn is delivered by use of small aperture satellite terminals and other wireless infrastructure gear including antennas, satellite modems, and routers. Most of STM's customers include emerging international telecommunications providers who are interested in the firm's lower-cost alternative to land-based networks. As a result of STM's targeting of customers overseas, exports account for nearly 80% of sales.

SUN MICROSYSTEMS

Sun Microsystems, whose customer base outside the US is increasingly growing, has several products that fall under its name. Among them include UNIX-based servers that are used for corporate computer networks and Web sites; workstation computers and a widening range of disk- and tape-based storage systems; and computers that use their own chips (SPARC) and operating system (Solaris). Software that the company produces includes application servers, office productivity, and network management applications. Sun is also credited for developing Java. Specifically, the Java 2 Platform, Micro Edition gives businesses the opportunity to accommodate a new set of enterprise clients: cell phones, two-way pagers, and palmtops.

SUPERCONDUCTOR TECHNOLOGIES, INC.

Initially founded to serve as an R&D company dedicated to researching high-temperature superconductors, the company transformed itself to an operating firm in 1997 to sell superconducting technology products to the wireless telecommunications infrastructure market. The company's primary product, the SuperFilter amplifier, comes complete with the high-temperature superconducting technology and proprietary cryogenic cooling features. Wireless service providers use the energy saving SuperFilter in base stations to reduce noise and extend range. With the US government having accounted for over 80% of sales since the company's founding in

1987, it is no wonder that the firm relies on government contracts to fund its R&D operations. ALLTEL is also a client.

SUREWEST COMMUNICATIONS

SureWest Communications, formerly Roseville Communications, is a provider of telecommunications products and services in central California. The SureWest Communications family includes: Broadband, Wireless, Long Distance, Directories, Foundation and Internet. SureWest Broadband provides telecom services to businesses, while SureWest Internet delivers high-speed DSL Internet access. SureWest Wireless operates a wireless PCS network, and the rest of the SureWest units offer pay phones and telephone directory publishing. The holding company's main subsidiary, Roseville Telephone, provides local phone service in the Placer and Sacramento counties, an excess of 133,000 lines in its 83-square territory.

TCI INTERNATIONAL

TCI International makes transmission, receiving, and test equipment. Subsidiaries of TCI International include Technology for Communications International, BR Communications, and TCI Wireless. TCI consists of two product groups: the Broadcast and Communications Group and a Signal Processing Group. The former builds high-power MF and HF broadcasting antennas for both civilian and military use, while the latter builds spectrum monitoring, direction finding, and signal collection products strictly for military use.

TRANSMETA

Based in Santa Clara, California, Transmeta develops software-based microprocessors, hardware, and software for use in the mobile computing industry. The company's trademark Crusoe processor uses "code morphing" software to perform microprocessor functions usually handled by transistors. The result of this technology is considerable energy savings and the reduction of heat. Notebook computer makers such as Sony, Fujitsu, and NEC are among Transmeta's customers, to name a few. The Crusoe processor has also been used in the production of low-power servers, with possible applications in devices such as TV set-top boxes and networking equipment.

TRIMBLE

Trimble provides laser, optical, and advanced positioning technologies to customers in several key markets. These markets include engineering and construction, agriculture, fleet and asset management, component technologies, and the military. The company's advanced positioning technologies are based on the US government-owned global positioning system (GPS) satellite network. Using this technology, Trimble's navigation equipment can track such variables as time, longitude, latitude, and altitude. The company also produces devices that track vehicle and aircraft fleets, and timing devices that synchronize wireless communication infrastructure equipment. Trimble's products have proven to be most useful in industries such as engineering, construction, and agriculture. Customers for the firm's products include Bosch, Caterpillar, Nortel Networks, and Philips.

U.S. WIRELESS CORP.

U. S. Wireless Corporation has developed a geolocation and tracking system that pinpoints the location of mobile phones within a wireless network. The U.S. Wireless network offers multiple carriers, Internet Portals, call centers, and other service providers means for gathering location data. The technology, which is called RadioCamera, helps wireless service providers locate customers who are calling 911, in addition to helping them track traffic. Authorities have also used RadioCamera to tabulate cell phone usage along highways and pinpoint the location of traffic congestion.

VIASAT
Founded in 1986, ViaSat produces digital satellite, networking, and signal processing equipment. Products made by its satellite networks unit include satellite modems, networking processors, and network control systems and software. ViaSat's other subsidiary, the communications systems group, supplies mobile satellite systems, simulation and tactical data systems, and network security encryptors. The firm's revenues in 2001 were in excess of $164 million. Although Viasat still services the US Department of Defense, commercial customers now make up over half of the firm's sales.

VYYO
Vyyo, a supplier of broadband fixed wireless systems, makes wireless access systems that consist of wireless hubs and modems which allow telecom service providers to connect their high-speed data networks to business and residential customers without installing cable. The technology used to deliver voice and data over the Internet via the network is a point-to-multipoint architecture based on IP. The firm also supplies network management software, and sells directly to service providers and through reseller agreements with ADC Telecommunications, Nortel, and Convergence Communications.

WESTERN MULTIPLEX
When companies have gaps in their wireline networks, one option to bridge these gaps is Western Multiplex. The firm builds point-to-point Lynx systems that are used by telecom service providers to forge connections in their wireline networks. Western Multiplex also manufactures Tsunami systems that are used to increase the size of private Internet-based networks. The firm sells more than half its products to wireless providers such as AT&T, Cingular, Motorola, Nextel, and Voicestream.

WIRELESS FACILITIES INC.
The company designs, deploys, and manages wireless mobility and broadband wireless networks. Products range from single-cell sites to advanced digital wireless networks. The company also has a number of service offerings, including business and market planning, site acquisition and development, network installation, and network management services. Notable customers include AT&T Wireless, Cingular, Telcel, and Verizon Wireless. Wireless Facilities sells its products in over 100 countries.

WJ COMMUNICATIONS
The company's broadband products – which include semiconductor components, thin film substrates, wireless, and fiber optic networking equipment – allow for voice, data, and image transmission over fiber-optic, broadband cable, and wireless networks. The majority of the firm's customers include large manufacturers such as Nortel, which accounts for 44% of sales alone, and Lucent, which accounts for 25%. WJ Communications recently sold off its semiconductor equipment and telecom units in order to focus more on the commercial market.

Appendix 4

Table of Significant Merger and Acquisition Activities[135]

Company	Description	Completion Date
AT&T Wireless **TeleCorp PCS**	AT&T Wireless acquired the 77 percent of TeleCorp PCS it does not already own in an all-stock deal valued at $4.7 billion.	**Oct-01**
Webraska **AirFlash**	France's Webraska and the U.S.'s AirFlash, two heavyweights in the wireless location-based services (LBSs) market, have agreed to a merger that will create an international company, including twelve carriers serving in excess of 80 million mobile phone customers.	**Sep-01**
GE Medical Systems **Data Critical**	GE Medical Systems acquired Data Critical Corp., a provider of wireless communication technologies for the healthcare sector.	**Aug-01**
VoiceStream **PowerTel, Inc.** **Deutsche Telekom AG**	Deutsche Telekom AG acquired VoiceStream and Powertel, Inc. This merger combines the two largest GSM wireless providers in the US. In the US, the merged entity holds licenses covering over 272 million POPs, representing 97 percent of the US population. In the year 2000, VoiceStream and Powertel provided service to a total of 4.8 million U.S. wireless customers.	**May-01**
Ericsson **Sony**	Sony Corp. and LM Ericsson merged their mobile phone divisions in an effort to revitalize their struggling handset businesses.	**May-01**
Singapore Telecommunications, Ltd. **Optus**	SingTel purchased Australian's Cable & Wireless Optus for $8.3-billion. The Australian telecom accepted SingTel's offer for a 52.5 percent stake in the company.	**Apr-01**
Sybase **NEON**	Sybase acquired New Era of Networks, Inc. (NEON), an e-business application company, in a move to accelerate its e-Business strategy.	**Mar-01**
Palm, Inc. **Extended Systems, Inc.**	Palm, Inc. acquired mobile solutions provider Extended Systems Inc., in a strategic move to go beyond its traditional individual consumer base to serving the enterprise.	**Mar-01**
National Semiconductor **InnoCOMM**	National Semiconductor Corp. acquired chipset developer InnoCOMM wireless for about $13 million in a move to strengthen its position in the next generation of wireless networking technologies.	**Feb-01**

Intel Corp. **Xircom**	Intel Corp. purchased Xircom for $748 million in hopes of expanding into product lines that connect mobile devices to corporate networks.	**Jan-01**
Handspring **Bluelark Systems**	Handspring, Inc. acquired Bluelark Systems, Inc., a developer of technology that enables the delivery of Web content to wireless devices. Handspring hoped to make Web browsing a basic application for its family of handheld computers with the merger.	**Jan-01**
Palm, Inc. **WeSync**	Palm acquired WeSync, a provider of group-information sharing for handheld devices, to enhance its position in the mobile Internet industry.	**Jan-01**
Vodafone Group PLC **Japan Telecom**	Vodafone Group PLC secured a 15 percent stake in Japan Telecom for $2.2-billion. Japan Telecom now has access to global technology, content, expertise, and a global network.	**Jan-01**
OmniSky **NomadIQ**	Omnisky acquired NomadIQ, a provider of location-based applications and services, for 2.5 million in common stocks.	**Jan-01**
Wireless Matrix **Norcom Networks**	Canada Wireless Matrix Corp. acquired Norcom Networks Corp. of Virginia. With the purchase, Wireless Matrix expects to target under served vertical and geographic markets, including utilities, transportation, logistics, and workflow management.	**Jan-01**
724 Solutions **TANTAU Software**	Toronto-based 724 Solutions Inc. acquired Texas based TANTAU Software. The deal was an all stock transaction valued at $375 million.	**Dec-00**
3Com **Nomadic Tech**	3Com acquired Nomadic Technologies, Inc. to strengthen its presence in the area of specialized wireless networking devices.	**Nov-00**
US Wireless Data **CellGate Technologies**	US Wireless Data, in hopes of capturing a significant share of the growing fixed and mobile wireless transaction market, acquired CellGate Technologies for approximately $10 million in cash and stocks.	**Nov-00**
TCS **Xypoint**	TeleCommunications Systems Inc. (TCS) acquired wireless communications firm Xypoint Corp for an estimated $68 million in stock.	**Nov-00**
Verizon Wireless **Price Wireless**	Verizon Wireless acquired Price Communications Wireless for app. $2 billion. Price Wireless's network covers 3.4 million POPs in 16 markets, and the company serves 500,000 customers throughout Georgia, Alabama, South Carolina, and Florida. Price	**Nov-00**

	Wireless's network uses TDMA, which Verizon Wireless plans to convert to CDMA as quickly as possible.	
AT&T **SBC**	AT&T acquired licenses from SBC in Indianapolis, IN.	**Oct-00**
AT&T **Verizon Wireless (GTE)**	AT&T acquired wireless systems from SBC in San Diego, CA.	**Oct-00**
Alltel **SBC**	Alltel acquired licenses from SBC in LA including: New Orleans, Baton Rouge, Iberville, St. James, Plaquemines.	**Oct-00**
SBC **BellSouth**	SBC and BellSouth have combined their U.S. wireless businesses. The joint venture will be a separate entity and will be owned 60% by SBC and 40% by BellSouth.	**Oct-00**
TELUS Corporation **Clearnet Communications, Inc.**	TELUS acquired Clearnet.	**Oct-00**
Leap Wireless International **Radiofone PCS, L.L.C.**	Leap Wireless International has acquired a wireless operating license in Pittsburgh, PA from Radiofone PCS, L.L.C.	**Sep-00**
AT&T Wireless **U.S. Cellular**	AT&T acquired interests in Hawaii RSA 3 from U.S. Cellular.	**Aug-00**
France Telecom **Vodafone AirTouch - Orange**	France Telecom acquired the UK operator, Orange, from Vodafone AirTouch for $40.6 billion	**Aug-00**
Nextel **Chadmoore**	Nextel acquired Chadmoore, a dispatch company with licenses covering 180 small to medium-sized markets.	**Aug-00**
Cisco Systems **IPmobile**	Cisco Systems, Inc. acquired Ipmobile, Inc. Cisco's motivation for this acquisition was to accelerate the development and adoption of open, Internet-based protocols throughout communication networks.	**Aug-00**
Saratoga International Holdings, Corp. (SHCC) **Access World Wireless Services, Inc.**	SHCC acquired Access World Wireless Services, Inc. for approximately $1.4 million. The deal further strengthened SHCC's place in the worldwide telecommunications industry.	**Aug-00**

Leap Wireless International **PCS DevCo, Inc.**	Leap Wireless International acquired a license in Dayton, OH from PCS DevCo, Inc. which covers POPs of 1.2 million.	**Jul-00**
Verizon Wireless **CFW Communications Company.**	Verizon Wireless acquired licenses in Highland, VA from CFW Communications Company.	**Jul-00**
CFW Communications **PrimeCo PCS**	CFW Communications Company acquired PrimeCo's PCS licenses, assets and operations in the Richmond and Hampton Roads areas of VA.	**Jul-00**
AT&T **Wireless One Network**	AT&T acquired Wireless One Network which operates in northwest and southwest Florida covering POPs of 1.6 million and has 177,000 subscribers.	**Jun-00**
Telapex, Inc. (Cellular South) **Alltel**	Telapex acquired all of Alltel's PCS operations in Mobile, AL & Pensacola, FL, to eliminate overlap caused by Alltel's pending wireless property transactions with GTE/Bell Atlantic/Vodafone AirTouch.	**Jun-00**
AT&T **Vodafone AirTouch, GTE, Bell Atlantic**	AT&T acquired wireless properties in San Francisco from Vodafone AirTouch/GTE/Bell Atlantic.	**Jun-00**
Alltel **GTE/Bell Atlantic/Vodafone AirTouch**	Alltel and Bell Atlantic/GTE/Vodafone AirTouch completed the final phase of a wireless property exchange in 13 states. This phase added markets in Alabama, Florida, Ohio and South Carolina to Alltel’s network, and markets in Illinois, Indiana, New York and Pennsylvania to Bell Atlantic's network.	**Jun-00**
Bell Atlantic **GTE**	Bell Atlantic merged with GTE to form Verizon Communications.	**Jun-00**
Qwest Communications Inc. **US West**	Qwest Communications acquired US West.	**Jun-00**
A&T Wireless **Vodafone AirTouch**	AT&T Wireless acquired the remaining partnership interests it didn't own in the Bay Area Telephone Company from Vodafone AirTouch - a joint venture between the two companies.	**Jun-00**

Bell Atlantic **VodafoneAirTouch**	Bell Atlantic and VodafoneAirTouch PLC launched Verizon Wireless entity. Bell Atlantic-GTE owns 50 percent and Vodafone 45 percent. The company is managed by Bell Atlantic.	**Apr-00**
QUALCOMM Inc. **SnapTrack Inc.**	QUALCOMM Inc. acquired SnapTrack Inc., provider of wireless positioning location technology. The companies foresaw the introduction of powerful location-enabled mobile phones and other devices utilizing Wireless Assisted GPS technology in the future.	**Feb-00**
3COM **Aether Systems, Inc.**	3COM and Aether announced the formation of a joint venture called OpenSky to deliver next generation wireless data services to corporations and consumers.	**Jul-99**

Appendix 5

California's Wireless Firms
Sorted by Region

Company Name	Description	Location	Region
@Road, Inc.	Mobile positioning system provides vehicle location information, as well as two-way messaging and dispatch communications.	Fremont	Bay Area
3COM, INC.	Sells networking hardware and software. Makes LAN-level infrastructure gear (hubs, switches, and servers), networked telephony systems, and wireless networking equipment for enterprises. Also sells network interface cards and PC modem and memory cards primarily to PC manufacturers. CommWorks, its carrier networks business, makes IP infrastructure gear and network management software for Internet service providers and communications carriers.	Santa Clara	Bay Area
3d4W	Provider of a cross-platform solution for wireless and handheld 3D applications world-wide.	Santa Clara	Bay Area
Absolute Time Corp.	Produces a family of products that are optimized for time and frequency applications using the Global Positioning System (GPS) signals	San Jose	Bay Area
Actisys	Supplier of wireless IrDA and ASK-IR protocol software, adapters and tester for 115.2k to 4M bps	Fremont	Bay Area
Adaptive Broadband Corp.	Supplies a range of broadband wireless packet-on-demand products and systems.	San Jose	Bay Area
Aeluros	Early stage start-up developing integrated circuits for broadband communications.	Palo Alto	Bay Area
Aeris Communications, Inc.	Develops and markets proprietary, two-way technologies that enable the wireless connectivity and control of remote intelligent devices	San Jose	Bay Area
Air Communications, Inc.	Manufactures combination cell phone/modem	Sunnyvale	Bay Area
Airify Communications	Silicon solutions for wireless applications	Mountain View	Bay Area

Airlink Communications, Inc.	AirLink Tracking System, a system that uses GPS and CDPD technology to transmit vehicle and location information to a tracking system console	Mountain View	Bay Area
AirPrime	Provider of high-speed, CDMA (Code Division Multiple Access) wireless data and voice products to the OEM (Original Equipment Manufacturer) market	Santa Clara	Bay Area
AirSpeak, Inc.	Single solution wireless products and data access software for the corporate enterprise	Campbell	Bay Area
AirTouch Communications	Part of Verizon Wireless network, air touch is a wireless communications provider	Walnut Creek	Bay Area
Airwave	Wireless LAN security and management software	Campbell	Bay Area
AKM Semiconductor, Inc.	AKM products are used in a broad range of cellular and cordless phone applications. Builds chips which enable reduced packaging space and decreased noise	San Jose	Bay Area
Aligo	Start-up that is a next-generation mobile commerce solutions provider; enterprise software solution using M-1 mobile application server	San Francisco	Bay Area
Aliph	Develops speech capture and processing technologies for mobile devices. Primary technology employs a non-acoustic EM sensor that provides a new layer of speech information for a variety of mobile speech processing applications.	San Francisco	Bay Area
Allayer Communications	Developer of high-performance enterprise and optical networking communications chips	San Jose	Bay Area
Alloptic Inc	Access network equipment provider, offering optical IP Ethernet solutions. Broadband technology delivers bundled data, video, and voice services over fiber directly to businesses and homes.	Livermore	Bay Area
Aloha Networks	Provides advanced telecommunications services for multiple access wireless networking. Uses existing satellites to connect Internet service providers	San Francisco	Bay Area

Altamar Networks	Long haul optical transport systems	Mountain View	Bay Area
Altera	CMOS-based programmable logic devices address high-speed, high-density and low-power applications in the data communications and computer peripheral market.	San Jose	Bay Area
Alvesta	10Gbps optical transceiver modules	Sunnyvale	Bay Area
Aperto Networks	Wireless, multiservice broadband access	Milpitas	Bay Area
Arch Communications	Wireless e-mail, instant text messaging, mobile Internet access and custom end-to-end enterprise solutions	San Jose	Bay Area
ArrayComm, Inc.	Portable, wireless broadband access system	San Jose	Bay Area
Atmel	Advanced semiconductor solutions, including logic, nonvolatile memory, mixed signal and RF Integrated Circuits.	San Jose	Bay Area
Avanex	DWDM	Fremont	Bay Area
AvantGo Inc.	Software developer; offers applications that let PDAs receive content from more than a thousand channels. Enterprise software runs corporate process applications.	Hayward	Bay Area
Azanda Network Devices	Optical networking silicon solutions for multi-gigabit and terabit routers and switches	Sunnyvale	Bay Area
BeamReach Networks (FKA: Radix Wireless)	Develops the next generation of wireless technology for broadband wireless access. The company focuses on providing high speed Internet via wireless technology	Sunnyvale	Bay Area
Blaze Network Products	Fiber optic transceivers and PONs	Dublin	Bay Area
Blue Kite Solutions, Inc. (AKA: BlueKite.com)	Develops software services to enable network operators to provide access to critical data such as corporate intranets, the Internet, and e-mail via notebook computer or handheld devices, connected via a mobile phone or integrated terminal. Provides wireless internet technology services through products such as bandwidth optimization, service provider platform and technical specs.	San Francisco	Bay Area

Blue Wireless, Inc.	Provides applications and services for voice-enabled wireless portals. The company connects mobile professionals and consumers to personalized news, enterprise data, transactions, and other time-sensitive information in audio format.	Burlingame	Bay Area
Bluefish Wireless	Develops a wireless platform for two-way infrared communication between Palm-based handheld devices and the Internet.	San Francisco	Bay Area
Blue-Silicon	Provides extended enterprise messaging solutions to businesses around the world. Licenses its product to service providers such as carriers, ISP's and Web Portals, integrating existing email infrastructure, Centrex, and corporate PBX systems to deliver subscription-based, extended messaging services.	San Jose	Bay Area
Bops, Inc.	Licenses and integrates scalable, broadband DSP cores used in communications, mobile multimedia, and wireless SOCs	Santa Clara	Bay Area
BridgeWave Communications	Broadband wireless subsystems for millimeter wave (MMW) subscriber terminals, and other high-frequency wireless devices	Mountain View	Bay Area
Broadlink Communications	Wireless Broadband service provider	Santa Rosa	Bay Area
Broadlogic	Satellite	Milpitas	Bay Area
Calient Networks	MEMs based photonic switching platform	San Jose	Bay Area
California Eastern Laboratories, Inc.	Semiconductor manufacturers	Santa Clara	Bay Area
Catamaran Communications	Silicon for optical networks	Fremont	Bay Area
Certicom Corp.	Provides digital encryption products and services that ensure secure communications between handheld computers, mobile phones, pagers, and other wireless devices. Also offers enterprise software for providing virtual private networks (VPNs).	Hayward	Bay Area
Chameleon Systems	Reconfigurable communications processors for wireless infrastructure equipment manufacturers	San Jose	Bay Area

CISCO SYSTEMS, INC.	Controls almost two-thirds of the global market for routers and switches that link networks and power the Internet. Also makes network access servers and management software.	San Jose	Bay Area
ClearVox Communications	Headsets for cellular and cordless phones	Los Gatos	Bay Area
Clickmarks.com, Inc.	Provides infrastructure software and products for the mobile Internet. The company provides end-to-end solutions for enterprises seeking instant aggregation, personalization and mobilization of content and applications for their wireless products.	Fremont	Bay Area
Commagine Inc	Develops and markets platform solutions integrating standard cellular "native" networks (current and future like GSM, GPRS, 3G) with "non native" wireless networks (like IEEE 802.11x Wireless LAN and Bluetooth networks).	Palo Alto	Bay Area
Communications & Power Industries, Inc.	Manufactures components used to generate, amplify and transmit microwave and radio frequency signals. The company's products include microwave and power grid tubes, microwave amplifiers, modulators and various other power supply equipment. It also focuses on product technologies in the wireless telecommunications field.	Palo Alto	Bay Area
CommUnique Wireless Corp.	Software company that has developed wireless routing protocol, called Dynamic Forward Routing	Alameda	Bay Area
ComTier	Satellite communications product, that is interoperable with existing IP-based networks; CPFSK (Continuous Phase Frequency Shift Keying) and symbol synchronous TDMA (Time Division Multiple Access) technology	Santa Clara	Bay Area
Conductus, Inc.	Develops, manufactures, and markets electronic products based on High-Temperature Superconductor (HTS) technology.	Sunnyvale	Bay Area

Converge Labs Corporation	Provides services for the wireless industry. The Company works with wireless operators to understand their business model and then helps them plan, design and build next generation converged wireless networks. The Company targets existing GSM operators wanting to upgrade to 2.5G/3G.	Emeryville	Bay Area
Corrigo, Inc.	Mobile service management (MSM) applications using a Web-based platform and wireless devices to coordinate service providers	Redwood City	Bay Area
CoWave Networks, Inc.	Develops products and services to facilitate wireless communications. The Company develops fixed wireless equipment that provides broadband residential Internet access.	Fremont	Bay Area
Cranite Systems Inc.	Developing secure mobile networking solutions. The Company's technology will combine network security, management, and mobile functions into one platform.	San Jose	Bay Area
Critical Path, Inc.	Provides e-mail hosting, wireless device support, integrated calendaring, and bi-directional fax; also licenses software.	San Francisco	Bay Area
Crosslayer Networks	Silicon for 10-Gigabit Ethernet and MPLS systems	Fremont	Bay Area
Cypress Semiconductor	Semiconductor solution for Wireless Infrastructure, Wide Area Networks and Storage Networks	San Jose	Bay Area
Danger, Inc. (AKA: Danger Research, Inc.)	Develops end-to-end wireless Internet solutions. The Company produces wireless online digital hardware, software, and services.	Palo Alto	Bay Area
Data911	Modular in-vehicle computer	Alameda	Bay Area
DataLink Systems Corp.	XML-based interface that allows applications to route wireless messages from in-house systems over public wireless carrier networks for distribution	San Jose	Bay Area
Deskin Research Group	Products include satellite systems, ground stations, software, antenna systems, and related components	Santa Clara	Bay Area

Digital Microwave Corp.	Alternatives to fiber for last-mile access, wireless-fiber transmission services, network back-haul, and interconnection in multiple communications applications worldwide	San Jose	Bay Area
DMC Stratex Networks	Makes digital microwave radios used in wireless communications systems. Radios transmit voice, video, and data through microwave frequencies. Also makes add/drop multiplexers, UNIX-based ProVision software.	San Jose	Bay Area
Dura Electronics	Seller of RF and Microwave components including Transceivers, Converters, Amplifiers, Microwave Cable Assemblies, Lowpass, Bandpass, & Highpass Filters, Power & Low Noise GaAs FETs, MMIC's, RF Power Modules, SAW Filters, Thin Film Circuits, Surface Mount Inductors, Trimmer Capacitors and Microwave Coils for Microelectronics.	Cupertino	Bay Area
Ecrio, Inc.	Develops wireless messaging applications and infrastructure. The Company is utilized by customers, wireless carriers, ISPs, ASPs, and portals as a plug-in for their existing instant messaging solutions, or as a turnkey solution, to offer instant messaging to their customers.	Cupertino	Bay Area
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EFC Startime	Satellite service	San Francisco	Bay Area
Endwave Corp.	Designs components for broadband wireless systems. Products include radio-frequency modules, transceivers, and antennas.	Sunnyvale	Bay Area
Enuvis	Develops wireless infrastructure solutions in all relevant metrics; GPS Software	South San Francisco	Bay Area

Envara	Wireless LAN chipsets compatible with 802.11a and 802.11b standards	Palo Alto	Bay Area
ePocrates, Inc. (FKA: nCircle Communications)	Provides handheld Internet enabled computing systems for physicians. The products are designed to improve the quality of healthcare by allowing physicians access to the information they need at the point of care; database of medical information	San Carlos	Bay Area
Equator Technologies	Programmable broadband DSPs	Campbell	Bay Area
Escort Memory Systems	Radio Frequency Identification (RFID) label	Scotts Valley	Bay Area
eWingz Systems, Inc.	Operates as a global SMS carrier. The Company provides media companies, consumer brands, and mobile operators with carrier-grade SMS connectivity	San Francisco	Bay Area
Exar	Networking silicon	Fremont	Bay Area
Extreme Networks	"Ethernet Everywhere" networks	Santa Clara	Bay Area
Fast-Chip Inc.	Packet classification silicon	Sunnyvale	Bay Area
Feeva Wireless	Wireless broadband infrastructure and applications based on the WiFi IEEE 802.11b standard	Berkeley	Bay Area
Filtronic Solid State	Design and manufacture of a broad range of customized RF, microwave and millimeter wave cellular and broadband components and subsystems	Santa Clara	Bay Area
Firepad	Single integrated platform that runs on 7 out of 8 PDAs	Palo Alto	Bay Area
Fujitsu Compound Semiconductors & Fujitsu Network Communications	Service outlet for compound semiconductor devices used in the telecommunications and wireless industries	San Jose	Bay Area
GBase Communications	Provides and supplies wireless base station system core technology. GBase also offers products for the wireless Voice Internet market	Walnut Creek	Bay Area
General Dynamics	GDAIS provides joint, interoperable and integrated mission solutions using intelligence, surveillance, reconnaissance and information operations businesses	Mountain View	Bay Area
Geoworks	Provides mobile data software and services that allow users to access information and services through mobile devices.	Alameda	Bay Area

GHz Technology, Inc.	Supplier of RF and Microwave power transistors for application specific products	Santa Clara	Bay Area
Glenayre Wireless Access	Traditional and IP telephony networks and open Application Protocol Interfaces (API) to simultaneously support 2, 2.5G and 3G networks.	Santa Clara	Bay Area
GlobalLocate	Assisted-GPS technology to locate wireless devices anywhere in the world	San Jose	Bay Area
Globe Wireless LLC (AKA: Globe Wireless, Inc.)	Provides wireless communication services to the maritime industry. The Company offers service and technology to simplify worldwide communications to and from ships at sea. Services include electronic messaging system to send and receive written communication and a file transfer platform to move data files to and from shore.	Foster City	Bay Area
GPM Systems	E-commerce store with wireless products for home office / small office wireless networking	San Jose	Bay Area
GRIC Communications, Inc.	Makes software products that enable ISPs to cooperate in Internet roaming, where one ISP's points of presence (POPs) are used by another's subscribers.	Milpitas	Bay Area
GWcom, Inc. (FKA General Wireless Communications, Inc.)	Provides wireless paging and two-way personal messaging products. Products designed to access a range of diversified information-on-demand services: news headlines, stock quotes, plane/train schedules, weather reports, Internet information access, event schedules, sport updates, FAX notification, and travel reservations.	Santa Clara	Bay Area
Handspring	Licenses Palm's operating system; handheld expansion bay accommodates additional modems and extra memory.	Mountain View	Bay Area
Harmonic Lightwaves	Enabling interactive video, voice, and data services over cable, telecommunications, satellite, wireless, and terrestrial broadcast networks	Sunnyvale	Bay Area
Harris Corp. Farinon Division	Microwave, broadcast, network support, secure tactical radio, and government communications systems	Redwood Shores	Bay Area

HereUare Communications	Develops wireless broadband data application service provider that allows roaming on any wireless data network.	San Jose	Bay Area
Hybrid Networks	Broadband wireless	San Jose	Bay Area
Hyundai Electronics America	Development, sales, marketing and distribution of a wide variety of semiconductors	San Jose	Bay Area
I.C.E. Wireless Group	Management reporting and control capabilities that simplify and automate a wireless procurement program	San Francisco	Bay Area
IDT (Integrated Device Technology, Inc.)	Semiconductor solutions for communications companies. ASSPs include telecom products, ATM switches and SARs, high-speed PHYs, communications processors, and IP co-processors.	Santa Clara	Bay Area
INTEL	World's #1 maker of chips; commands about four-fifths of the PC microprocessor marketMost computer makers use Intel processors; Dell is its largest customer (14% of sales). Intel also makes flash memories (it's #1 there, too) and chips for many networking and industrial applications.	Santa Clara	Bay Area
Interwave	Builds compact wireless systems for voice and data communications. Products such as the WAVEXpress line of wireless base station transceivers and controllers are designed for discrete spaces like corporate, government, or school campuses.	Menlo Park	Bay Area
Iospan Wireless (FKA: Gigabit Wireless)	Provides fixed wireless broadband antenna technology. The Company's technology enables a non-line-of-sight and an improved spectral reuse technology for fixed wireless systems.	San Jose	Bay Area
Jarna, Inc.	Develops intelligent communications platforms to unite the wired and wireless worlds. The Company is developing critical components of the infrastructure required to support the exploding wireless market.	Atherton	Bay Area
JDS-Uniphase	Fiber optics products for the telecommunications and cable television industries	San Jose	Bay Area

Kendin Communications	Designs, develops and markets PHYs, repeaters and switches for Ethernet, Fast Ethernet and Gigabit Ethernet	Sunnyvale	Bay Area
Kivera	Provides location services for Web, wireless, and in-vehicle navigation applications.	Oakland	Bay Area
Lanwave Technology, Inc.	Researches, designs, manufactures and markets digital wireless IC components, modules and software for the consumer electronics market worldwide	Cupertino	Bay Area
Legend Silicon Corp	Provides, develops and supplies infrastructure and terminal silicon for broadband wireless datacasting and Digital Television (DTV) technologies.	Fremont	Bay Area
LetsTalk.com	Wireless products reseller (modems, phones, etc.)	San Francisco	Bay Area
LGC Wireless, Inc.	Supplies broadband wireless networking solutions. The Company's wireless networking products provide mobile users access to high quality voice and high-speed wireless data via cellular and PCS networks.	San Jose	Bay Area
LINEAR TECHNOLOGIES, INC.	Makes a broad range of linear integrated circuits (ICs) used in a variety of electronics applications. The company's ICs translate analog data (such as sound, pressure, temperature, and speed) into digital information that can be used by electronic devices; it also makes chips to regulate and control power and voltage. Its amplifiers, interface circuits, and other devices are used in products such as cellular phones, radar systems, satellites, computers, and factory automation systems.	Milipitas	Bay Area
LinkAir Communications, Inc.	Develops LAS-CDMA (Large Area Synchronized Code Division Multiple Access) -- a patented third generation wireless technology designed to advance the performance and capacity of wireless telecommunications systems.	Santa Clara	Bay Area

LSI Logic	Design and manufacturing of custom, high-performance semiconductors. ASIC, microprocessor and system-on-a-chip solutions for a wide variety of applications, including Gigabit and 10 Gbps Ethernet, ATM, ADSL, storage, wireless, digital TV and DSP. White Paper: Software vs. hardware RAID: choosing the best solution	Milpitas	Bay Area
Marvell	Integrated circuits for communications and storage systems	Sunnyvale	Bay Area
Massana	Custom signal processing compilers and processing algorithms for broadband semiconductors	Campbell	Bay Area
Mattson Technology	Supplier of advanced, high productivity semiconductor processing equipment used in the fabrication of integrated circuits	Cupertino	Bay Area
Mellanox Technologies	InfiniBand silicon	Santa Clara	Bay Area
MICRO LINEAR	Develops analog and mixed-signal integrated circuits for a range of communications markets. It has sold its power management, bus interface, and video divisions (about 50% of sales), and is focused on expanding its data communication and wireless units. Products include baseband processors and radio-frequency transceivers.	San Jose	Bay Area
Mobex Communications, Inc.	Provides two-way mobile radio services. The company specializes in selling, installing and servicing two-way radio systems manufactured by various national brand names including: Motorola, Uniden, Zetron, Ericsson, Johnson, Kenwood, SpectralLink, Iridium, Cerulean, Dataradio and American Mobile.	Lafayette	Bay Area
MobileID Inc.	Provides wireless services for wireless devices	Menlo Park	Bay Area
MobileWay, Inc.	Provides global data access over wireless networks for businesses and mobile operators. The Company manages the deployment of wireless data applications and enables associated payments.	San Ramon	Bay Area

MorphICs Technology, Inc.	Supplies ICs for base stations and Semiconductor Intellectual Property (SIP) Cores for handset and terminal products	Cupertino	Bay Area
Multipath Reduction Tech.	Smart Antennas for Broadband Wireless	Cupertino	Bay Area
National Semiconductor Corp.	Wireless handset, information appliances, information infrastructure, and display and imaging technologies	Santa Clara	Bay Area
Neomar	Enterprise server, secure enterprise router proxy, and a browser client, that enable delivery of enterprise applications to smart devices over any wireless network	San Francisco	Bay Area
Netro Corp.	Builds radio equipment used by PCS providers to wirelessly deliver voice and data signals to small and midsize business customers. System is made up pf an outdoor transmission and reception unit and a customer network interface device.	San Jose	Bay Area
NightFire Software	Network Management - IP service provisioning	Berkeley	Bay Area
Nishan Systems	IP-based Storage Area Networking equipment	San Jose	Bay Area
Notor Research	Independent information resource for the wireless community and those interested in wireless issues.	San Jose	Bay Area
Nova Crystals	Laser and LED components for optical communications	San Jose	Bay Area
Nuance	Develops voice interface software used by companies to make their information and services accessible by phone. Software incorporates speech recognition, natural language understanding, text-to-speech synthesis, and voice authentication technologies. Clients include brokerages, airlines, telecom carriers, and retailers.	Menlo Park	Bay Area
Oki Semiconductor	Designs and markets a broad line of advanced integrated circuits for telecommunications, network, automotive, computer, and consumer products	Sunnyvale	Bay Area
Onset Technology	Solution to print email attachments received on wireless devices	Santa Cruz	Bay Area

OpenGrid (FKA: Ensemble Solutions, Inc.)	Develops wireless solutions for the travel and conference industries. The Company's core technology allows mobile messaging, contextual information and transaction solutions. Their product, FastBook provides the ability to review hotel and hospitality information, make and update reservations and obtain directions to your destination, all on a wireless phone or handheld device.	San Jose	Bay Area
OpenWave	Mobile Internet software	Redwood City	Bay Area
OracleMobile.Com	Leading provider of systems software (database management, application development, and application server software).	Redwood Shores	Bay Area
Orsus Solutions	Rapid creation and deployment of Web and wireless applications	Mountain View	Bay Area
Pacific Wireless	Passive feed dipoles, 15dBi, 19dBi 21dBi and 24dBi grid style reflector antennas, 9dB and 12dB Omni directional antennas, 12dB and 16dB 95 deg sector antennas and GaAs MMIC integrated functional block IC's	Aptos	Bay Area
PageMart Wireless, Inc.	Wireless messaging	Hayward	Bay Area
Pagers Online	Paging service and products	San Jose	Bay Area
Palm, Inc.	Owns largest share of the market for handheld organizers. Products include entry-level m100, the pricier III and V series (feature color displays and increased memory), and the Palm VII model (offers wireless Internet access).	Santa Clara	Bay Area
Paxonet Communications	Semiconductor subsystems for optical networks	Fremont	Bay Area
Paybox Global	Mobile payment system using audio functions	San Francisco	Bay Area
P-com, Inc.	Provides microwave radio transmission equipment for use by telecommunications and Internet service providers. Used as an alternative to laying cable. Transmission equipment includes point-to-point, point-to-multipoint, and spread-spectrum products. Also provides software and network installation and support services.	Campbell	Bay Area

PC-tel, Inc.	Analog soft modems, digital broadband, home networking, wireless, and embedded Internet access technology	Milpitas	Bay Area
PetaSwitch Solutions	Multi-terabit switch fabric	San Jose	Bay Area
Phaethon	Tunable optical devices	Menlo Park	Bay Area
Philips Consumer Communications	Cellular phones, digital and analog cordless phones, corded phones, answering machines and fax machines	Fremont	Bay Area
Photuris	Optical networking solutions	Mountain View	Bay Area
Pico Communications	Manufactures access points based on Bluetooth technology that allow users with Bluetooth handhelds and PDAs to connect to the LAN and Internet.	Cupertino	Bay Area
Pocket Science, Inc.	Mobile e-mail and information service compatible with WAP Phones and Palm Connected Organizers	Santa Clara	Bay Area
PocketThis, Inc.	Provides Web content to wireless devices. Provides wireless carriers with a platform for rapid development, enabling carriers to expand their customer base and retain existing customers.	Oakland	Bay Area
PointBase, Inc.	Solutions for managing and synchronizing data outside the firewall for mobile work forces	Mountain View	Bay Area
PointRed Technologies, Inc.	Provides fixed wireless solutions for last mile connectivity.	Sunnyvale	Bay Area
Polaris Networks	New generation optical transport switching systems for the metro core. Designed for native support of TDM, cell and packet traffic using a single programmable switching fabric, and enables easy migration to a multi service intelligent architecture.	San Jose	Bay Area
Positive Communications	Provides wireless communications products and services. The Company operates three major lines of business which include retail marketing of pagers and paging subscriptions, direct-to-customer marketing via e-commerce and subscriber management support for complementary businesses and off-net paging service capacity.	Pleasanton	Bay Area

POWER INTEGRATIONS, INC.	Makes high-voltage analog integrated circuits (ICs) that convert alternating current (AC) to lower-voltage direct current (DC).	San Jose	Bay Area
Pragmatic Communications Systems, Inc.	Designs, develops, markets, and licenses technologies for wireless and wired audio, video and data communications	Sunnyvale	Bay Area
Protura Wireless	Antenna solutions for wireless devices	Half Moon Bay	Bay Area
Proxim, Inc.	Makes wireless networking components. Products include adapter cards, modems, and Ethernet bridges - used to access wireless local-area and building-to-building networks.	Sunnyvale	Bay Area
Pumatech, Inc.	Produces software lets users access, exchange, and synchronize data stored on computers and mobile devices. Primary product is known as Intellisync Anywhere.	San Jose	Bay Area
Quicksilver Technology, Inc.	Develops telecommunications components. The Company's technology enables software-based cellular phones and wireless platforms for mobile commerce (m-commerce).	San Jose	Bay Area
Radio LAN	5 GHz wireless connectivity products	Sunnyvale	Bay Area
Raditek	Isolator and circulator products including Cellular/PCS Base Station units and ultra low IMD units for 3G and UMTS applications	San Jose	Bay Area
RedSwitch	Infiniband silicon	Milpitas	Bay Area
Remec Magnum	Broadband wireless access systems, microwave radio links, satellite terminals, spacecraft payloads, and optical fiber clock recovery	San Jose	Bay Area

Repeater Technologies, Inc.	Builds wireless network repeaters that receive, amplify, and retransmit signals between wireless customers and cellular base stations. Infrastructure products designed for networks using CDMA wireless standard. Manufactured antennas are used to provide both indoor and outdoor wireless connectivity; network management software used to control its equipment; and battery systems used to provide backup power.	Sunnyvale	Bay Area
Resonext Communications	Radio Frequency (RF) technology on CMOS and 802.11a WLAN chipsets	San Jose	Bay Area
RF Micro Devices	Supplier of radio frequency integrated circuits (RFICs) for the wireless, broadband and cable communications industries	Scotts Valley	Bay Area
SANcastle Technologies	Switching systems that integrate Fibre Channel and Gigabit Ethernet	San Jose	Bay Area
Semotus Solutions, Inc.	Wireless application service provider - products allow info. to be delivered to customers using wireless portable devices. Users receive real-time wireless data feeds.	San Jose	Bay Area
ServiceHub	Wireless, web-based dispatch services	Cupertino	Bay Area
Siemens Information & Communications Networks	Integrated voice and data networks	Santa Clara	Bay Area
Sierra Digital Communications	Designs and develops Millimeter Wave transmission equipment	Rocklin	Bay Area
Signia Technologies	Provides System-on-Chip (SoC) products for Wireless Personal Area Networks (WPAN), Wireless Local Area Networks (WLAN) and ultra-low power short-range wireless connectivity.	Milpitas	Bay Area
Silicon Access	Chipsets for terabit routers	San Jose	Bay Area
Siliconians, Inc.	Application-specific integrated circuit (ASIC) products as well as custom solutions to wireless communication application customers	Santa Clara	Bay Area

SIRENZA*	Designs and packages radio-frequency (RF) integrated circuits that boost the performance of wireless and broadband telecom systems. Company's amplifiers, drivers, switches, and discrete devices are made from advanced materials like gallium arsenide and silicon germanium.	Sunnyvale	Bay Area
SiRF Technology, Inc.	GPS Enabled Location Technologies	San Jose	Bay Area
SkyStream Networks	Satellite-based content distribution services	Sunnyvale	Bay Area
SkyTel Communications	Provides traditional paging, text messaging, interactive two-way messaging and wireless telemetry services	Cupertino	Bay Area
Snap Track	GPS wireless location system	Campbell	Bay Area
Soft Net Systems, Inc.	Provides two-way satellite-based Internet access using proprietary wireless technology. Target markets include ISPs, telecommunications carriers, schools, and business clients.	San Francisco	Bay Area
SoHo Wireless	802.11 standardized radios	San Jose	Bay Area
Soma Networks	Offers software that enables service providers to offer the residential and small-office market carrier-grade voice services, broadband Internet access, and value-added services, all together in a single, software-based package.	San Francisco	Bay Area
Spectrian Corp.	Produces linear power amplifiers. Used by wireless communication providers to (1) carry an increased no. of calls on a single frequency, (2) to boost radio signal quality. Products include multi carrier amplifiers and single-carrier amplifiers.	Sunnyvale	Bay Area
SS8 Networks	IP Advanced Intelligent Network (IP AIN) solutions	San Jose	Bay Area
Standard Telecom America, Inc.	Manufacturer and distributor of nixxo pagers	Santa Clara	Bay Area
Stanford Micro devices	RF integrated circuits - products include power modules, low noise amplifiers, high-linearity gain blocks, modulators and mixers	Sunnyvale	Bay Area

Star Microwave Service Corp.	Supplier of reconditioned telecommunications equipment such as microwave radios, broadcast equipment and multiplexers	Fremont	Bay Area
Sun Microsystems	Maker of UNIX-based servers used to power corporate computer networks and Web sites	Palo Alto	Bay Area
Sybase	Enterprise portal (EP) products, wireless technology, and vertical market software and services	Emeryville	Bay Area
SyberSay Communications Corp.	Provides wireless communications devices that allow voice-activated connection to information devices, communication tools, entertainment products, and Internet appliances.	San Jose	Bay Area
Sylantro	Telephony service creation environment that bridges IP and TDM	Campbell	Bay Area
Symbian	Software licensing company, owned by wireless industry leaders, that is the supplier of the advanced, open, standard operating system - Symbian OS - for data-enabled mobile phones	Redwood City	Bay Area
Symbol Technologies, Inc.	Laser bar code scanners, hand-held computers and wireless communications networks for voice and data	San Jose	Bay Area
Synacom Technology, Inc.	Develops authentication software and systems for interoperability of wireless networks. The Company designs, and delivers fraud prevention, roaming, and mobile phone activation products to wireless service providers worldwide.	San Jose	Bay Area
SynTera	Application Standard Specific Product (ASSP) silicon solutions for optical networking systems	Fremont	Bay Area
Tahoe Networks, Inc.	Provides mobility and IP services to next generation networks. The Company is developing a new category of networking infrastructure and operations systems for the Mobile Internet Edge (MIE), the point in mobile data networks where mobile data subscribers are aggregated into data networks, and where Internet ptocols and services must be adapted to the unique requirements of mobile networks.	San Jose	Bay Area

Talaris Corporation (F.K.A.:Gazoo Corporation)	Provides application that delivers business and personal services to users via mobile device	San Francisco	Bay Area
Talley Communications	Distributor in wireless communications infrastructure and mobile products	Hayward	Bay Area
TCI International, Inc.	Makes transmission, receiving, and test equipment. Also provides engineering, installation, and integration services. The US government accounts for 18% of sales.	Fremont	Bay Area
Telamon, Inc.	Mobile Urgent Messaging System	Oakland	Bay Area
Teledesign Systems, Inc.	Wireless modems with integrated radios	San Jose	Bay Area
TelenComm	Provides Wireless Personal Area Network (WPAN) solutions for the personal communications and computing market	Santa Clara	Bay Area
Telephia, Inc.	Provides network and marketing data on for wireless carriers. The Company collects accurate network and marketing data for all of the wireless carriers through multiple methods and sources including: proprietary data gathering networks, pricing and media tracking services, Internet survey capabilities, and network quality drive tests.	San Francisco	Bay Area
Telera	Platform that enables voice applications driven by standard Internet tools and technologies	Campbell	Bay Area
Telespree Communications	Develops prepaid, disposable wireless phones systems. The Company's prepaid wireless system includes a server handset combination which enables operators to provide the wireless communications solution for the masses. The Company is developing a revolutionary new end-user device focused on ease of use and affordable price point.	San Francisco	Bay Area
Televigation Inc.	Provides wireless communication services by focusing on integrating Internet, wireless and location technologies. The company is a wireless location based services with real focus in real time dynamic navigation platform through mobile phones.	Sunnyvale	Bay Area

Televoke, Inc.	Solutions by integrating GPS, wireless, phone and web technologies	San Francisco	Bay Area
Tellus Technology	Provides wireless Internet access devices and related services. The Company develops, manufactures, and supplies CDPD (cellular digital packet data modems) and other dedicated wireless terminal products for system integrators, value-added resellers, wireless distributors, and service providers.	Fremont	Bay Area
Teradiant Networks	Silicon for next generation terabit networks	San Jose	Bay Area
Tesaria (FKA: Symmetry Communications Software)	Develops high-speed wireless communications products. The Company develops wireless data-communications infrastructure equipment targeted at wireless carriers looking to reduce the infrastructure and operational costs providing mobile GPSR data services.	San Jose	Bay Area
Transmeta Corp.	Makes chips that metamorphose computer instructions in transit, touting it for embedded processing applications in devices such as TV set-top boxes and networking equipment.	Santa Clara	Bay Area
Traxsis	Provides location-position technology.	Burlingame	Bay Area
Trimble Navigation, Ltd.	GPS components	Sunnyvale	Bay Area
Tropian	Advanced wireless semiconductors supporting multiple standards, including EDGE, GSM, GPRS, TDMA, GAIT and AMPS	Cupertino	Bay Area
TrueSAN Networks	Fibre Channel disk arrays	San Jose	Bay Area
Unimobile, Inc.	Global mobile messaging solutions	Santa Clara	Bay Area
Vayusphere	Provides seamless infrastructure services for mobile data exchange among wireless carriers, service providers and enterprise customers. Company's services are device-independent, air link-independent, and delivered on a global footprint.	Mountain View	Bay Area
Velio Communications	Signaling and switch-fabric integrated circuits	Milpitas	Bay Area

Vernier Networks, Inc.	Provides hardware and software for managing and controlling wireless networks.	Mountain View	Bay Area
VertiCom, Inc. (FKA: YRLS Comm., Inc.)	Manufactures frequency converters and wireless commercial radio subsystems. The Company provides converters for the satellite communications and point to point terrestrial market sectors. The Company also markets commercial radio subsystems for system integrators in wireless.	Santa Rosa	Bay Area
ViaFone, Inc.	Provides application services (ASP) for mobile commerce solutions. The Company allows online merchants to quickly and easily make their Web presence 'mobile-ready' and enable consumers to shop and purchase items via the Internet anytime, anywhere from any wireless device.	Brisbane	Bay Area
Vivo wallet, Inc.	Platform that aggregates the consumers entire financial profile and presents it anywhere anytime either online or at a synchronized mobile device	Los Altos	Bay Area
Vocera Communications, Inc.	Develops Bluetooth wireless communication applications.	Cupertino	Bay Area
vVault, Inc.	Develops platform technology for mobile productivity applications.	San Francisco	Bay Area
Vyyo Inc.	Makes wireless access systems that consist of wireless hubs and modems which enable communications service providers to bridge the gap between their high speed data networks and business and residential customers without installing cable.	Cupertino	Bay Area
Watkins-Johnson Co.	Develops and manufactures high quality radio frequency and optical fiber communications products for networks	Palo Alto	Bay Area
Web Link Wireless	Provides wireless data services and traditional paging services in the United States	San Francisco	Bay Area

Western Multiplex Corp.(merged w/ Proxim)	Makes links for broadband networks; their point-to-point Lynx systems are used by telecom service providers to wirelessly bridge gaps in their wire line network, selling more than 70% of its products through distributors and resellers primarily to wireless providers including AT&T, Cingular, Motorola, Nextel, and Voicestream.	Sunnyvale	Bay Area
Wheels Of Zeus (AKA: wOz)	Provides consumer electronics wireless products. The Company will develop such technologies as global positioning systems, cheap wireless access and processing power.	Los Gatos	Bay Area
WhereNet Corp. (FKA: WiData Corporation)	Develops wireless solutions for locating, tracking, and managing supply-chain resources. The Company provides on-demand information which translates into improved customer service, ROA, and increased revenues.	Santa Clara	Bay Area
Wherify Wireless	Developer of patented wireless location products and services	Redwood Shores	Bay Area
WiredPocket	Develops applications to download full Web pages to wireless devices.	Santa Clara	Bay Area
WiredPocket	Develops applications to download full Web pages to wireless devices.	Santa Clara	Bay Area
Wireless Data Corp.	Wireless wide area network products including wireless data network services, wireless modems and a variety of software applications	Mountain View	Bay Area
Wireless Interconnect	Point-to-point wireless Ethernet bridges with capacity of up to 430 Mbps, as well as point-to-multipoint systems with capacity of up to 60 Mbps	Sunnyvale	Bay Area
Wireless Link	Develops, manufactures and markets cost-effective wireless communication products for mobile and fixed asset management applications	Milpitas	Bay Area
Wireless Networks, Inc.	IP enabled, low powered smart packet radios, robust multi-point to multi-point mesh networks, and system wide web based total network management	San Mateo	Bay Area

Wireless Online, Inc.	Develops two-way wireless paging and messaging communications via the Internet. The Company provides products from smart base stations and smart applications to smart antenna systems.	Santa Clara	Bay Area
WJ Communications	Manufactures broadband products which enable voice, data, and image transmission over fiber-optic, broadband cable, and wireless networks.	San Jose	Bay Area
Woodside Networks	Develops technology to make the wireless Internet devices.	Mountain View	Bay Area
Wytec, Inc.	Wide-sector point-to-multipoint systems that provide flexible, high-speed wireless access to broadband core networks for subscribers who require bi-directional voice and data communications services	Santa Clara	Bay Area
Xindium Technologies, Inc. (FKA: Petalogic Network Devices)	Supplies receivers and drivers for commercial and defense network applications.	San Bruno	Bay Area
Xpedion Design Systems Inc.	Provides electronic design automation solutions. The company targets commercial and defense wireless communication systems and integrated circuits.	Santa Clara	Bay Area
Zayante	IEEE 1394 software and silicon solutions	Scotts Valley	Bay Area
Zeevo	Bluetooth silicon	Santa Clara	Bay Area
ZettaCom	Silicon for multi-service switches	San Jose	Bay Area
Zilog, Inc.	Develops advanced semiconductor solutions	Campbell	Bay Area
ZK Celltest	Provides field measurement test equipment to wireless service providers	Santa Clara	Bay Area
AdaptiveInfo	Personalizes delivery of content for wireless devices	Irvine	LA Area
Adicom Wireless Inc	Designs & manufactures A-CDMA based wireless access systems suitable for voice, fax and high speed data.	Pleasanton	LA Area
Aircept.com, LLC	Two-way wireless voice and data messaging to both consumer and commercial customers for metropolitan and rural areas nationwide	Irvine	LA Area

AML COMMUNICATIONS, INC.	Produces amplifiers for wireless communications -- cellular phone systems, satellite communications systems, and wireless local-loop systems.	Camarillo	LA Area
Armen N Sahagen	Provides silicon-on-sapphire transducers, sensors, probes and transmitters.	Huntington Beach	LA Area
ASPAC COMMUNICATIONS, INC.	Develops wireless broadband Internet services. Finhorn Enterprises holds more than 42% of ASPAC.	Torrance	LA Area
Assuresat, Inc.	Provides GEO satellite operators with temporary satellite replacements in the event of a launch or satellite failure.	El Segundo	LA Area
Axiom Navigation, Inc	Supplies Global Positioning Systems (GPS) products and services. Manufactures GPS receiver products and custom products that use GPS and wireless technology for consumer and industrial markets.	Anaheim	LA Area
Bluekite.com Inc	Leading Internet software company providing a platform to enable the efficient delivery of rich content to mobile computing devices.	Irvine	LA Area
Boeing Satellite Systems Inc	Commercial aviation	El Segundo	LA Area
Bravo Tech Inc	Manufactures linear power amplifiers for use in wireless base stations.	Los Alamitos	LA Area
BROADCOM*	Sells integrated circuits (ICs) used in digital set-top boxes and in more than 90% of cable modems. Also makes ICs for digital subscriber line (DSL), satellite and terrestrial broadcasting, home networking, and wireless devices.	Irvine	LA Area
CALIFORNIA AMPLIFIER, INC.	Makes microwave amplification and conversion components that improve reception in satellite television (nearly 70% of sales), wireless cable, and wireless broadband access systems. Its products include antennas, amplifiers, and transceivers.	Camarillo	LA Area
Cellcom-One Inc	Wireless services	Corona	LA Area
Charmed Technology (FKA: InfoCharms)	Develops wireless, wearable Internet products, services and technologies. Designs various groundbreaking internet receivers such as eyeglasses and business cards.	Santa Monica	LA Area

Comant Industries Inc	Provides the general aviation marketplace with the industry's broadest line of antennas and related components	Santa Fe Springs	LA Area
COMARCO, INC.	Provides wireless network engineering and monitoring services to telecommunications carriers.	Irvine	LA Area
CONEXANT	Specializes in chips used to run communications devices and networks. Also makes ICs and subsystems for computer and cable modems, cordless and cellular phones, and television set-top boxes.	Newport Beach	LA Area
Consumer Direct Link Inc	Designs, develops and delivers an integrated suite of mobile devices, security chipsets, and enterprise applications for conducting mobile commerce interactions and transactions	Camarillo	LA Area
Cue Paging Corporation	Offers nationwide, regional, and local messaging, as well as data services, including real-time traffic information	Irvine	LA Area
D M X Music Inc	Offers continuous, CD-quality music to business and residential customers via digital cable	Los Angeles	LA Area
D X Communications Inc	Builds RF power amplifiers	Los Angeles	LA Area
Entridia	Optical edge router Ics	Irvine	LA Area
ESRI	Geographic Information System (GIS) software	Redlands	LA Area
Executive Cellular Inc	Provider of cell phones and other accessories	Van Nuys	LA Area
Fakheri Inc	Provides wireless products and services	North Hollywood	LA Area
Fiberspace	Optical components based on semiconductor laser technology	Woodland Hills	LA Area
Field Centrix, Inc.	Develops enterprise software to automate mobile field-service operations. Product package includes user-customizable software linked wirelessly to mobile devices for use by operators in the field.	Irvine	LA Area
GTRAN Wireless, Inc.	CDMA and GSM based data card and module products for multimedia internet access applications	Westlake Village	LA Area

Holl Technologies	Develops electronic components and electromagnetic composites for wireless communications devices such as antennas, filters, amplifiers, and duplexers for cellular phones.	Camarillo	LA Area
Hughes Communications Inc	Aviations, electronics	El Segundo	LA Area
HUGHES ELECTRONICS*	Unit of General Motors, which owns all of the company's assets and holds about 30% of its tracking stock. GM has agreed to sell the company to DIRECTV's main US rival, EchoStar.	El Segundo	LA Area
InnovICs Corporation	Operates as a communications semiconductor firm. The Company provides multi-antenna processing for wireless data products.	Los Angeles	LA Area
INTERSIL	Makes high-speed wireless LAN chipsets and other integrated circuits (ICs), primarily for the communications and computing markets. Analog and mixed-signal ICs for communications and power management account for more than 70% of sales. Company's power management chips are used in PCs, servers, and storage networking gear.	Irvine	LA Area
IP MobileNet Inc.	Manufactures and distributes wireless voice and data systems for government. Products include mobile IP radios, IP base station, high-power amplifier, IP network controller, voice interface unit, and mobile computer products.	Santa Fe Springs	LA Area
JAMDAT Mobile	Provides middleware technologies for mobile entertainment applications. Designed its middleware components to allow mobile entertainment to be created for and distributed across these disparate devices and networks.	Los Angeles	LA Area
LYNX Photonic Networks	Photonic switching devices and photonic routing sub-systems	Woodland Hills	LA Area
M M Comm Inc	Provides broadband wireless RF equipment	Torrance	LA Area
Max Air Inc	Provides digital cellular products	Tarzana	LA Area
Metro Net	Wireless infrastructure	San Bernardino	LA Area

Metrocall Inc	Delivers short messaging services (SMS), wireless e-mail and Internet connectivity to mobile two-way devices.	Tarzana	LA Area
Mindspeed Technologies	Semiconductor and software solutions for the network edge, switch fabrics, and network processor products	Newport Beach	LA Area
Network Services Llc	Offers messaging products and solutions, including wireless data and web-based services.	El Segundo	LA Area
NextWave Communications Inc	Wireless	Irvine	LA Area
Ophir Rf Inc	Manufactures high power, solid state, broadband and communication amplifiers and subsystems	Los Angeles	LA Area
Paradigm Wireless	Produces radio frequency amplifiers for wireless communications.	Irvine	LA Area
POWERWAVE TECHNOLOGIES, INC.	Powerwave Technologies makes radio-frequency power amplifiers that are used in the base stations of cellular and personal communications service (PCS) networks.	Santa Ana	LA Area
Production & Satellite Service, Inc. (PSSI)	Satellite service	Los Angeles	LA Area
Sensor Systems Inc	Manufactures antennas available for commercial, business and military aircraft	Chatsworth	LA Area
STM WIRELESS, INC.*	Makes satellite and wireless communications systems. Using its DAMA hardware and software, STM builds networks for transmitting voice and data using small aperture satellite terminals and other wireless infrastructure gear including antennas, satellite modems, and routers.	Irvine	LA Area
Strix Systems, Inc.	Develops wireless communications equipment for mobile Internet access. Target markets include distribution, manufacturing, healthcare, and hospitality.	Westlake Village	LA Area
SUPERCONDUCTOR TECHNOLOGIES, INC.*	Uses high-temperature superconducting technology and proprietary cryogenic cooling in its SuperFilter amplifier and filter systems for mobile telecommunications.	Santa Barbara	LA Area

T F Burke Enterprises Inc	RF Distribution design	Huntington Beach	LA Area
Telasic	integrated circuits for base stations	El Segundo	LA Area
Telemobile Inc	Manufacturer of wireless rural loop telecommunication equipment for radio telephone industry	Torrance	LA Area
Tornado Development, Inc.	Provides unified messaging technology.	El Segundo	LA Area
Trivec-Avant Corporation	Supplier of antenna systems to the U.S. and NATO governments	Huntington Beach	LA Area
TSR Wireless Llc	Network services	El Segundo	LA Area
Tunable Photonics	Tunable laser components and technologies	Pasadena	LA Area
Universal Space Network, Inc.	Operates a multi-user satellite to ground network. Firm's satellite communications network permits numerous satellite users to share a telemetry, tracking and control network to provide communications.	Newport Beach	LA Area
Velocitel LLC (FKA: NetCom Technologies, Inc.)	Provides wireless infrastructure services and owns and operates wireless towers. Services include architecture and engineering, site acquisition and development, radio frequency and network engineering, construction and maintenance and tower leasing.	Irvine	LA Area
Verizon Wireless Inc	Telecommunications firm	Los Angeles	LA Area
Vision Accomplished, Inc.	Satellite service	Oxnard	LA Area
VSK Photonics	InP semiconductor technology for opto-electronic components	Irvine	LA Area
V-Star Inc	1KTV technology for 2G cellular infrastructure	Woodland Hills	LA Area
Wavestream Wireless	Produces millimeter wave solid state power amplifiers targeting the telecom industry	West Covina	LA Area
Wireless Resources Inc	Designs wireless communications systems that provide enterprise wide access to network resources	Anaheim	LA Area
Wynd Communications Corp	Provides complete wireless communication via email, TTY, fax, alphanumeric paging and even voice telephones.	San Luis Obispo	LA Area
Adversoft, Inc.	Wireless enterprise communication software company	San Diego	SD AREA

AirFiber, Inc.	Develops wireless optical networking equipment. The Company provides wireless optical networking products that enable carriers to quickly and economically connect urban commercial buildings to high-bandwidth services.	San Diego	SD AREA
Alvarion Ltd.	Broadband wireless access provider	Carlsbad	SD AREA
Aradiant (FKA: National Dispatch Center, Inc.)	Provides network management and support services to paging companies. Products include multilingual operator-assisted messaging, personal toll-free numbers, wireless email, custom numeric paging, and wireless information services.	San Diego	SD AREA
Axesstel, Inc.	Wireless local loop (WLL) handsets, modem cards, and network optimization products for CDMA communications market	San Diego	SD AREA
Cubic Communications	RF and DSP-based equipment for wireless applications	San Diego	SD AREA
Ensemble Communications, Inc.	Makes wireless communications equipment designed for telecom carriers that want to provide high-speed data services primarily to business subscribers. System includes radio transmission base stations and antennas, multiplexers, and network management software capable of providing both Internet connections and voice services.	San Diego	SD AREA
Ethertronics	Develops antennas for the mobile wireless market. Used in GPS, Bluetooth and other applications.	San Diego	SD AREA
JABRA Corporation	Researches and develops hands-free and wireless communication	San Diego	SD AREA
Kyocera Wireless Corp.	Manufactures wireless phones	San Diego	SD AREA
Leap Wireless International, Inc.	Wireless communications carrier; operates CDMA (code division multiple access) digital networks; plans to introduce wireless data services	San Diego	SD AREA
Lightpointe Communications	Free space optics company	San Diego	SD AREA
LittleFeet, Inc.	Develops, manufactures and sells hardware and software products for wireless telecommunication networks.	Poway	SD AREA

M7 Networks, Inc.	Mobile infrastructure hosting company. Provides integrated infrastructure and related services to enterprises, ASPs and network operators.	San Diego	SD AREA
Magis Networks, Inc.	Develops a wireless home networking chipset. Chips distribute multiple streams of broadband video, voice, and data (TCP/IP data, high-quality HDTV video) to mobile devices.	San Diego	SD AREA
Maxima	Free space optics company	San Diego	SD AREA
Mforma	Integrated mobile solutions platform for the wireless industry	San Diego	SD AREA
Mitsumi Electronics Corporation	Bluetooth electronic components manufacturer (GPS antennas, switching power supplies and wireless data transmitters)	San Diego	SD AREA
Mobilian	Analog and digital integrated circuits and embedded software for wireless communications	San Diego	SD AREA
Novatel Wireless, Inc.	Designs wireless WAN modems. Offers the Minstrel series of modems for personal digital assistants such as Palm devices; the Merlin and Sage Wireless series for portable and desktop PCs; and other modems for ATMs, point-of-sale terminals, and vehicle tracking systems.	San Diego	SD AREA
OMM	MEMs-based optical switches	San Diego	SD AREA
PacketAir Networks	Systems for packet-based mobile wireless networks	San Diego	SD AREA
PacketVideo	MPEG-4 codecs for audio/video over wireless	San Diego	SD AREA
Peregrine Semiconductor	10 Gbps physical layer devices, as well as 6 GHz RF integrated circuits, based on silicon-on-insulator processing technology.	San Diego	SD AREA
Pulse-Link, Inc.	Potential mobile wireless solutions to issues of broadband capacity, cost, device interoperability and frequency availability	San Diego	SD AREA
Qualcomm, Inc.	Created CDMA technology that is used in cell phones, wireless telecom equipment, and satellite ground stations. Makes CDMA chipsets and system software, licenses that technology to others. Other products include OmniTRACS global positioning system, Eudora e-mail software.	San Diego	SD AREA

Remec, Inc.	Makes high-frequency voice and data transmission infrastructure equipment for wireless and defense applications; products include microwave radio transmitters, amplifiers, and filters -- products are used in weapons, satellite systems, and networks for mobile telephony and cable TV.	San Diego	SD AREA
San Diego Teleproductions	Satellite service, teleconferencing audio and video service	San Diego	SD AREA
SDTV San Diego Teleproductions	Satellite service	San Diego	SD AREA
SensCom, Inc.	Wireless internet solutions provider for the financial services industries	San Diego	SD AREA
Silicon Wave	Designs chips for Bluetooth and other wireless communications	San Diego	SD AREA
Solectek Corporation	Personal communications network/services	San Diego	SD AREA
SONIK Technologies, Inc.	RF solutions for specialized communication needs	Vista	SD AREA
Standard Communications	Manufactures OEM, cell phone/radio modem modules for wireless machine to machine communications	Carlsbad	SD AREA
Stellcom Technologies	Computer and communications solutions for product development and info technology	San Diego/Orange County	SD AREA
StratEdge Corporation	Designs and manufactures microwave components for the high frequency wireless industry. Products include ceramic semiconductors for the High Speed Digital (OC-48, OC-192, OC-768), broadband wireless, satellite, optical Point-to-Point/Multipoint and VSAT industries.	San Diego	SD AREA
Tele Tran Tek Service	Develops traffic management systems	San Diego	SD AREA
Titan Linkabit	Develops modems	San Diego	SD AREA
Viasat, Inc.	Builds digital satellite, networking, and signal processing equipment. Products include satellite modems, networking processors, network control systems and software.	Carlsbad	SD AREA
Wavecom Inc.	Designs, develops and manufactures fully integrated wireless modules and modems	San Diego	SD AREA
WaveWare Communications, Inc.	Wireless products	San Diego	SD AREA
Widcomm	Bluetooth networking software and systems	San Diego	SD AREA

Wingcast	A joint venture of Ford and QUALCOMM targeting wireless applications and telematics services	San Diego	SD AREA
Wireless Facilities, Inc.	Plans, designs, and manages wireless networks. Construction projects range from single-cell sites to entire advanced digital wireless network.	San Diego	SD AREA
Wireless Knowledge	Enterprise grade software and services to mobilize company information	San Diego	SD AREA
Zyray Wireless	A wireless processor core that is reconfigurable between multiple standards	San Diego	SD AREA
Extenex Corporation	Develops handheld and mobile devices.	Soquel	Other
Occam Networks	Broadband access network solutions	Santa Barbara	Other
Sage Instruments, Inc.	Test solutions to the telecommunications industry	Freedom	Other
Superconductor Technologies, Inc.	Builds amplifier and filter systems for mobile telecommunications. Superconductors used in base stations to reduce noise and extend range.	Santa Barbara	Other
Surewest Communications, Inc.	Operates a wireless PCS network.	Roseville	Other

[1] See Cellular Telecommunications and Internet Association Semi-Annual Wireless Industry Survey (http://www.wow-com.com) and International Telecommunication Union (http://www.itu.org).
[2] The Economist, The Internet, Untethered, The Economist, Oct. 11, 2001, http://www.economist.com.
[3] Ibid.
[4] Ibid.
[5] See Margo McCall, A Wild Ride for Wireless, Wireless Week, June 6, 2001.
[6] See NTIA website, http://www.its.bldrdoc.gov/fs-1037/dir-036/_5348.htm.
[7] See, e.g., San Diego Telecom Council, http://www.sdtelecom.org/industries/index.htm and http://www.whatistechtarget.com/definition/0,289893,sid9_gci213380,00.html. Obviously, defining the industry is complicated because many companies, especially in the integrated circuits area, provide solutions and equipment for the wireless industry – and other industries.
[8] Overall, classifying the industry and developing comparative data outside of a particular subsector (such as wireless carriers) is difficult because government statistics do not adequately segment the rapidly changing marketplace. Although recent revisions in government reporting codes, from Standard Industrial Classification (SIC) codes to the North American Industrial Classification System (NAICS), come closer to accurately describing technology industries, there are still significant gaps. Furthermore, the NAICS was only implemented in 1998, making longitudinal analysis impossible. Finally, as in all government reporting there is a time lag – so the most current information is from 1999. Nevertheless, the SIC codes were selected because they provide the only unified consistent method of comparison and analysis over time. In this analysis, NAICS statistics from 1998 and 1999 were converted into relevant SIC codes.
[9] In some respects, these codes are overinclusive, encompassing areas that most would not consider "wireless", such as television camera equipment. However, in other respects the codes are underinclusive – one of the preeminent wireless firms in California, Qualcomm, is included in the research and development SIC code and not in the above codes. Finally, some companies, such as 3COM, do manufacture wireless equipment – but also manufacture other computer equipment, making its classification difficult as well.
[10] Interview with Joel Balbien, General Partner of Smart Technology Ventures, February 2002.
[11] The Los Angeles area is defined as the counties of Los Angeles, Orange, San Bernardino, Riverside and Ventura. The Bay Area is defined as the counties of Alameda, Contra Costa, Marin, Napa, San Francisco County, Santa Clara, Solano, and Sonoma, the definition of the Association of Bay Area Governments. The San Diego area is defined as San Diego county.
[12] Employment figures include statistics from Qualcomm. Qualcomm is classified as a research and development company and therefore, employment from the firm is added in this report to the government statistics.
[13] See San Diego Regional Technology Alliance, Wireless Wonders: Assessing San Diego's Wireless Industry, 2000, p. 5. This graphic was developed by Martha Dennis of Windward Ventures.
[14] Source for information are the universities. More detail is provided in Appendix 6.
[15] A further digital standard exists in the US – iDEN (Integrated Digital Enhanced Network), used by Nextel. Fewer than 1 million users use this standard.
[16] Qualcomm receives licensing royalties from those who use CDMA technology.
[17] As indicated in the chart below, current CDMA has a far greater penetration rate in the United States, compared to the rest of the world.
[18] In fact, the Federal Communications Commission and the International Telecommunication Union (ITU) has described 3G system capabilities as 144 kbps in heavy vehicular traffic, 384 kbps in pedestrian traffic and 2 Mbps in indoor traffic; interoperability and roaming; common billing/user profiles that can be shared between service providers; geographic positioning; and multimedia services capabilities, including bandwidth on demand. See http://www.fcc.gov/3G.
[19] NTIA, Why 3G?, http://www.ntia.doc.gov/ntiahome/threeg/3gintro.htm
[20] Federal Communications Commission, Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services, July 17, 20001. Cingular will deploy GSM for its voice service.
[21] Elisa Batista, Analysts Blast NTT DoCoMo, Wired News, Nov. 28, 2001, http://www.wired.com/news/print/0,1294,48633,00.html.
[22] See Cahners In-Stat Group, In-State Predicts Bleak Short Term Prospects for Wireless 3G, Despite Heavy Technology Investment by Carriers, April 24, 2001, http://www.instat.com/pr/2001gw0105in_pr.htm.
[23] Ibid.

[24] Phillips Publishing International, Cingular Takes GSM Route to 3G, Wireless Week, Nov. 7, 2001. As part of this plan, Cingular will introduce phones that run on both GSM and TDMA core networks and can roam between the networks; furthermore, Cingular will introduce dual-band, dual-mode GSM and GPRS handsets, enabling customers to access both voice and data. See Peggy Albright, Cingular's 3G Route, Wireless Week, Nov. 5, 2001.
[25] See Cahners In-Stat Group, In-Stat Predicts Bleak Short Term Prospects for Wireless 3G, Despite Heavy Technology Investment by Carriers, April 24, 2001, http://www.instat.com/pr/2001gw0105in_pr.htm.
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[27] PriceWaterhouseCoopers, Technology Forecast: 2001-2003, 2001, p. 503-504.
[28] Compiled from numerous sources including presentation by Mark Kelley, Chief Technical Officer, to CTIA Wireless IT & Internet 2001, Hoovers.com, http://www.leapwireless.com, Carolyn Koo, "Too Bit a Leap? Wireless Provider Targets an Untapped, but Poorer, Audience," The Standard, January 8, 2001, http://www.thestreet.com/_standard/tech/telecom12345138.html, Tish Williams, FCC Decision Will Kick Off a Mating Dance in Wireless, November 12, 2001, http://www.thestreet.com/tech/telecom/10003765.html; Deborah Mendez-Wilson, "Cricket Copycats On the Make," Wireless Week, August 20, 2001, http://www.wirelessweek.com; Sue Marek, "Leap Looks to Simplify Cellular Surfing," Wireless Week, April 23, 2001, http://www.wirelessweek.com.
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[30] Sue Marek, "Leap Looks to Simplify Cellular Surfing," Wireless Week, April 23, 2001, http://www.wirelessweek.com
[31] Sue Marek, Making of the Brand, Wireless Week, June 19, 2001, http://www.wirelessweek.com
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[125] See report from the Response Insurance Natoinal Driving Habits Survey, which released a 1999 study showing that 62 percent of drivers listed tuning a radio as the worst driving distraction, 57% eating, 56% turn head around to speak, 44% reaching for something, 32% reading and 29% talking on the cell phone. See results in http:///www.wow-com.com.
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[127] Allyson Vaughan, Finally: An E911 Decision, WirelessWeek, Oct. 9, 2001, http://www.wirelessweek.com.
[128] In a related measure, California Assembly Member Tim Leslie has introduced in 2002 AB1769 which would ban "spam" on wireless phones.
[129] Adam Stone, The Impact of E-911 on Consumer Expectations, Dec. 11, 2001, http://www.mcommercetimes.com/Services/196.
[130] A number of additional policy measures, not explored in detail here, impact wireless companies. These include siting and zoning measures, which impact carriers and ultimately companies that provide the core infrastructure for base stations, and other federal issues, which include wireless portability, a policy advocated by consumer groups as encouraging competition but opposed by operators as an additional regulatory burden.
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[132] See Universal Services Administrative Company, which administers the e-rate program. http://www.universalservice.org/reports/2000/
[133] Nevertheless, differences in broadband definitions prevent rural telecommunications providers from accessing loan guarantee and other programs of the national Rural Utilities Service. See Comments of the National Rural Telecommunications Cooperative, Letter to the National Telecommunications and Information Administration, Dec. 19, 2001, http://www.ntia.doc.gov/htiahome/broadband/comments/NTRC.html.
[134] Source: Hoovers.com, company reports
[135] Organized in reverse chronological order.