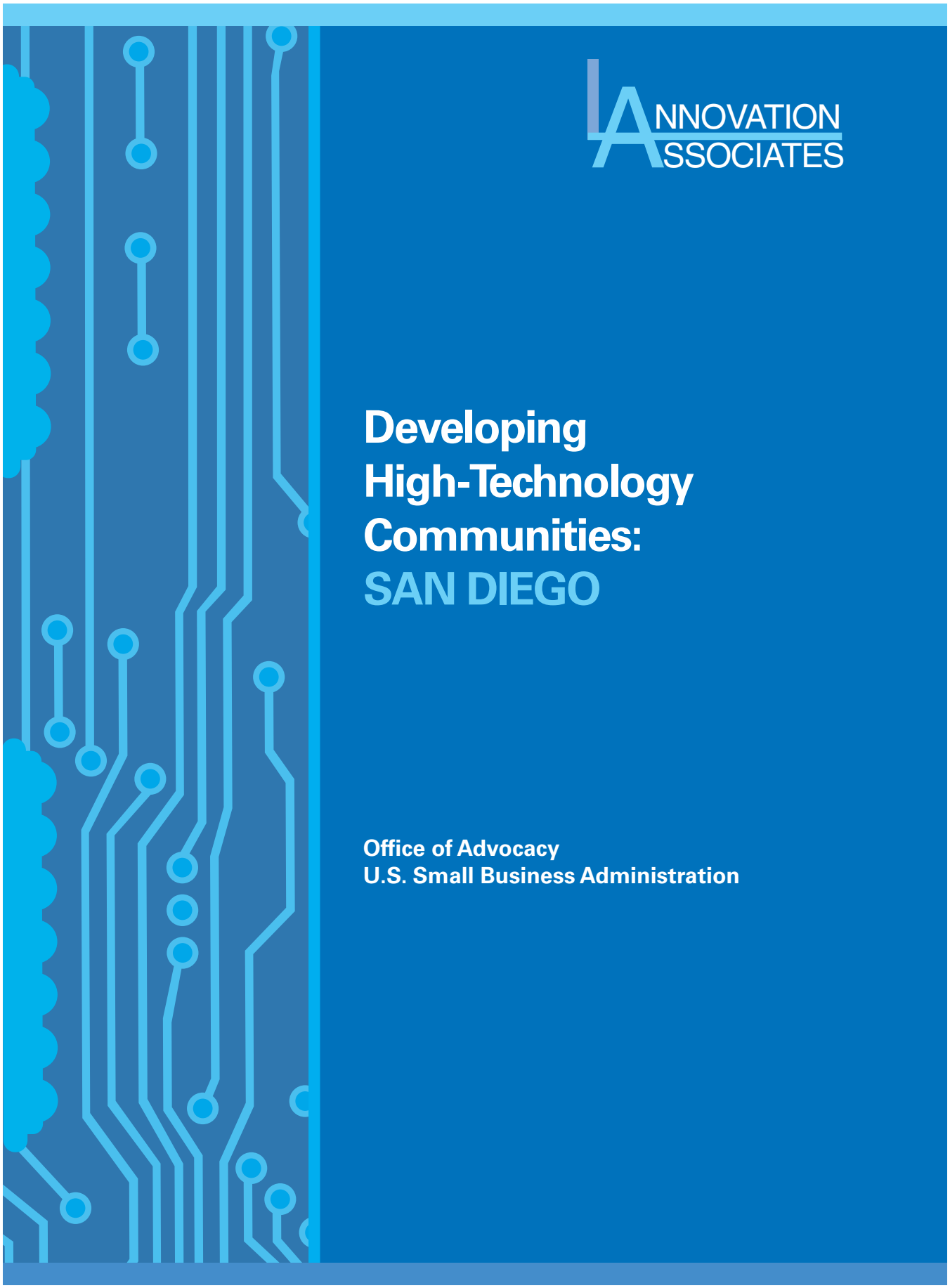

INNOVATION ASSOCIATES

Developing High-Technology Communities:
SAN DIEGO

Office of Advocacy
U.S. Small Business Administration

DEVELOPING HIGH-TECHNOLOGY COMMUNITIES:

SAN DIEGO

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Under Contract to:
Office of Advocacy
U.S. Small Business Administration
Contract No. SBAHQ-97-M0970

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April 2000

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ABOUT THIS REPORT

Innovation Associates, with support from the Office of Advocacy, wrote this report to help communities, universities, and the private sector develop high-technology regions. The San Diego region, as many others, experienced some economic downturns. But despite these downturns, San Diego bounced back by using its resources — universities and other educational institutions, existing industries, and research centers — to spawn new high-technology enterprises.

For over a decade, Innovation Associates has provided technical assistance to public and private sectors that has enabled them to develop technology-based communities, regions, and states. This report adds to other Innovation Associates best practice reports, and is intended to be the first in a series on successful technology-based communities. We hope this report will stimulate public and private efforts to create new technology enterprises and optimize each community's unique resources and strengths.

Diane Palmintera
President
Innovation Associates, Inc.

ACKNOWLEDGMENT

Innovation Associates wishes to thank the Office of Advocacy for funding this study. We particularly wish to note the significant contribution of Mr. Terry Bibbens, Entrepreneur-in-Residence. Mr. Bibbens, who was active in San Diego's economic renaissance, provided us with invaluable contacts, input and insight. Dr. Bruce Phillips, Director, and Dr. Robert Berney, Chief Economist, Office of Economic Research also provided input and helpful suggestions.

Most importantly, we thank the many academic, public and private sector leaders who generously contributed their time and experience to this report. We would like to particularly note the contribution of University of California President Richard Atkinson, Mayor Susan Golding, UCSD-CONNECT former Director, the late William Otterson, UCSD Dean of Extension Mary Walshok, EDC former Executive Director Daniel Pegg, and Peter Preuss, Regent of the University of California and President of the Preuss Foundation. An impressive list of community and corporate leaders contributed invaluable input and appear in Appendix A. The willingness of these leaders to participate in interviews for this report attest to the strong community involvement and spirit in San Diego. We also thank the San Diego Association of Governments for providing data, and in some cases, conducting special data runs, for this report.

EXECUTIVE SUMMARY

This report has been written to assist business leaders, university heads, economic developers, and other key community players to better understand some of the processes involved in developing a supportive environment to grow small, high-technology businesses. San Diego is one of several cities in the U.S. that have exhibited resiliency in the face of economic downturns. San Diego in the late 1980's and early 1990's was hard hit by defense cutbacks that caused severe economic dislocations of defense workers, particularly in aerospace and supplier industries. But less than one decade later, all of the lost jobs were replaced, mainly by new jobs in business services, high-technology clusters, and tourism. Small firms almost exclusively created these jobs as small, service and high-technology firms grew at unprecedented rates during the 1990's.

From 1990 to 1998, high-technology clusters added over 46,000 new jobs to the region. Some of this growth has mirrored rapid national expansion in high-technology clusters. But growth in some clusters, such as biotechnology and pharmaceuticals, and communications, have exceeded the national average employment growth. Jobs in biotechnology and pharmaceuticals doubled adding almost 12,000 new jobs to the San Diego region. These jobs were almost exclusively in small firms, averaging under 50 employees. Employment in software and computer services, also doubled, and communications grew by over one-half, together adding 16,000 new jobs. QUALCOMM, Inc., which started in San Diego in 1985, became a dominant force in the region's communications cluster. But most communication employees still work for small firms, and firms in software and computer services averaged under 15 employees. Wages in most of the clusters are below national averages. However, wages in biotechnology and pharmaceuticals are increasing at a much faster pace than the national average and the wage gap in other clusters is narrowing. In addition to biotechnology and pharmaceuticals, communications, and software and computer services, other promising high-technology clusters in the San Diego region are recreational goods, environmental technology, and biomedical products. All of the growing technology clusters are characterized by small firms, and except for a few major companies, technology firms and small firms in the San Diego region are synonymous.

The San Diego region has developed new high-technology jobs, despite a major economic disruption from defense downsizing, and one of the highest costs of living in the country. The success of the San Diego region's ability to create and expand high-technology businesses is due to multiple factors. These factors include a rich research and development base, active university promotion of science and technology to local businesses, availability of a skilled workforce, an involved business community, and improving public support. In addition, CEO's say that the physical environment continues to attract their firms and workers to the region.

San Diego's technology growth was not the result of a master strategic plan, and the region's business, academic, and public sectors were not always in sync. In the 1980's San Diego mounted unsuccessful bids for major national R&D centers, particularly the Microelectronics and Computer Corporation and Sematech, which were awarded to another city. The loss of these centers to a city in which key players banded together, taught San Diego about the importance of community

cohesiveness. The San Diego Regional Economic Development Corporation (EDC) took the lead in promoting greater community participation by private sector leaders and involvement of the academic community to reduce the region's economic dependence on defense. At a time of impending economic distress, the EDC's efforts resulted in better networking among business leaders, a closer working relationship between the University of California at San Diego (UCSD) and the business community, and improved communication between the public, academic, and private sectors. Although the intent of early community efforts was to attract diversified businesses and R&D centers to the region, the efforts that rallied business leaders and brought together key players, ultimately resulted in strengthening the region's environment for technology development. These early initiatives included the Financial Forum, the San Diego chapter of the Massachusetts Institute of Technology Enterprise Forum, and UCSD's CONNECT program. Some of these efforts also attracted federal funding from the U.S. Economic Development Administration which seeded entrepreneurial initiatives at San Diego State University, and small business incubation at the Center for Applied Competitive Technology, San Diego City College.

San Diego's defense industries provided the base for spin-offs in fields such as wireless communications, and computer and software services. Two of the largest homegrown technology firms — Science Applications International Corporation (SAIC) and QUALCOMM Inc. — started by serving the defense industry in the San Diego region. Although SAIC's defense work increased with the rapid expansion of its business in the late 1990's, the company diversified, and the majority of its business is now devoted to commercial sectors. QUALCOMM Inc. also started its business based on its predecessor's defense communications work. The firm used its expertise in defense communication technology to develop commercial products in cellular technology, making it the second largest producer of cellular telephone technology in the world. Although San Diego suffered from major losses in aerospace and related industries in the early 1990's, the rich R&D base left behind by the defense industry provided fertile ground for new technology growth aimed at meeting the demands of emerging commercial markets. San Diego's world renown research institutions — Scripps Research Institute (formerly the Scripps Clinic and Research Foundation) and Salk Institute for Biological Studies — also provided fertile ground for growth in medical services, biotechnology, and medical device industries.

The development and growing prestige of UCSD was particularly important in promoting the development of high-technology firms in the region. UCSD not only trained many of the engineers and scientists who would later take positions with new and growing high-technology firms, but also provided a valuable science and technology base for these firms. One of QUALCOMM's founders was a member of UCSD's faculty, and other firms, such as Hybritech Inc., which is credited with starting the biotechnology industry in the San Diego region, traces its roots to UCSD. According to UCSD, most of the high-technology firms in the San Diego region were based on technology developed at the University or founded by its faculty or graduates.

UCSD's Chancellor from 1980 to 1995, Richard Atkinson, now President of the University of California system, played a vital role in building UCSD's science and engineering disciplines and in placing the University at the center of the region's high-technology development. He established a school of engineering and enhanced the University's national credibility and prestige by attracting

academic “stars” in science and engineering. He convinced local firms to endow chairs and fund the University’s major expansions. He also expanded the depth and breadth of the campus’s basic research capacity, especially through the creation of interdisciplinary research centers, established in cooperation with technology companies. Under Dr. Atkinson’s leadership, the University successfully bid for one of the national Supercomputer Centers and was one of the top five university recipients of federal research funding. Dr. Atkinson worked externally, with community organizations, and internally, with the University’s department heads, to forge a relationship between the University, the community, and the private sector. He believed that it was part of the University’s mission to create a more favorable environment for attracting and developing technology-based industries around the University and in the community.

Local organizations also added a key element in developing a supportive environment for high-technology industries. The San Diego chapter of the Massachuset’s Institute of Technology Enterprise Forum, started in the early 1980's, has provided advice and education services to the region’s growing companies. UCSD’s CONNECT program, which started a few months after the Forum, has helped technology start-ups and small companies through business assistance, venture capital fora, networking, awards, and public advocacy. BIOCOM has represented the region’s biotechnology and medical device industries, and the Software and Internet Council serves as an important networking organization for the region’s computer and software industries. The San Diego Regional Technology Alliance has implemented programs aimed at promoting science and technology in schools and disseminating technological know-how. One ingredient of the region’s success has been the inclusive cooperative spirit of these industry organizations.

San Diego’s future as a technology community looks promising. Only a few years ago, reductions in defense spending caused severe disruptions to the economy. Today, rapidly growing technology industries have driven the unemployment rate below the national average, and have set the stage for future growth. Although defense spending is still strong in the San Diego region, diversification of the economy should make the region more resistant to future economic downturns than in the recent past. Moreover, the legacy of UCSD’s former Chancellor, Richard Atkinson, who created a nationally recognized research university, and the commitment of the region’s business leaders to build a technology region, should continue to provide a healthy environment for new technology growth. Technology clusters that have developed in the region, particularly communications, and biotechnology and pharmaceuticals, are well positioned in rapidly growing markets. In addition, firms in these clusters have developed strong supplier relationships in the region, and this should further stimulate growth in clusters such as business services, and computer and software services. High costs of living, transportation and other issues may somewhat slow growth. Moreover, improvements in K-12 education, particularly for a growing minority population, are essential to supply future skilled workers for technology industries, to insure continuing wage increases, and to lessen the widening wage gap. But, in the near future, San Diego’s economy shows every sign of remaining healthy and growing, as it continues to diversify and as technology clusters in emerging markets continue to expand.

ABBREVIATIONS

BIC	Biomedical Industry Council
BID	Business Improvement District
BLM	San Diego Tijuana/Tecate Border Liaison Mechanism
BLS	U.S. Bureau of Labor Statistics
CACT	Center for Applied Competitive Technology
CalTIP	California Technology Investment Partnership Program
DoD	U.S. Department of Defense
EDA	U.S. Economic Development Administration
EDC	San Diego Regional Economic Development Corporation
IDB	Industrial Development Bond
IUCRP	Industry-University Cooperative Research Program
MCC	Microelectronics and Computer Corporation
MEP	Manufacturing Extension Partnership
MIT	Massachusetts Institute of Technology
NAFTA	North American Free Trade Agreement
NIH	National Institutes of Health
NIST	National Institute for Standards and Technology
NSF	National Science Foundation
SAIC	Science Applications International Corporation
SANDAG	San Diego Association of Governments
SanMEC	San Diego Manufacturing Extension Center
SBA	U.S. Small Business Administration
SBAB	Small Business Advisory Board
SBIR	Small Business Innovative Research
SBTT	Small Business Technology Transfer
SDCC	San Diego City College
SDRTA	San Diego Regional Technology Alliance
SDSC	San Diego Supercomputer Center
SDSU	San Diego State University
SIC	Software and Internet Council
UCSD	University of California, San Diego

I. INTRODUCTION

This report was written to assist business leaders, university heads, economic developers and other community leaders to better understand some of the elements and processes involved in developing a high-technology community. It is intended to present an overview of one community, San Diego, which has quickly become a high-technology success story, and to present some insights by key community and business leaders.

Under contract to the Office of Advocacy, U.S. Small Business Administration, Innovation Associates (IA) chose to examine San Diego, California because of the proliferation of small, high-technology firms that developed during the late 1980's and 1990's. Despite an economic downturn caused by defense cutbacks in the region and a slowing of the state's economy, San Diego quickly turned around its economy by building on the region's rich research and development resources. These resources included several world renown research institutes and the University of California at San Diego (UCSD). In addition, the region's strong defense industry promoted small, high-technology spin-offs that served the area's defense needs. When those defense needs diminished, the spin-offs diversified to serve commercial sectors. Biotechnology and pharmaceuticals, communications, software and computer services, and business services all grew rapidly as defense manufacturing declined in the 1990's.

As in other areas known for technology development, technology industries in the San Diego region were started by entrepreneurs who left established industries or academia to start small, high-technology firms. In the San Diego region, many entrepreneurs left defense industries. Well known firms such as Hybritech, SAIC, QUALCOMM, and Titan all got their start in San Diego because of individuals who recognized opportunity and were flexible enough to meet changing market demands.

This report is intended to provide an understanding of why those individuals started firms in San Diego, and some of the elements that contributed to the development and expansion of their firms. This study is not exhaustive, but is intended to provide some of the experiences and factors that contributed to one community model. The extent to which these experiences are transferrable from one region to another depends on multiple factors, including some tangible factors such as the presence of San Diego's R&D institutions, and some less tangible factors such as San Diego's entrepreneurial spirit, community cohesiveness, and leadership.

METHODOLOGY

Innovation Associates set out to determine what factors contributed to the development of a "technology environment" in which small, technology businesses started and grew in the San Diego region. Our assumptions in conducting this study were:

1.) As defense industries downsized and closed, new industries were started to fill the gap left by defense industries.
2.) Entrepreneurs started new firms by using technological know-how gained in defense industries to develop products, processes and services aimed at emerging commercial markets.
3.) The business community and development organizations responded to defense downturns by putting into place strategies to diversify existing defense industries and build small technology businesses based on local strengths.
4.) Research generators such as universities and research institutes, particularly the University of California at San Diego, provided fertile ground for growing new technology businesses.
5.) Leadership from the University further promoted spin-offs and growth of small, high-technology businesses.
6.) As the region's industries diversified, business and financial services shifted their focus to meet new demands of small, high-technology firms.

In order to assess the factors that contributed to San Diego's rapid start-up and growth of high-technology industries, Innovation Associates collected economic data and interviewed over 30 representatives from the city government, community and industrial organizations, academia, and private sector. Most economic data for this report was provided by the San Diego Association of Governments (SANDAG), which in some cases, provided special computer runs for this report. Innovation Associates analyzed data on employment, annual payroll, real per capita income, consumer price indices, retail sales, export/import ratios, venture capital investment, utility patents, SBIR awards, and other factors.

We examined 15 clusters, using SANDAG's cluster definitions, and in conjunction with SANDAG, targeted 10 clusters as high-technology: (1) biomedical products, (2) biotechnology and pharmaceuticals, (3) business services, (4) communications, (5) computer and electronics manufacturing, (6) defense manufacturing, (7) environmental technology, (8) financial services, (9) recreational goods manufacturing, and (10) software and computer services. At the suggestion of SANDAG, medical services was not included as a technology cluster in this report. Innovation Associates also compared the rate of employment growth, wage rates, and the rate of wage growth for four high-technology clusters in the San Diego region with that of the United States. These clusters were: (1) biotechnology and pharmaceuticals, (2) communications, (3) software and computer services, and (4) business services. Specific cluster definitions, shown by SIC code, can be found in Appendix D.

We were not able to analyze some factors because data was unavailable. For example, employment data on technology clusters were only collected by SANDAG after 1990, and therefore, we were unable to provide longitudinal analysis prior to 1990. Other data, such as the number of firms or average payroll by technology clusters, were unavailable for most years, due in part, to the lag in U.S. Census Bureau classifications and analysis in emerging industries. Moreover, comparisons and analysis between various employment data, and between employment, wage, and firm size data collected at the local level were not always possible because of different definitions and different time periods.

Innovation Associates collected substantial information through personal interviews with over 30 representatives. From the public sector and government-related sectors, Innovation Associates interviewed the Mayor of San Diego, a City Council Member, the Vice President of the Economic Development Corporation, and the Executive Director of SANDAG. From UCSD, Innovation Associates interviewed the former Chancellor of the University (currently the President of the University of California), the Dean of University Extension, the Director and staff of the CONNECT Program, the Associate Director of the Supercomputer Center, and others involved in technology transfer. Innovation Associates also interviewed the Director of the Center for Applied Competitive Technologies at the San Diego City College, the Executive Director of the Entrepreneurial Management Center at San Diego State University (SDSU), and the Coordinator of the Defense Conversion Center at SDSU. From industrial associations and community organizations, Innovation Associates interviewed the Director of BIOCOM, which represents the bioscience and biotechnology industry; the Director of San Diego Dialogue, a group involved in cross-border issues; the Executive Director of the San Diego Manufacturing Extension Corporation; the Executive Director of the San Diego Regional Technology Alliance; a Regent of the University of California and President of the Preuss Foundation. Innovation Associates also interviewed CEO's or top level representatives from eight corporations: General Atomics, IDEC Pharmaceuticals Corporation, Myelos Neurosciences, Inc., ORINCON Corporation, QUALCOMM, Inc., Science Applications International Corporation, Stellcom, and The Titan Corporation. A list of all persons interviewed appears in Appendix A.

Innovation Associates interviewed public, community, and academic leaders about their role in the development of high-technology industries in San Diego. We also asked corporate representatives about the history and development of their corporations, their interaction with R&D resources and community organizations, and major factors that led them to develop and maintain their corporations in the San Diego region. We asked representatives from academic institutions and community organizations about specific activities that have stimulated and supported technology growth in the region. In addition, we asked all those interviewed about their perceptions of the factors that contributed to the development of high-technology firms in San Diego and lessons for other communities trying to stimulate and support small, high-technology firms.

REPORT STRUCTURE

In this report, we present economic data, a history of high-technology industries, discussion about the role of universities and community organizations, public policy and infrastructure influences, brief descriptions of corporations, and lessons learned. Chapter II summarizes major themes and presents lessons for communities that want to grow high-technology businesses. Chapter III presents economic data on the San Diego region. Chapter IV gives a brief history of the development of high-technology industries. Chapter V discusses the importance of the university-industry connection and describes UCSD's CONNECT Program, the Supercomputer Center, and SDCC's Center for Applied Competitive Technology. Chapter VI describes community-based organizations and their role in business development. Chapter VII presents the role of public policy and infrastructure issues. Chapter VIII discusses cross-border issues and their effect on San Diego's high-technology industries. Chapter IX presents brief case studies of several high-technology corporations.

II. LESSONS FOR COMMUNITIES

San Diego, in the late 1980's and early 1990's, experienced severe economic losses caused by defense downsizing. In this defense-dependent region, the U.S. Department of Defense (DoD) reductions could have resulted in a downward economic spiral, had it not been for the rapid growth of other businesses and industries to replace defense jobs. In the 1990's, San Diego moved from a defense-dependent economy to a diversified economy, partly driven by the emergence of small, high-technology firms. Employment losses, caused by the defense downturn, were quickly replaced by jobs in business services, tourism, and several technology clusters. Three technology clusters — communications, biotechnology and pharmaceuticals, and software and computer services — added over 28,000 new jobs to the San Diego region in just eight years (1990 to 1998). These three clusters alone replaced the direct jobs lost in defense manufacturing. Growth in business services added more new jobs than any other cluster; but some of this growth was from new and expanding businesses needed to support emerging technology industries. Small firms, almost exclusively, were responsible for creating new jobs, and almost all new firms in growing clusters employed less than 50 workers.

Some of the factors that contributed to the start-up and growth of technology firms in the San Diego region were much the same as factors that have stimulated growth in other technology regions. These factors included a rich R&D base supported by a major research university; leadership from individuals in economic development organizations, the universities, and the private sector; a local government that adopted business-friendly policies; an attraction of investment capital; and a cohesive private sector that was committed to stay and grow in the region and to help other technology firms get started. The presence of world renowned research institutes, and the coming-of-age of UCSD, which grew into a nationally prominent research university, provided an important R&D platform for new technology firms. In the 1980's, under the direction of Chancellor Richard Atkinson, UCSD built up its engineering and science disciplines. A few professors spun off technology firms based on research conducted at the University. But more importantly, the University created a labor pool of highly trained students in emerging science and technology fields, who would supply the region's growing industries. Some of these students became employed in local defense industries, and later, started their own technology firms based on UCSD education and defense industry experience.

Chancellor Atkinson's leadership of UCSD was a significant factor in promoting university-industry relations that underpinned San Diego's technology development. The Chancellor, who had been the Director of the National Science Foundation before heading up UCSD, brought an enlightened view of the university's role in the community. He believed that a research university, in addition to striving for teaching excellence, should play a role in developing a technology-based economy. The Chancellor viewed the University as a source of basic and applied research upon which technology firms could build and expand. Chancellor Atkinson brought several science and technology "stars" to the University, increased federal funding for R&D, established an engineering school, and developed a program through the University Extension — the CONNECT program — that would

provide assistance to, and networking of, technology firms. Under former Chancellor Atkinson's leadership, one of the national Supercomputer Centers was awarded to San Diego and located at UCSD.

The predominance of the defense industry in San Diego, prior to the early 1990's, was another critical element in the region's technology development. DoD funding supported the early growth of technology industries in the region to meet the defense needs generated by the Cold War. As significant as DoD funding was to the start of technology industries, the rapid decline of DoD funding, in the early 1990's, was just as significant to the generation of new technology firms and the diversification of existing defense firms. As defense industries reduced their work forces, employees began forming their own technology firms. Many of these firms developed products, processes, and services in niche technology markets and became suppliers to the defense industries for which they had worked. Later, when defense cutbacks caused further defense industry reductions, and as DoD priorities shifted to different technology areas, these small technology firms adapted their products, processes, and services to commercial markets.

Economic development, community, and private sector leaders played key roles in helping new technology start-ups and promoting the diversification of firms into new market areas. The Executive Director of the Regional Economic Development Corporation (EDC) took the lead in organizing public, private, and academic sectors to address economic opportunities and respond to downturns. At first, public and private leaders organized to attract national research centers to the region. Later, this core group of leaders worked together to help technology firms get started and to leverage the strengths of regional R&D resources. Partly as a result of their efforts, several initiatives were started in rapid succession. In 1985, the San Diego chapter of Massachusetts' Institute of Technology (MIT) Enterprise Forum was founded, and UCSD's CONNECT program was formed a few months later. In the early 1990's, the Financial Forum (now part of CONNECT) was started, and industrial associations such as BIOCOM and the Software Industry Council (now the Software and Internet Council) were established. These groups provided important networking, investment match-making, advocacy, and technical assistance to start-up and growing technology firms. UCSD's CONNECT program was further strengthened by the hiring of a well-recognized, local technology entrepreneur, the late William Otterson, who brought private sector credibility to the university-based program.

In the early 1990's, a coordinated community effort also attracted federal funds from the U.S. Economic Development Administration, which supported start-up of several initiatives aimed at diversifying the region's economy. These initiatives included entrepreneurial training at San Diego State University, and technical training and establishment of an incubator — the Center for Advanced Competitive Technologies (CACT) — at San Diego City College. The CACT provided an often overlooked part of the technology development process, training of skilled technicians for high-technology industries.

The cross-border economy added another dimension to the region's economic growth. The system of maquiladoras, in which San Diego firms supply technology inputs and Mexican industries provide manufacturing at value-added, tax deferred rates, has produced benefits for both sides of the border.

Mexico not only provides low-cost manufacturing capacity to San Diego's regional economy, but also contributes substantially to San Diego's retail trade, and is the major importer of San Diego's goods.

The growth of some of San Diego's technology firms is impressive. QUALCOMM Inc., a firm which only started in 1985, and Science Applications International Corporation, which started in the 1970's, each had revenues of over $4 billion in 1999. When executives from these firms and several other technology firms were asked why they got started and remain in San Diego, the executives concurred on the reasons: (1) the presence of UCSD, which provides access to students and a window on technology research, (2) the region's "technology culture" and synergy among the technology firms, and (3) the physical beauty and lifestyle of the region.

CEO's and executives were concerned that shortages of skilled workers could hamper continued growth of technology firms in the region. They cautioned that Congressional restrictions on working visas for foreign engineers and scientists could exacerbate an already tight labor market. Moreover, K-12 education in the region must be improved, particularly for minority populations, to meet future skill requirements of growing technology firms. High housing costs, water shortages, and limited land also may hinder continued growth of the region's technology firms. In addition, environmental issues concerning the storage and disposal of low-level radioactive waste generated by the medical research community, need to be resolved. San Diego's infrastructure also must keep pace to support the region's expanding technology firms.

Although most communities cannot recreate the beauty and climate of the San Diego region, there are some elements that have contributed to the region's economic turnaround, which communities can learn from and apply to their own environments. Some of these lessons are:

- **A research university provides a valuable resource for technology firms, but does so only if the university is open to and actively facilitates linkages with the private sector**. Technology transfer offices and industry relations offices can provide help in patenting and licensing university technologies, organizing industrial sponsored or collaborative research, and identifying professors and students for consulting. Organizations such as UCSD's CONNECT, which operates as part of the University, can provide additional entrepreneurial assistance, venture capital match-making, information dissemination, networking, and advocacy. In other cities, these activities often are provided by independent, non-profit organizations supported by state technology programs, and located at major research universities. There are advantages and disadvantages to both types of models. A university program may have greater credibility in the community, but less flexibility, than an independent program located at or near a research university.

- **Leadership within the university, from the top, sets the tone and direction for cooperation with industry.** In the case of UCSD, former Chancellor Richard

Atkinson viewed the research university as a platform for technology-based economic development. He set into motion technology transfer policies and university-industry programs that helped create the foundation for a growing technology community.

- **Universities, as well as technology firms, benefit from university-industry collaboration.** Industries benefit from having a window on emerging technologies and access to faculty and students. Universities benefit from increased funding of R&D, financial support for faculty and students, and having a window on "real world" industry needs.

- **Research universities not only are an important source of R&D, but perhaps more importantly, are a source of future skilled labor for growing technology firms.** The university provides a valuable source of skilled labor from which technology firms can draw, as well as a source of future entrepreneurs. Industry support of research universities helps insure a continuing labor supply of skilled labor.

- **The supply of technicians and technical support is equally important as the availability of engineers and scientists to support growing technology firms.** In San Diego, San Diego State University and San Diego City College provide a valuable source of highly skilled technical labor. Moreover, entrepreneurs who start service firms that support technology industries often come from technical backgrounds.

- **Industry organizations can provide an important forum for technology industries to exchange ideas, keep abreast of developments in their field, and advocate for issues that affect their industries.** In San Diego, organizations such as BIOCOM, Software and Internet Council, and MIT Enterprise Forum are important sources of information, networking, and advocacy for the region's technology firms.

- **University and industry organizations can provide valuable services for small technology firms.** Small firms, unlike larger firms, often do not have access to capital sources, and may not be able to afford business planning, market research, and other services needed for start-up and growth. University and industry organizations can be a valuable resource for these small firms. UCSD's CONNECT program and the MIT Enterprise Forum, in San Diego, provide small firms the opportunity for introductions to the investment community, licensing and partnering, business planning, and help with other critical services.

- **Current and in-depth analysis of cluster data is essential for economic development planning. A local or regional organization can provide this information service.** The San Diego Association of Governments (SANDAG)

provides information services to the region by collecting and analyzing data, not only on traditional industrial categories, but also on high-technology and other clusters. In addition to conducting economic analysis of traditional indicators, SANDAG assesses demand and supply relationships among clusters, collects data on firm size, and provides other data inputs upon which to base regional economic planning and decision-making.

- **Economic data provided by federal agencies is lagging behind the information needs of communities and regions.** In a rapidly changing economic environment, once useful industrial classifications and data collection, no longer provide adequate information for local economic development needs.

- **Local and state governments can make a difference by creating a "business friendly" environment for technology firms.** In San Diego, Mayor Golding cut numerous regulations and streamlined permit processing. The Mayor let it be known that the City was willing and able to work with technology industries. In addition, the state government supported a technology environment by increasing tax credits on business investments in university research, and providing other direct incentives for technology industries.

- **Cooperative leadership from all sectors — academic, government, and private — is an indispensable element in creating a technology environment.** In San Diego, leadership came from several sources: the Director of the Economic Development Corporation, the UCSD Chancellor and Dean of University Extension, the Mayor, CEO's of corporations, heads of local foundations, and service providers.

- **A severe economic event can unite leaders, but it takes a common vision of the future and a local plan of action to sustain the momentum.** In San Diego, the loss of defense contracts brought the community together temporarily to seek other government funding. But it wasn't until the leaders got together to develop a strategic plan aimed at building a technology base on local resources, that real cohesiveness was achieved.

- **The technology firms that survived defense cutbacks were those which remained flexible enough to diversify.** Some of San Diego's defense industries survived the up's and down's of defense budgets by quickly diversifying their technologies to meet new government priorities and commercial market demands. QUALCOMM, Inc., for example, originally developed and supplied defense communications, but quickly applied this technology to the commercial market for wireless communications.
- **As firms in certain technology clusters developed, they spawned other firms in that cluster.** New firms resulted when employees of technology firms spun off other firms in niche areas, often becoming suppliers to the original firm, or providing secondary or tertiary products, processes and services. In San Diego, this clustering

of firms appeared most prominent in communications, biotechnology and pharmaceuticals, and biomedical devices.

- **Networking of technology firms appeared to help develop and maintain small, technology suppliers in the region.** Technology luncheons, award events, and other opportunities for firms to interact, helped provide an opportunity for service providers and suppliers to learn about the needs of growing technology firms and develop relationships with those firms.

- **Small firms, in business services and technology, were the driving forces of San Diego's economic turnaround.** Almost all of the new jobs created by San Diego firms in the 1990's were created by small firms. Entrepreneurs, primarily from UCSD and defense industries, led the way in creating technology firms to meet the demands of evolving defense and commercial markets.

As San Diego enters the year 2000, its economy is much stronger than just one decade earlier. The region's economic landscape is being reshaped by a committed and cohesive private sector, a rich research base that involves university-industry collaboration, and an active community leadership. Although tourism and defense industries still are major sectors of the region's economy, technology industries have become a major economic force, and have set new directions for San Diego's economic future. Small technology firms have led the way. As these technology firms continue to grow and spawn other technology firms, they increasingly will change San Diego's image from a town known for Sea World to a town known for technology.

III. ECONOMY OF THE SAN DIEGO REGION

EMPLOYMENT OVERVIEW

Since the early 1990's, the San Diego region has experienced severe economic dislocations caused by defense cutbacks affecting aerospace, space systems, shipbuilding, and other military-driven industries. According to the San Diego Association of Governments (SANDAG), from 1990 to 1993, San Diego lost 58,000 jobs, 60 percent of which were in high-wage manufacturing and aerospace sectors. From 1990 to 1995, three out of four, or 21,200 highly skilled, highly paid aerospace personnel were laid off.

In the mid to late 1990's, there was a dramatic turnaround in the employment situation. By 1998, all of the jobs that were lost in defense and aerospace had been replaced. In fact, there were over 100,000 more jobs in 1998 than in 1990. (See Table 1.) The employment rebound was largely due to record gains in the service sector, which represented the largest and fastest growing employment sector in the San Diego economy. Three sub-sectors — business services, health services, and engineering and management — together accounted for over half of service employment. Jobs in these three sub-sectors were highly remunerated, with wages above the regional average, while other service sector jobs, as in amusement, and hotel and lodging, below the regional average.

High-technology jobs represent a growing and important part of the region's economy. High-technology jobs represented almost one-fourth of the region's civilian employment in 1998. Between 1990 and 1998, biotechnology and pharmaceuticals, communications, and software and computer services added more than 28,000 new, high-paying jobs, and employed a total of 61,318 workers. Employment in biotechnology and pharmaceuticals, and software and computer services doubled, and high-technology clusters grew, on average, 27 percent. In the late 1990's, as defense manufacturing continued to decline, the service sector and the high-technology clusters were driving San Diego’s economy.

Table 1
Employment by Industry, 1980, 1990, 1998
San Diego Region

Industry	Employment			Change (1990-1998)	
	1980	1990	1998	Numeric	Percent
Agriculture and Mining	16,717	11,500	10,700	-800	-7.0
Construction	42,161	51,600	61,100	9,500	18.4
Manufacturing	110,462	134,100	127,300	-6,800	-5.1
Trans., Comm., Utilities	29,991	36,000	44,600	8,600	23.9
Wholesale Trade	27,246	44,100	47,100	3,000	6.8
Retail Trade	139,656	192,600	200,500	7,900	4.1
Finance, Insurance, Real Estate	42,946	63,900	64,200	300	0.5
Services	171,869	266,300	360,400	94,100	35.3
Hotel and Other Lodging	N/A	22,700	23,500	800	3.5
Business Services	N/A	51,400	85,600	34,200	66.5
Amusement, including Movies	N/A	17,000	23,200	6,200	36.5
Health Services	N/A	59,600	70,800	11,200	18.8
Engineering & Management	N/A	34,500	52,600	18,100	52.5
Other Services	N/A	81,100	104,700	23,600	29.1
Civilian Subtotal	581,048	800,100	915,900	115,800	14.5
Government	141,088	177,400	194,800	17,400	9.8
Wage and Salary Employ. Subtotal	722,136	977,500	1,110,700	133,200	13.6
Self-Employed and Domestic Workers	N/A	107,300	99,700	-7,600	-7.1
Military	118,271	111,011	93,890	-17,121	-15.4
Region Total	**840,407**	**1,195,811**	**1,304,290**	**108,479**	**9.1**

Source: 1990 and 1998 - California Employment Development Department (EDD), compiled by SANDAG; 1980 - SANDAG Regionwide Historical Database. Military 1980 and 1990 - U.S. Census Bureau; Military 1998 - SANDAG estimates.

Note: Due to definition changes, data prior to 1988 is not comparable to later years. 1990 self-employed and domestic workers = total employment (TE) - industry employment (IE);1998 self-employed and domestic workers = .5748 (TE - IE).

In the wake of their defense-related job losses, the San Diego region had an unemployment rate which reached a peak of 7.7 percent in 1993. By 1998, San Diego's unemployment rate had declined to 3.0 percent, lower than that of California or the U.S. (See Table 2.)

Table 2
Unemployment Rate, 1980-98
San Diego Region, California and United States

Year	San Diego	California	United States
1980	6.8	6.8	7.0
1981	6.9	7.4	7.6
1982	9.3	9.9	9.7
1983	8.2	9.7	9.6
1984	6.0	7.8	7.5
1985	5.3	7.2	7.2
1986	5.0	6.7	7.0
1987	4.5	5.8	6.2
1988	4.3	5.3	5.5
1989	3.9	5.1	5.3
1990	4.5	5.8	5.5
1991	6.3	7.7	6.7
1992	7.3	9.1	7.4
1993	7.7	9.4	6.8
1994	7.0	8.6	6.1
1995	6.4	7.8	5.7
1996	5.3	7.2	5.3
1997	4.2	6.0	4.7
1998	3.0	4.4	4.0

Source: San Diego - California Employment Development Department, Labor Market Information Division, 1999, and Greater San Diego Chamber of Commerce, 1999. California-California Employment Development Department, Labor Market Information Division, 1999, and Greater San Diego Chamber of Commerce, 1999. United States - U.S. Bureau of Labor Statistics, 1999.

Note: Data collected for the San Diego region reflect the 1999 employment benchmark.

SMALL AND MINORITY BUSINESSES

Small businesses, those with fewer than 50 employees, accounted for 95 percent of San Diego's businesses in 1998. (See Table 3.) The increase in new businesses during the 1990's was almost exclusively small businesses, especially those with fewer than five employees. The growth rate in small businesses has outpaced that of California or the United States.

Table 3
1998 Civilian Employment and Firms, San Diego Region
by Number of Employees

Number of Employees	Total Employment	Percent	Number of Firms	Percent
1 - 4	61,363	6.6	46,092	62.0
5 - 9	73,740	7.9	11,235	15.1
10 - 19	101,336	10.9	7,609	10.2
20 - 49	164,751	17.7	5,595	7.5
50 - 99	130,138	14.0	2,055	2.8
100 - 249	165,259	17.9	1,216	1.6
250 - 499	87,874	9.5	321	0.4
500 - 999	63,287	6.8	123	0.2
1000 +	80,770	8.7	79	0.1
Total	**928,518**	**100.0**	**74,325**	**100.0**

Source: California Employment Development Department, 1999; complied by SANDAG.

Note: Percentages may not add to 100 due to rounding. Data in several employment categories are suppressed by the California Employment Development Department because confidential data could be extrapolated from totals. Data in Table 1 and Table 3 are not comparable because of the suppressed data in Table 3.

San Diego has made progress in business ownership by minorities and women. The latest data available showed that between 1987 and 1992, there were large increases in Black-owned firms (70 percent), Hispanic-owned firms (83 percent), and Asian-owned firms (76 percent). Women owned one-third of all businesses in the region.[1]

PERSONAL INCOME AND COST OF LIVING

From 1985 to 1997, San Diego's real per capita income growth mirrored that of California, but fell short of average U.S. growth. In the early 1990's, San Diego's per capita income growth slightly exceeded that of California, but significantly trailed that of the U.S. Between 1990 and 1994, as the U.S. real per capita income rose by 15.2 percent, San Diego's rose by 8.7 percent. San Diego's real per capital income growth accelerated between 1994 and 1995, and between 1996 and 1997, exceeding California's growth for those years. (See Table 4.)

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[1] *1992 Survey of Minority Owned Businesses*, U.S. Census Bureau.

Table 4
Real Per Capita Personal Income Index, 1985-97
San Diego Region, California and United States

Year	San Diego	California	United States
1985	100.0	100.0	100.0
1986	105.3	104.4	105.1
1987	111.0	110.0	110.7
1988	117.3	116.6	118.1
1989	124.2	122.4	125.8
1990	129.1	129.3	132.9
1991	131.7	130.1	136.3
1992	134.9	134.3	142.9
1993	137.2	135.8	147.3
1994	140.4	138.9	153.1
1995	150.0	145.1	161.1
1996	152.3	152.2	165.0
1997	159.2	159.3	169.0

Source: U.S. Bureau of Economic Analysis, 1999.

In 1998, in terms of average pay, San Diego ranked 92nd among the 302 largest counties. Average annual pay of employees in San Diego county was $32,221, slightly higher than the national average.[2] In the 1990's, low earnings growth and the slow rise in real personal per capita income were due to the loss of high-wage, defense-related jobs, to an increase in low-paid visitor industry services, and to increases in the region's consumer price index. San Diego has had one of the highest consumer price indices in the country, according to the U.S. Bureau of Labor Statistics. Compared to 13 equivalently sized metropolitan regions, San Diego had one of the highest costs for transportation and housing, and the third or fourth highest for medical care, public transportation, and food and beverages. Although one of the least affordable housing markets in the country, San Diego's situation has been improving. Housing permits, which were stagnant in the early and mid 1990's, increased in the mid and late 1990's. In 1998, 41 percent of San Diego's families could afford the price of a home, compared to 17 percent in 1989.[3]

[2]U.S. Bureau of Labor Statistics, 1999.

[3]*Housing Opportunity Index,* National Association of Home Builders, 1999.

RETAIL SALES

Throughout the 1980's, per capita retail sales exceeded that of California and the U.S. In the late 1980's and early 1990's, however, there was a significant falloff in the growth of per capita retail sales in the San Diego region, which kept pace with California but fell short of the average growth in the U.S. By 1995, per capita retail sales were about the same as in 1990, but were above California and the U.S., and were growing. Retail sales were expected to continue growing as the employment and earnings picture improves and as tourism increases. (See Table 5.)

Table 5
Per Capita Retail Sales, 1980-95
San Diego Region, California and United States
(in 1995 Dollars)

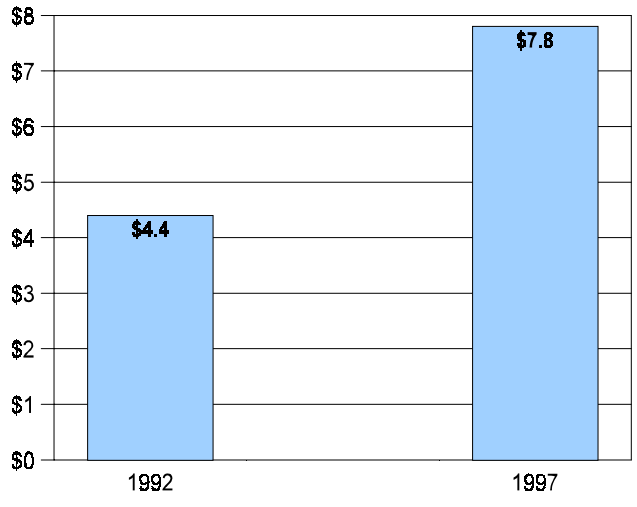
Year	San Diego	California	United States
1980	10,132	8,843	7,800
1981	9,402	8,694	7,689
1982	9,213	8,546	7,447
1983	9,391	9,268	7,890
1984	9,822	9,564	8,318
1985	10,340	10,005	8,595
1986	10,768	10,198	8,901
1987	11,107	10,670	9,118
1988	11,850	10,905	9,381
1989	12,282	11,406	9,546
1990	11,364	11,387	9,503
1991	10,202	10,639	9,174
1992	10,707	10,294	9,330
1993	11,079	10,086	9,655
1994	10,864	10,529	10,140
1995	11,224	10,765	10,367

Source: San Diego and California - Table K3, California Statistical Abstract, 1996; United States - DRI/McGraw Hill History Tables for the United States Economy, 1970-95.

INTERNATIONAL TRADE AND CROSS-BORDER MANUFACTURING

San Diego's economy has become increasingly intertwined with Mexico's economy. Under the maquiladora program, unfinished goods produced in San Diego are exported to Mexico. Manufacturers in Mexico add value to the goods and return them to San Diego for further refinement and/or sales. This export and import system has been largely responsible for a rapid increase in the value of international trade moving through San Diego's ports in the mid and late 1990's. From 1992 to 1997, the total value of exports moving through the San Diego region rose from $4.4 billion to $7.8 billion, an increase of 77 percent. (See Figure 1.)

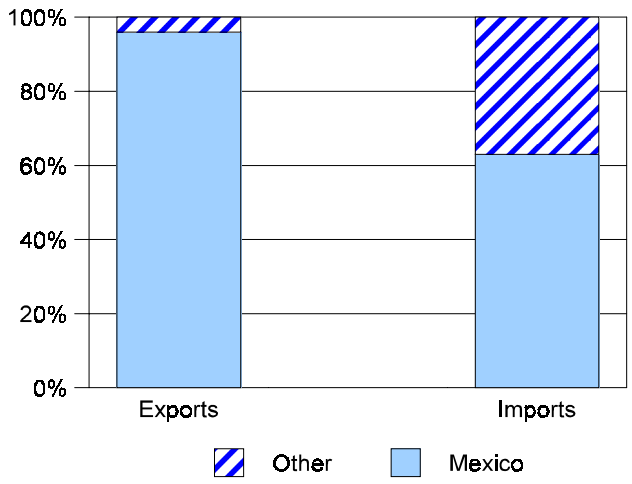
Figure 1
Value of Exports and Cross-Border Manufacturing Originating Within the San Diego Region, 1992 and 1997
($ in Billions)



Source: U.S. Census Bureau.

Largely because of the maquiladora program, Mexico received 90 percent of all exports from the San Diego region and accounted for 63 percent of all imports to the region in 1997. (See Figure 2.) The leading commodity for both exports and imports with Mexico was electrical machinery, which included manufactured television sets. In 1997, the San Diego-Tijuana, Mexico region was the largest producer of television sets in the world. Although Mexico was San Diego's main trading partner, the region also traded with Canada, Europe, and Asia.

Figure 2
International Trade
(Exports, Imports and Cross-Border Manufacturing)
Passing Through the San Diego Region, 1997



Source: U.S. Census Bureau.

THE GROWTH OF HIGH-TECHNOLOGY CLUSTERS

SANDAG has defined 15 economic clusters in the San Diego region. For purposes of this report, we have considered 10 of these clusters as high-technology: (1) biomedical products, (2) biotechnology and pharmaceuticals, (3) business services, (4) communications, (5) computer and electronics manufacturing, (6) defense manufacturing, (7) environmental technology, (8) financial services, (9) recreational goods manufacturing, and (10) software and computer services. The distinction between high-technology and other clusters, however, has become blurred as other clusters increasingly use technology equipment and services. (For cluster definitions, see Appendix D.)

In 1998, high-technology clusters employed over 216,000 workers in the San Diego region. Of the 10 high-technology clusters, business services employed the most people, while paying the lowest average wages. In the 1990's, the region's high-technology clusters were growing rapidly. From 1990 to 1998, the average rate of growth in high-technology clusters was 27.2 percent; or 57.1 percent, if defense manufacturing is excluded. During this period, recreational goods was the fastest growing cluster, but represented a small portion of total high-technology jobs. Employment in biotechnology and pharmaceuticals more than doubled, and by 1998, the San Diego region had the fourth highest concentration of biotechnology jobs in the country, according to SANDAG. Employment in software and computer services increased at similar rates as biotechnology and pharmaceuticals. Other fast growing, high-technology clusters were business services and communications. (See Table 6.)

Table 6
Average Annual Employment, San Diego Region
by Industry Cluster, 1990 and 1998

Industry Cluster	Year		Change	
	1990	1998	Numeric	Percent
Biomedical Products	7,363	5,774	-1,589	-21.6
Biotechnology & Pharmaceuticals	11,267	22,999	11,732	104.1
Business Services	48,159	78,792	30,633	63.6
Communications	13,166	20,619	7,453	56.6
Computer & Electronics Manufacturing	21,338	25,006	3,668	17.2
Defense Manufacturing	39,114	19,109	-20,005	-51.1
Environmental Technology	3,111	4,467	1,356	43.6
Financial Services	15,750	15,778	28	0.2
Recreational Goods Manufacturing	2,023	6,195	4,172	206.2
Software & Computer Services	8,804	17,700	8,896	101.0
High-Technology Cluster Subtotal	**170,095**	**216,439**	**46,344**	**27.2**
Entertainment & Amusement	9,455	16,032	6,577	69.6
Fruit & Vegetables	3,541	3,659	118	3.3
Horticulture	6,328	6,323	-5	-0.1
Medical Services	50,660	56,055	5,395	10.6
Visitor Industry Services	75,580	77,278	1,698	2.2
Total Cluster Employment	**315,659**	**375,786**	**60,127**	**19.0**

Source: California Employment Development Department, 1998; compiled by San Diego Association of Governments, 1999.

Innovation Associates (IA) compared the rate of employment growth in four of San Diego region's technology clusters – biotechnology and pharmaceuticals, business services, communications, and software and computer services – with the average employment growth for those clusters in the United States. IA found that the rate of employment growth, between 1990 and 1998, in two of the four clusters — biotechnology and pharmaceuticals, and communications — outpaced the average growth in the United States. (For more details, see Appendix B.)

Many of the jobs in expanding high-technology clusters were high-wage jobs. For example, in 1998, the average wage, adjusted for inflation, in software and computer services was $63,657, and in biotechnology and pharmaceuticals, was $55,974. From 1990 to 1998, the fastest growing wages were in recreational good manufacturing, computer and electronics manufacturing, software and computer services, and biotechnology and pharmaceuticals. (See Table 7.)

Table 7
Annual Payroll Per Employee, 1990 and 1998
San Diego Region, by Industry Cluster
(in 1998 Dollars)

Industry Cluster	Year		Change	
	1990	1998	Numeric	Percent
Biomedical Products	$36,673	$41,464	$4,791	13.1
Biotechnology & Pharmaceuticals	$43,280	$55,974	$12,694	29.3
Business Services	$31,651	$30,884	-$767	-2.4
Communications	$45,625	$51,352	$5,727	12.6
Computer & Electronics Manufacturing	$40,205	$54,218	$14,013	34.9
Defense Manufacturing	$42,622	$52,573	$9,951	23.3
Environmental Technology	$36,353	$43,201	$6,848	18.8
Financial Services	$36,869	$42,186	$5,317	14.4
Recreational Goods Manufacturing	$26,803	$36,340	$9,537	35.6
Software & Computer Services	$47,372	$63,657	$16,285	34.4
High-Technology Cluster Ave. Subtotal	**$38,745**	**$47,185**	**$8,440**	**21.8**
Entertainment & Amusement	$27,395	$30,944	$3,549	13.0
Fruit & Vegetables	$13,649	$16,412	$2,763	20.2
Horticulture	$18,015	$22,025	$4,010	22.3
Medical Services	$39,819	$38,015	-$1,804	-4.5
Visitor Industry Services	$15,312	$15,730	$418	2.7
Total Cluster Average	**$33,443**	**$36,275**	**$2,832**	**8.5**

Source: California Employment Development Department, 1998; compiled by San Diego Association of Governments, 1999.

Note: Average annual wages are adjusted for inflation based on the Consumer Price Index. Totals do not include the Uniformed Military cluster.

IA compared the growth rates of average annual wages between the San Diego region and the United States in four high-technology clusters — biotechnology and pharmaceuticals, business services, communications, and software and computer services — and found that average wages rose more quickly in biotechnology and pharmaceuticals, and software and computer services in the San Diego region than in the United States. However, in 1998, wages in all four clusters were, on average, 4.5 percent below that of the United States. (For more details, see Appendix C.)

High-technology businesses are mainly small businesses. In 1996, San Diego's most rapidly growing high-technology clusters—biotechnology and pharmaceuticals, business services, software and computer services, and recreational goods manufacturing— were composed of firms with an average of fewer than 40 employees. Moreover, business services, and software and computer services were

composed of businesses with an average of fewer than 15 employees. (See Table 8.)

Table 8
Average Firm Size, San Diego Region
by Industry Cluster, 1990 and 1996

Industry Cluster	Number of Establishments		Average Firm Size (No. of Employees)	
	1990	1996	1990	1996
Biomedical Products	91	134	81	48
Biotechnology and Pharmaceuticals	367	568	30	38
Business Services	4,018	5,497	12	11
Communications	146	273	47	42
Computer & Electronics Manufacturing	541	791	49	35
Defense Manufacturing	129	134	303	139
Environmental Technology	74	109	42	38
Financial Services	493	1,094	32	9
Recreational Goods Manufacturing	155	223	20	29
Software and Computer Services	474	990	19	14
High-Technology Cluster Subtotal	**6,488**	**9,813**	**64**	**40**
Entertainment and Amusement	350	542	31	29
Fruit and Vegetables	370	407	10	9
Horticulture	478	513	13	12
Medical Services	3,640	4,170	14	13
Visitor Industry Services	2,353	3,548	30	20

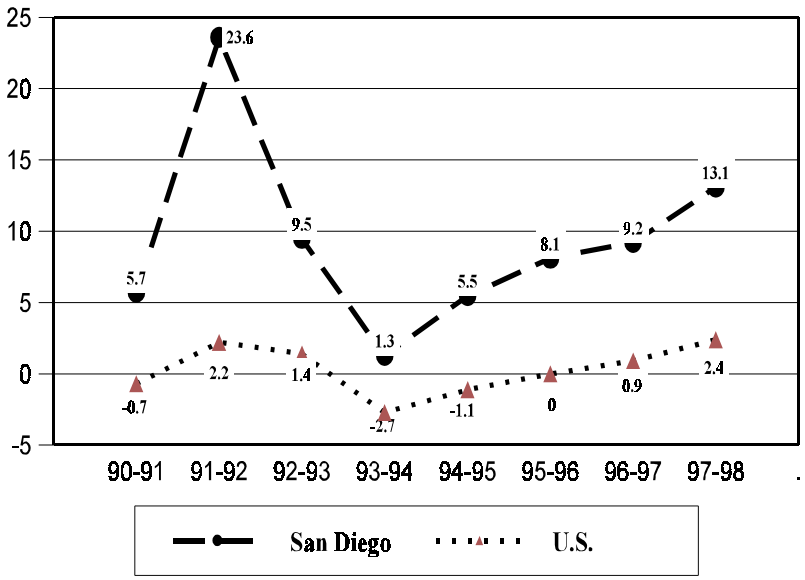
Source
: California Employment Development Department, 1997; San Diego Association of Governments, 1999.

Note: Total excludes Uniformed Military cluster.

Biotechnology and Pharmaceuticals

San Diego's biotechnology and pharmaceutical industries employed almost 23,000 people in the San Diego region in 1998. Between 1990 and 1998, employment in these industries doubled in the San Diego region, while remaining constant in the United States. (See Figure 3 and Appendix B.)

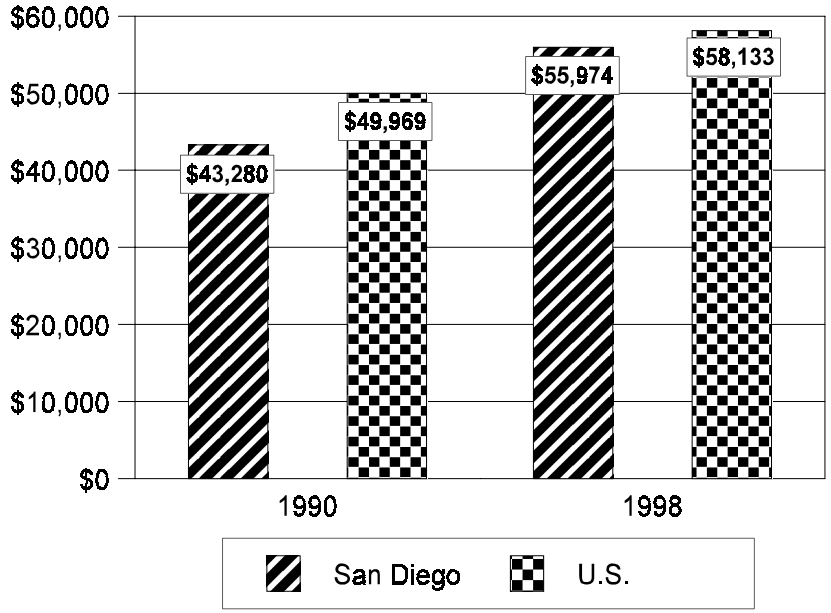
Figure 3
Biotechnology and Pharmaceuticals Cluster
Average Annual Employment, San Diego & U.S.
Percent Change, 1990-98



Source: San Diego - California Employment Development Department, U.S. - U.S. Bureau of Labor Statistics ES202.

Jobs in biotechnology and pharmaceuticals were high-wage jobs, with an average in 1998 of $55,974. Average wages in this cluster were slightly below the national average but, throughout the 1990's, the gap between wage rates in the San Diego region and the U.S. were steadily closing. (See Figure 4 and Appendix C.)

Figure 4
Biotechnology and Pharmaceuticals Cluster
Average Annual Wage, San Diego & U.S., 1990 and 1998



Sources: San Diego - California Employment Development Department, U.S. - U.S. Bureau of Labor Statistics ES202.

The majority of the region's biotechnology and pharmaceutical firms are located in, or adjacent to, La Jolla where the University of California at San Diego (UCSD) and two internationally renown institutes are located: the Salk Institute for Biological Studies and the Scripps Research Institute. These two institutes and UCSD have provided a rich base of scientific research in biotechnology and biosciences.

Biomedical Products

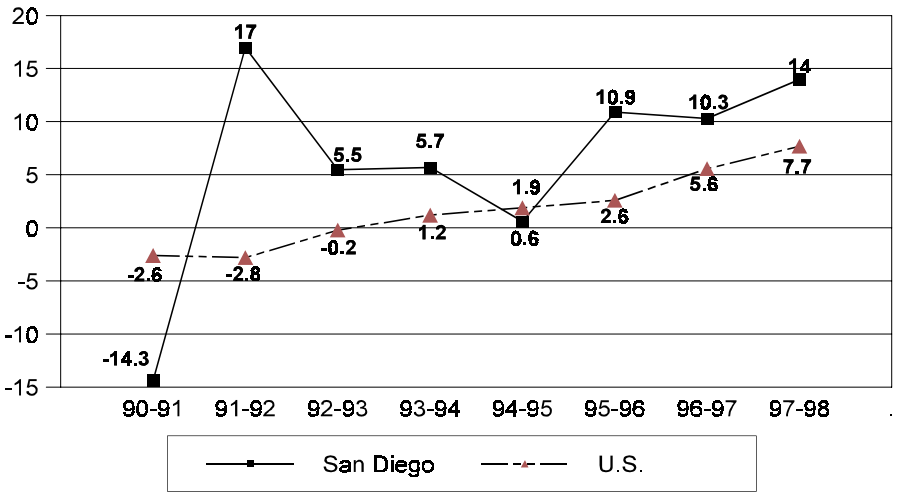
San Diego's biomedical product firms lost employment in the 1990's, but still remained strong. Between 1990 and 1996, the biomedical products industry restructured, resulting in 68 percent more firms with fewer employees in each firm. During this period, the number of employees dropped from an average of 81 to 48 employees per firm. Hybritech, started by two UCSD researchers, was responsible for many of the firms in this cluster. UCSD and the local research institutes continue to produce spin-off firms and provide a platform for this industry cluster.

Communications

Communications firms in San Diego focus on cellular, satellite, analog and digital products. Although San Diego is the home of major telecommunications firms, most firms are small, employing an average of 42 employees (1996). The proliferation of communication firms in San Diego's Sorrento Valley is so well known that the area has been named "Telecom Valley" or "Telecom Town" by local residents.

San Diego's communication firms employed almost 21,000 employees in 1998. From 1990 to 1998, the communications cluster grew by 56.6 percent. The rate of employment growth for communication firms in the San Diego region was greater than the average rate of employment growth for the nation, which grew at 13.9 percent. (See Figure 5.)

Figure 5
Communications Cluster
Average Annual Employment, San Diego & U.S., Percent Change, 1990-98



Source: San Diego - California Employment Development Department,
U.S.- U.S. Bureau of Labor Statistics ES202.

According to SANDAG, communication workers had an average wage rate 67 percent above the regional average. However, in 1998, average wages in the region's communication firms were 5.8 percent below the national average. In 1998, communication jobs in the San Diego region averaged $51,352.

Through the 1980's and 1990's, QUALCOMM has been San Diego's leading telecommunications company, and has largely been responsible for San Diego's growth in this field. A former professor in UCSD's Department of Applied Electro-physics, Dr. Irwin Jacobs, left his teaching position in 1971 to start Linkabit, which quickly grew to become a major communications firm. Dr. Jacobs, a few years later sold Linkabit and started QUALCOMM in 1985. QUALCOMM developed a pool of experts in satellite communications, focusing on radio, digital signal processing, control software, and control protocol. In 1998, QUALCOMM employed over 11,600 employees nation wide and was the second largest producer of cellular telephone technology in the world. Because of its growth in telecommunications, San Diego has attracted other telecommunication firms to the region. In 1997, Sony located the Sony Wireless Telecommunications Company in San Diego, and Ericsson, Nokia, LG Infocomm, and Motorola also have operations in San Diego.

Computer and Electronics Manufacturing

Employment in the computer and electronics manufacturing cluster grew slightly during the early and mid 1990's. The field restructured during that period, resulting in more firms with fewer employees. From 1990 to 1996, there were 250 more firms, a 46-percent increase, with an average of 35 employees. This sector not only was important because it provided more than 25,000 jobs in 1998, but also because it provided inputs for San Diego's other high-technology industries, including those in communications, biomedical products, defense, and software and computer services.

The computer and electronics manufacturing cluster in the San Diego region has extended beyond the border to encompass the Maquiladora factories in Mexico. Using computer and electronic inputs from San Diego firms, Tijuana's factories produced over 12 million television sets in 1997, making the cross-border region the television manufacturing capital of the world.

Among the computer and electronics companies located in San Diego were Kyocera, Composite Optics, Hewlett-Packard, Pulse, Rockwell Semiconductor Systems, XLNT Designs, and Doctor Design.

Environmental Technology

Although environmental technology employs a small number of people, it is a growing cluster in San Diego. Firms in this cluster provided environmental engineering; toxic, hazardous, and radiological waste disposal and monitoring; air and water filtration; and other products and services. From 1990 to 1998, employment in this cluster grew by 43.6 percent.

Recreational Goods

This small, but growing cluster achieved the highest growth rate of any cluster, more than tripling employment between 1990 and 1998. Firms in recreational goods have capitalized on new composite materials used in defense industries to develop high-performance recreational products. One of San Diego's firms is the leading manufacturer of golf clubs in the nation.

Software and Computer Services

In San Diego, the software and computer services industry has developed rapidly. Almost non-existent before the mid 1980's, there were about 1,000 firms in 1996, more than double the number of firms only six years earlier. From 1990 to 1998, employment in this cluster more than doubled and accounted for almost 18,000 jobs. Wages in this cluster were the highest of any technology cluster in San Diego, averaging $63,657 in 1998, an increase of 34.4 percent in eight years. Although the rate of change in wages was about the same for the San Diego region and the nation, wages in this cluster were slightly below the national average. (See Appendix C.) Software and computer services were characterized by very small firms, averaging fewer than 20 employees per firm.

Software and computer service firms in San Diego provided computer programming, prepackaged software, systems integration, data preparation and processing, information retrieval, multimedia development, and Internet applications. Software and computer services supported other major clusters in the region including defense, communications, biomedical products, and computer and electronics manufacturing.

Some of the firms in this cluster are SAIC, Image Ware Software, Inc., Intuit, Stellcom Technologies, and Visicom Laboratories, Inc. The largest of the firms, SAIC, was started in 1969, by Dr. J. Robert Beyster who left General Atomics to start this computer services firm. In less than thirty years, SAIC grew from a firm of 20 employees with $250,000 in annual sales to a firm of over 35,000 employees and $3.4 billion in annual revenue in 1999.

PATENT GRANTS

Patent and copyright grants are indicators of the region's potential for future growth in technology. In the 1990's, San Diego was a patent powerhouse, ranking eleventh among all metropolitan areas in the country. Total patents awarded in the San Diego region jumped from 761 in 1990 to 1,673 in 1998. (See Table 9.) Fully 74 percent of all patents were awarded in biotechnology and pharmaceutical fields.[4]

[4]Biotechnology and pharmaceuticals include patent classes 435, 514, 424, 536, and 530.

Table 9
U.S. Utility Patent Grants by Metropolitan Area, 1990-98
Rank Ordered by 1998 Grants

Rank	Metropolitan Area	1990	1994	1998
1	San Jose, CA PMSA	1,295	2,099	4,931
2	Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH NECMA	2,051	2,476	3,687
3	Chicago, IL PMSA	2,086	2,260	2,959
4	Los Angeles-Long Beach, CA PMSA	1,586	1,875	2,335
5	Minneapolis-St. Paul, MN-WI MSA	1,154	1,513	2,051
6	Detroit, MI PMSA	1,342	1,537	1,913
7	Philadelphia, PA-NJ PMSA	1,213	1,426	1,758
8	New York, NY PSMA	1,084	1,193	1,749
9	Rochester, NY PMSA	915	1,381	1,749
10	San Francisco, CA PMSA	557	682	1,705
11	San Diego, CA MSA	761	936	1,673
12	Orange County, CA PMSA	891	1,113	1,484
13	Dallas, TX PMSA	750	1,033	1,471
14	Oakland, CA PMSA	629	802	1,461
15	Houston, TX PMSA	1,009	1,234	1,445

Source: U.S. Patent and Trademark Office, 1999.

Note: Metropolitan areas are based on definitions effective July 1, 1998. MSA= metropolitan statistical area; NECMA= New England county metropolitan area; PMSA= primary metropolitan statistical area. The geographic distribution of patents is based on the residence of the first-named inventor.

SMALL BUSINESS INNOVATION RESEARCH AWARDS

The Small Business Innovation Research (SBIR) program provides grants and contracts to small technology firms to support feasibility studies (Phase I), and prototype development (Phase II), aimed at commercializing new and advanced products, processes, and services. The SBIR program is sponsored by 11 federal government agencies and can be used by small firms to develop and test new innovations, enter new markets, and increase federal procurement opportunities. It can be an important funding vehicle for start-up and emerging small technology companies.

In the 1990's, the U.S. Small Business Administration's Office in San Diego and UCSD- CONNECT, aggressively marketed the SBIR program to the region's small, high-technology firms. They did so as a way to fund high-risk technology research in a region with little venture capital in the early 1990's. By FY98, the San Diego region ranked sixth in the number of SBIR awards nationwide. The

five metropolitan areas that received a greater number of SBIR awards had larger populations than the San Diego region. Small technology firms in San Diego received over $47 million in grants. (See Table 10.)

Table 10
SBIR Awards by Metropolitan Area
Ordered by Decreasing FY98 Awards

Rank	Metropolitan Area	Population	FY98 (in $ Thou.)	FY98 No. of Awards
1	Boston, Lawrence, Salem, Lowel, MA	4,055,700	130,649	498
2	Bay Area (SF)	5,534,200	83,287	293
3	Los Angeles Area	13,074,800	72,935	273
4	Washington, DC-MD-VA	3,565,000	81,974	310
5	New York Area	15,529,300	63,016	429
6	San Diego, CA	2,201,300	47,208	161
7	Philadelphia Area	5,697,200	30,578	129
8	Denver-Boulder-Longmont, CO	1,847,400	41,592	168
9	Seattle-Takoma Area	2,284,400	25,976	87
10	Albuquerque, NM	474,400	11,320	56

Source: Office of Technology, U.S. Small Business Administration, 1999.

The SBIR program has provided an important source of seed and start-up capital for high-risk research projects performed by San Diego's technology firms. Because of the competitive nature and high research quality demanded by the program, winning one or more SBIR awards has given many San Diego firms the additional credibility needed to obtain follow-on capital from private sources and government procurement contracts. SBIR awards to San Diego firms increased substantially during the 1990's, with the total amount of grants to San Diego firms more than doubling in less than a decade. (See Table 11.)

Table 11
SBIR Awards to San Diego Firms
by Number and Funding

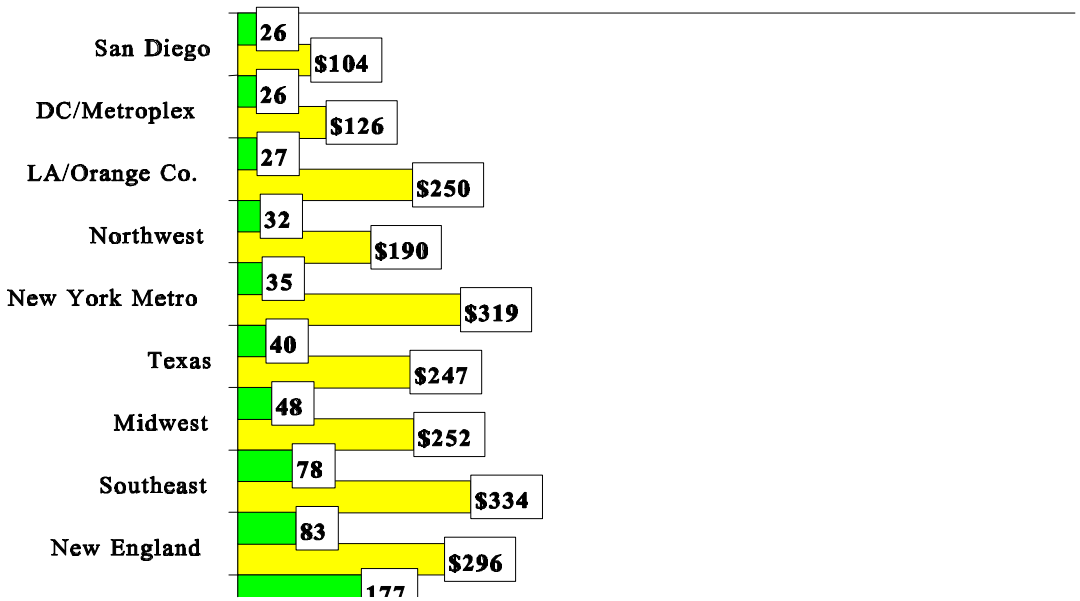
Year	No. of Awards	Funding (in $ Thou.)
1983	21	1,319
1984	49	5,534
1985	78	10,602
1986	111	16,824
1987	127	12,813
1988	131	16,411
1989	133	18,936
1990	126	19,943
1991	148	19,390
1992	147	19,613
1993	170	26,635
1994	169	27,224
1995	170	34,109
1996	178	40,943
1997	186	44,722
1998	161	47,208

Source: Office of Technology, U.S. Small Business Administration, 1999.

VENTURE CAPITAL

There were significant amounts of venture capital flowing into the San Diego region. In the third quarter of 1997, a total of $104 million in venture capital was invested in the region, funds which benefitted 26 small businesses. In 1997, San Diego ranked eleventh in the country in total venture capital invested. (See Figure 6.)

Figure 6
National Venture Capital Investment Over $100 Million
Third Quarter 1997
United States



Source: **"Venture Capital Roundup Report," Price Waterhouse, 1996-97.**

OUTLOOK

San Diego regional officials expect jobs to grow by 50 percent by 2020, more than double the rate of the U.S. Employment growth is expected to exceed population growth in San Diego, and income levels to rise faster than inflation. SANDAG expects that growth in real per capita income through the year 2020 will keep pace with that of the U.S. They also anticipate that through 2020, the price of a single family detached home will increase more than twice as fast as income.

Officials expect current trends in job creation to continue. Defense manufacturing and government sectors are expected to continue declining, while tourism, business services, and high-technology clusters are expected to rise. It is anticipated that, by 2020, only 25 percent of employees will be employed in manufacturing and government jobs; and 58 percent in services, trade, and various high-technology clusters. Moreover, the lessening dependence of the economy on defense and government, and the increasing diversity of the economy, should make the region more resistant to any future economic downturns.

In summary, the economy of the San Diego region during the 1990's has been a rapidly changing one. Prior to the 1990's, defense spending had anchored the economy. With the decline in defense spending in the early 1990's, the local economy suffered through a rise in unemployment, a decline in real per capita income, and a local cost of living which remained high. However, in recent years there has been a turnaround. Certain high technology clusters, such as biotechnology and pharmaceuticals, and software and computer services are growing rapidly. Wage levels and real household income are rising, although real wages remain below national averages in high-technology clusters. Trade flowing through San Diego's ports is increasing. Venture capital is coming into the local economy. The formation of new businesses is outpacing that of the U.S. and California. San Diego’s economy is robust and the economic signs indicate that this should continue for the next several years.

IV. THE ROAD TO DEVELOPING SMALL, HIGH-TECHNOLOGY FIRMS

HISTORY OF HIGH-TECHNOLOGY FIRMS

San Diego has a history of technology-based industries that were created to serve the military's naval presence. The region's technology-based industries began to grow during World War II when Consolidated Aircraft Company was tapped by the Pentagon to manufacture war planes. Its employment swelled from 13,000 people in 1940 to 45,000 by the end of 1942. During the war, other aircraft manufacturers and suppliers flocked to the area. By the end of the war, tourism was still a major part of San Diego's economy but aerospace employment, and the military contracts that fed it, were increasingly becoming the lifeblood of San Diego's economy. The groundwork had been laid for the development of future small, high-technology industries that would begin to appear in the 1980's and 1990's.

Postwar San Diego boomed from the presence of naval bases and military contracts. But as the threat of the Cold War ended in the late 1980's and early 1990's, and as national defense budgets were cut, the Department of the Navy reduced its presence in San Diego. Once leading defense firms such as General Dynamics closed its doors, and others such as Rohr reduced its workforce in San Diego.

But reductions in defense industries gave impetus to new small, high-technology firms in communications, computer and electronics manufacturing, and computer software services, which grew out of defense industries. These new firms responded to the ebb and flow of defense spending, meeting defense industry demands when defense spending was up, and meeting commercial market demands with diversified products and services, when defense spending was down. Other industries, such as those in biotechnology and pharmaceuticals, emerged from the rich environment of private research institutions, and all types of new technology industries benefitted from the establishment of the University of California at San Diego (UCSD) in 1960.

THE ORIGIN AND "BEGATTING" PROCESS OF HIGH-TECHNOLOGY FIRMS

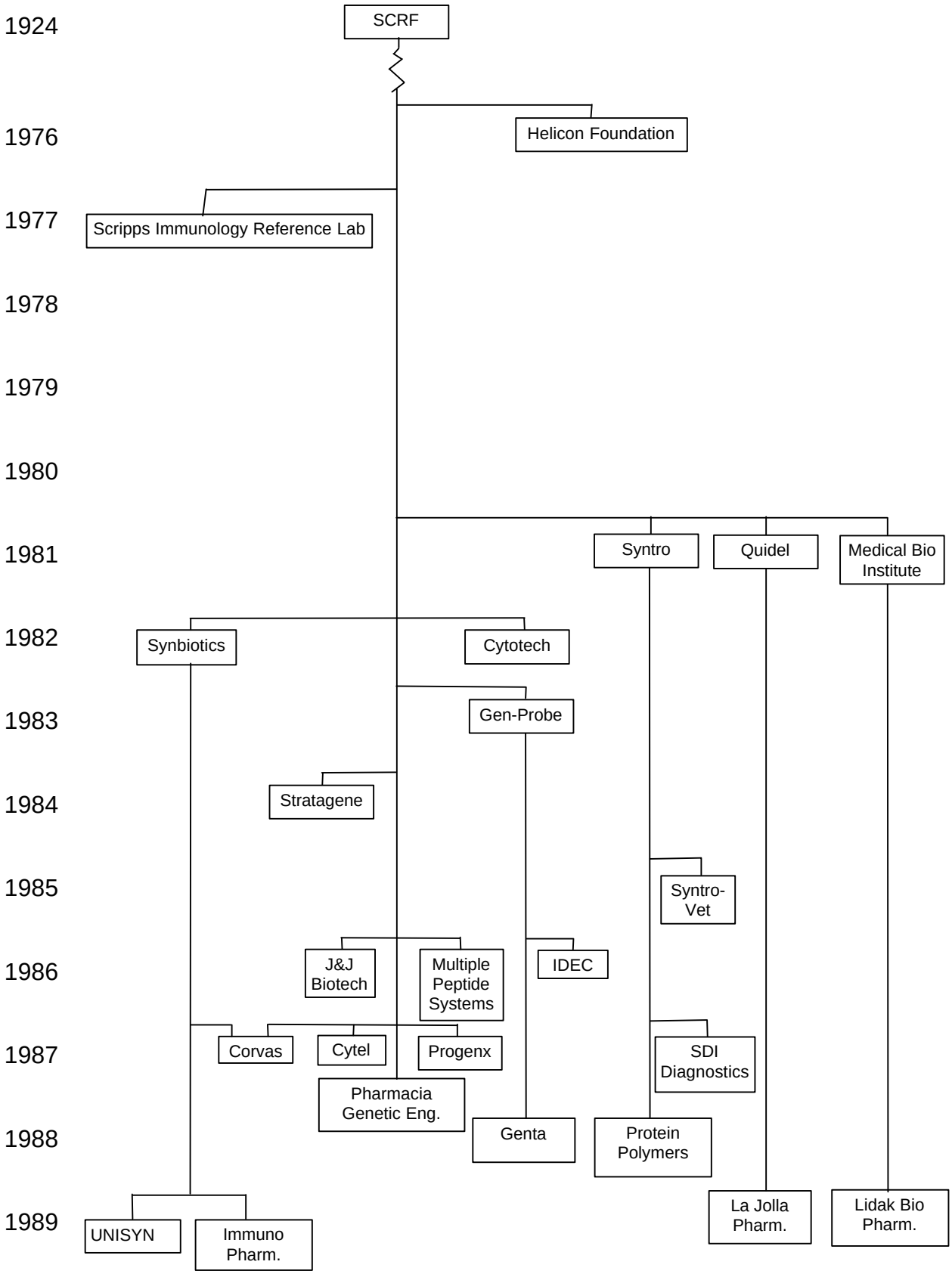
There were three major sources of high-technology industries in the San Diego region — the universities, particularly UCSD, the medical and bioscience institutes, and the defense complex. UCSD provided a particularly fertile ground for developing and nurturing high-technology and biotechnology industries. The University's Center for Wireless Communications and School of Engineering proved rich spawning grounds for telecommunications, software, electronics manufacturing, and defense and space manufacturing. According to CONNECT, at least 41 San Diego-based communications and telecommunications companies were either founded by students or faculty, or spun off from firms with ties to UCSD. Telecommunications entrepreneurs from UCSD included former faculty members Dr. Irwin Jacobs and Dr. Andrew Viterbi, cofounders of Linkabit and QUALCOMM.

San Diego's renown Scripps Research Institute (formerly the Scripps Clinic and Research Foundation) and Salk Institute for Biological Studies, and UCSD's Center for Molecular Genetics, Cancer Center, Center for Marine Biotechnology and Bio-medicine, and Institute for Biomedical Engineering provided a rich R&D base for San Diego's biotechnology, pharmaceutical, and medical services industries. (See Table 12.) San Diego's first biotechnology firm, Hybritech Inc., was created by two UCSD researchers, Dr. Ivor Royston and Mr. Howard Birndorf. Hybritech has been credited with the birth of the biosciences industry in the San Diego region. (See Tables 13 and 14.) A recent example of a direct UCSD spin-off in pharmaceuticals is Myelos Neurosciences. Dr. John O'Brien started the firm based on research being conducted at the University.

The U.S. Department of Defense's (DoD) funding of naval facilities and regional contractors has played a major role in establishing San Diego's high-technology industries. DoD has funded contractors in software, electronics, and communications. As major defense corporations expanded through the 1980's, contracted in the early 1990's, and expanded again in the mid and late 1990's, high-technology entrepreneurs were born. These entrepreneurs spun-off from large defense contractors, filling specialized high-technology niches needed by DoD. In lean defense markets, entrepreneurs from downsizing defense firms diversified military products and services for commercial uses. Examples include Science Applications International Corporation (SAIC) and The Titan Corporation, which were started by individuals who had worked for the military contractor, General Atomics.

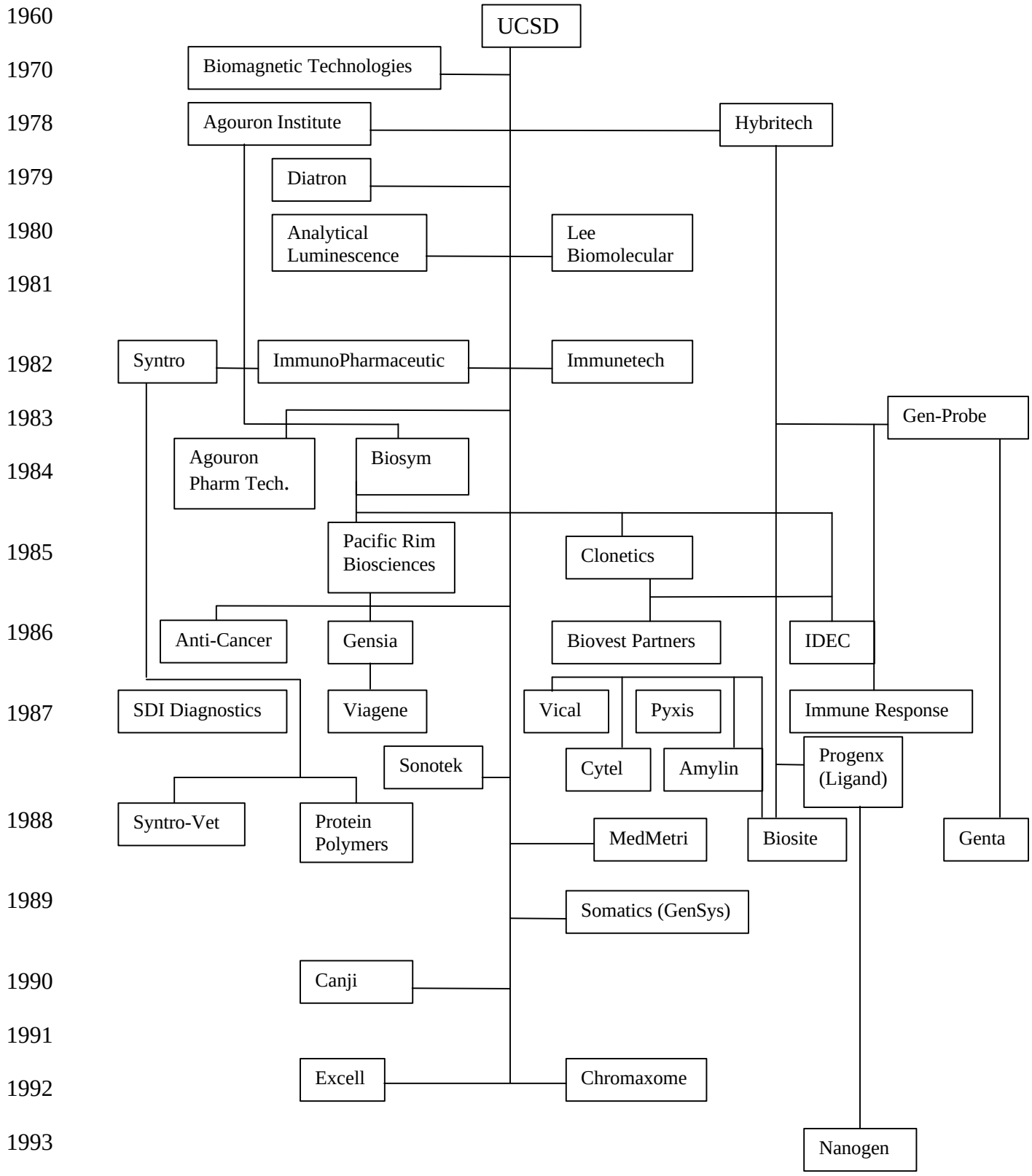
As small, high-technology firms spun off from UCSD and defense industry R&D, they began to grow and spin off other firms. Linkabit proved especially fruitful, spawning 36 communication companies including QUALCOMM. (See Table 15.) In the biotechnology and pharmaceuticals field, over 45 firms trace their lineage to Hybritech. Firms started directly by the founders of Hybritech, or by Hybritech alumni, include Gen-Probe, Inc., Idec Pharmaceuticals Inc., Genesia Inc., Pyxis Corporation, Chugai Biopharmaceuticals, and Dura Pharmaceuticals. This "begatting" process continues to produce new high-technology firms in San Diego, forming clusters in emerging technology areas and developing strong supply and demand relationships among them.

Table 12
Scripps Clinic and Research Foundation "Begatting" Pattern



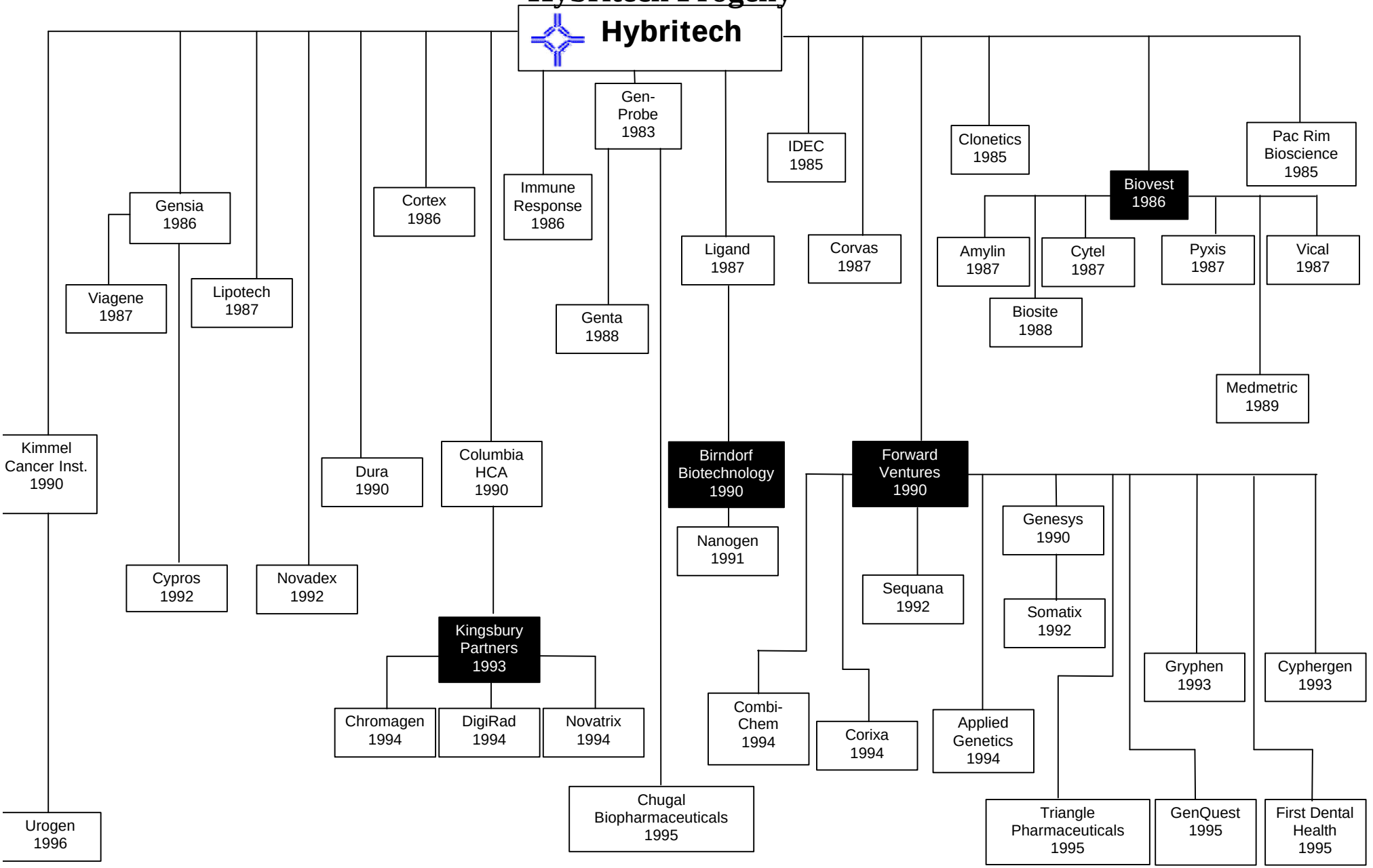
Source: CONNECT, University of California - San Diego.

Table 13
San Diego Biotechnology "Begatting" Pattern



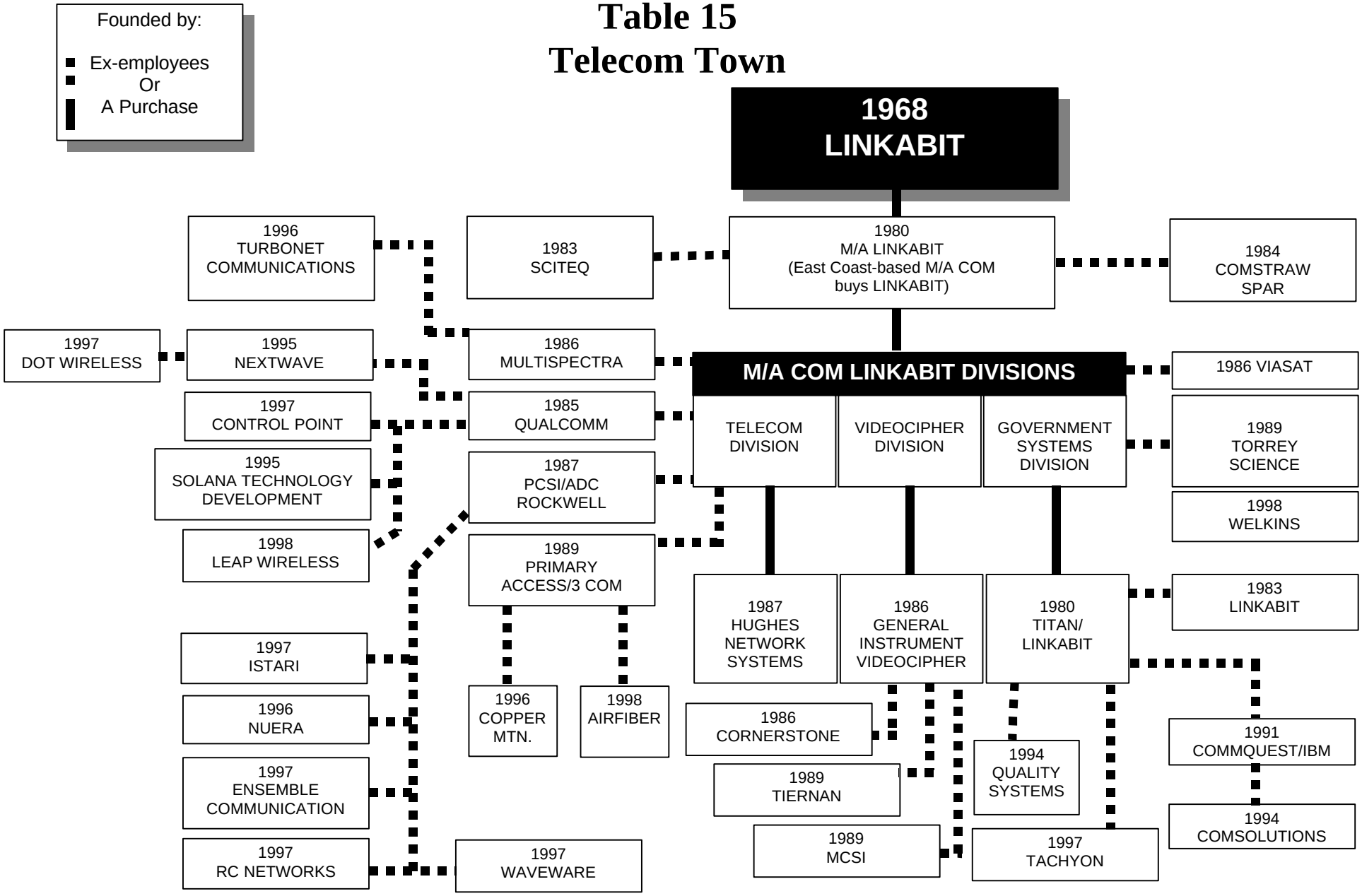
Source: CONNECT, University of California - San Diego.

Table 14
Hybritech Progeny



Source: CONNECT, University of California - San Diego.

Table 15
Telecom Town



Source: CONNECT, University of California - San Diego. (Originally created by Martha Dennis, Linkabit.)

RELATIONSHIP BETWEEN TECHNOLOGY CLUSTERS

There is a strong demand and supply relationship that links a number of the region's high-technology clusters. Some of the emerging high-technology industries in San Diego originally grew by supplying the defense industry. As defense industry demands decreased in the 1990's, and as other industries grew to replace defense industries, established suppliers developed relationships with new technology firms aimed at commercial markets. For example, growing telecommunications industries in the 1990's increasingly required inputs from electronics and computer manufacturers, primarily printed circuit board manufacturers, that had once supplied defense industries. Software and computer service firms, that had supplied defense industries, also shifted to supply new telecommunications industries. Other clusters, such as medical services, which grew from the region's research institutes, stimulated the growth of suppliers in biomedical products, biotechnology and pharmaceuticals, and related industries.

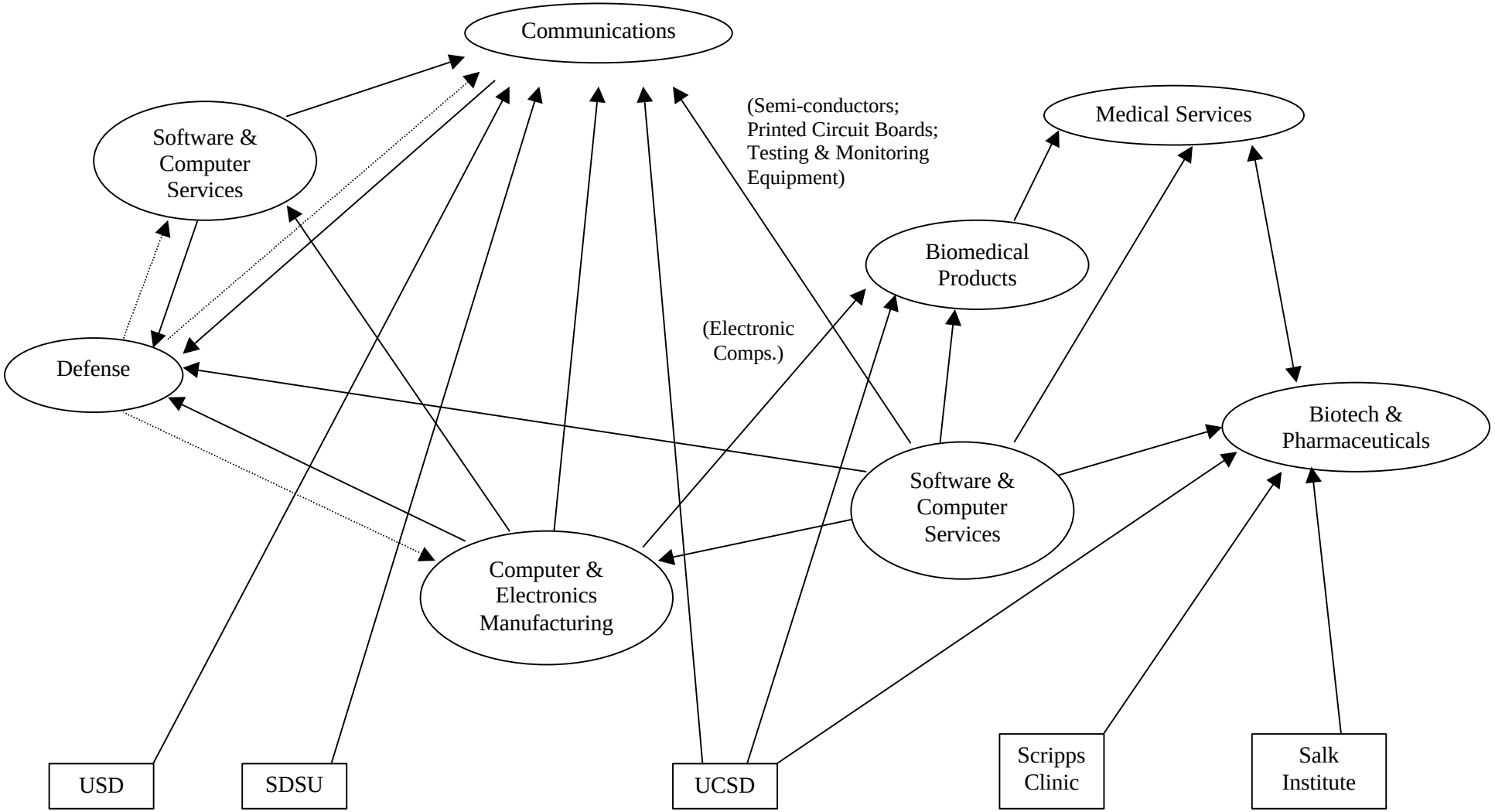
In order to track some of these complex relationships, SANDAG calculated "cluster dependency factors" among various clusters in the region. This analysis revealed strong primary support relationships among a number of growing industries. (See Figure 7.)

COMMUNITY AND UNIVERSITY LEADERSHIP IN BUILDING A HIGH-TECHNOLOGY ENVIRONMENT

Community and university leadership spearheaded activities that helped stimulate and nurture the development of small, high-technology firms. In the early and mid 1980's, economic development efforts in San Diego were led by the Economic Development Corporation (EDC). The EDC, as other EDC's of its time, pursued business attraction strategies focused on marketing San Diego and competing against other cities and states for major corporations and federal facilities. At that time, the City sought and lost two major federal bids for Sematech and the Microelectronics and Computer Consortium (MCC). These R&D facilities were awarded to Austin, Texas partly because the community in Austin worked together to collectively package and market the community. But San Diego's loss of these major facilities for the first time brought together the public, private, and academic sectors. According to Daniel Pegg, former Director of the EDC, "the lesson that the community learned from losing the MCC was that it had to pull together."

At the same time, some astute business leaders from the community noticed that new enterprises had been growing around major research institutions — Salk Institute for Biological Studies, Scripps Research Institute, and UCSD. In many of the cases, these new technology industries had been started by scientists and engineers who had graduated from UCSD or had some other connection with UCSD. The EDC formed a small advisory group, which involved their board members, UCSD's Chancellor Richard Atkinson, and private sector leaders, to develop ideas aimed at bridging the gap between public and private sectors, and leveraging research at UCSD and private sector institutions.

Figure 7
Primary Supply Relationships Between San Diego High-Technology Clusters



Source: **Innovation Associates, Inc.**
Note: **Business and financial services have primary supply relationships with all high-technology clusters.**

At the same time, the private sector started a separate initiative — the Technology Financial Forum. The Forum brought together high-technology entrepreneurs with potential investors. Attorneys, accountants, and management consultants from the community provided services to the Forum to help entrepreneurs develop business plans and make presentations to investors.

The EDC approached UCSD about initiating a program that would provide advocacy and networking activities for high-technology firms. Mr. Pegg worked with Chancellor Atkinson to implement these activities by establishing the CONNECT program. This program would be housed on campus, and administered through the University's Extension Program. Early in these efforts, Chancellor Atkinson involved Dr. Mary Walshok, Dean of University Extension, who had studied public-private partnerships and who had conducted executive programs for engineers and scientists. CONNECT first focused on public policy issues that attracted the attention and participation of private sector leaders. Later, it provided training and services to entrepreneurs and networking opportunities for high-technology firms in the community. CONNECT assumed responsibility for the Technology Financial Forum a few years after its start.

At first, the private sector did not willingly become involved in community efforts to support high-technology development. According to several corporate representatives, the EDC and UCSD "strong-armed" several leaders from the private sector, and later, others more willing followed. Mr. David Hale, President of Hybritech, Mr. "Buzz" Woolley, CEO of Girard Capital, Dr. Irwin Jacobs, CEO of Linkabit, and Mr. Bob Weaver from Deloite Touche, were some of the first private sector activists. Corporate leaders were reluctant to work with the University because they viewed the University as too bureaucratic and too academic. Aware of the private sector concerns about the University, Chancellor Atkinson kept a tight rein on the University to help insure that the University's department heads were receptive to corporate relationships. Moreover, Dr. Walshok, who led early development of UCSD's CONNECT program, carefully orchestrated the University's image portrayed to private sector. UCSD's CONNECT program grew quickly when some private sector representatives from service industries saw their involvement in the University's program as an opportunity to reach high-technology businesses, and when other high-technology industry representatives saw the program as a way to network.

In 1991, two trade associations on life sciences and biotechnology were founded by local CEO's representing those industries. The Biomedical Industry Council (BIC) was founded to represent life science industries, and BIOCOM was founded to represent biotechnology service firms. A few years later, these two organizations merged to form the present BIOCOM, which has became the region's leading advocate for issues affecting biotechnology, biosciences and medical device industries. San Diego's Software and Internet Council (formerly the Software Industry Council) also formed in 1993, and the San Diego Regional Technology Alliance was established by the State in 1995.

Public policy initiatives also created a more "business-friendly" environment. In 1992, Susan Golding was elected Mayor. Mayor Golding was determined to reverse San Diego's anti-business image. Mayor Golding's initiatives to streamline permit processing and cut red tape facilitated faster and easier development and added to a supportive business atmosphere.

In an atmosphere that included defense contract reductions, the coming-of-age of UCSD as a major research university, strong private research institutions, and an active community, small technology industries began to appear. Table 16 shows a chronology of major university and community events in relation to the growth of high-technology clusters.

In the next chapter, we detail actions taken by the universities, particularly UCSD, to stimulate and support the growth of high-technology firms in San Diego. In Chapter VI, we provide details on several of the community organizations mentioned in this chapter, and in Chapter IX, we describe, in greater detail, several of the firms mentioned in this chapter.

Table 16

SAN DIEGO HIGH-TECHNOLOGY CHRONOLOGY

Indicator	1960	1965	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998
University and Research Institute Events	UCSD founded			(1977) Scripps ImmunLab founded	Richard Atkinson becomes Chancellor of UCSD (1984) UCSD Engineering School founded	UCSD-CONNECT founded UCSD Supercomputer Center founded	SDCC-CACT founded	UCSD Dialogue founded		SDSU Entrep. Center founded	SDSU Defense Conversion Center founded	UCSD Center for Wireless Communication founded Richard Atkinson assumes UC Presidency			
Community Events	SD Institute founded	EDC founded	(1972) SANDAG founded		(1982) Small Bus. Adv. Board founded	MIT Enterprise Forum founded Tech. Finance Forum founded		Biomedical Industry Council founded Biocom founded	Susan Golding elected Mayor SD City Mgr. appoints Econ. Development Task Force City installs cable system	Software Industry Council founded EDC & SANDAG release five year plan	SD Technology Council founded Regional Tech. Alliance founded		Susan Golding re-elected Mayor	SANMEC founded	EDC & Team SD release 2nd five-year plan
Corporate Events	(1964) SAIC founded		(1971) Linkabit founded	(1976) Hellicom founded (1978) Hybritech founded (1978) Orincom founded	(1981) Titan founded (1984) Stellcom founded	QUALCOMM founded	General Dynamics closes most defense facilities in region				Myelos Neuroscience founded	Sony locates Sony Wireless Telecomm. Co. to region		DoD relocates SPAWAR to region	
Technology Clusters															
Biotech & Pharm.															
No. of firms							367	—	—	—	—	—	568	--	–
No. of employees							11,267	12,754	14,720	16,123	16,335	17,228	18,617	20,328	22,999
Business Svcs.															
No. of firms							4,018	—	—	—	—	—	5,497	–	–
No. of employees							48,159	48,606	47,967	50,521	51,869	55,149	65,871	71,039	78,792
Communications															
No. of firms							146	—	—	—	—	—	273	–	–
No. of employees							13,166	11,278	13,193	13,912	14,705	14,787	16,400	18,094	20,619
Defense Manufg.															
No. of firms							129	—	—	—	—	—	134	–	–
No. of employees							39,114	32,639	29,327	26,599	22,378	19,517	19,185	19,627	19,109
Software & Comp. Services															
No. of firms							474	---	—	—	—	—	990	–	–
No. of employees							8,804	8,869	9,443	10,245	11,422	12,366	13,643	15,179	17,700

Source: **Innovation Associates, Inc.; Technology Cluster Data - San Diego Association of Governments.**

V. THE UNIVERSITY-INDUSTRY CONNECTION

THE UNIVERSITY OF CALIFORNIA AT SAN DIEGO (UCSD)

The Critical Role of UCSD's Chancellor

> Industry-university cooperation enriches the university. In San Diego, UCSD took the lead in creating a more favorable environment for building knowledge-based businesses. As businesses built up, the University benefitted from the technology people (that the businesses) attracted.
>
> - Richard Atkinson, President, University of California

Dr. Richard Atkinson, President of the University of California, was the Chancellor of UCSD from 1980 to 1995. Dr. Atkinson played an important leadership role in promoting high-technology development in the San Diego region. As Chancellor, he set the tone and direction for the University, encouraging cooperation with industry, which helped the region's defense industries diversify and helped small, high-technology enterprises get started.

At UCSD, Dr. Atkinson actively involved local industries in recruiting science and technology "stars" and endowing chairs at the University. In fact, the campus recruited faculty of such stellar quality in virtually all disciplines that, despite the need to add positions quickly to keep pace with an increasing enrollment, by 1995, a National Research Council study ranked UCSD tenth in the nation in the quality of its graduate programs. The excellence of the faculty, and of the research the faculty produced, increased the credibility and visibility of the University in the community, state, and nation, and was a major factor in UCSD's success in contributing to the San Diego economy.

Dr. Atkinson's strategy included establishing a new school of engineering, whose principal advocate and architect he became as soon as he arrived on campus. The school has grown in size and distinction over the past 10 to 15 years, and one of its first faculty members, Irwin Jacobs, went on to found QUALCOMM. Under Dr. Atkinson's leadership, the campus successfully bid for one of five national Supercomputer Centers and aggressively sought and attracted research funding in science and engineering, making UCSD one of the top five university recipients of federal research funding during most of his tenure.

Dr. Atkinson encouraged collaborative research with industry by establishing technology transfer

programs in science and engineering departments and saw that UCSD mounted a vigorous campaign to attract industrial consortia — the Microelectronics and Computer Corporation (MCC) and Sematech — to San Diego. Although both eventually located in Austin, Texas, San Diego was the only city in California to be a finalist. He engaged the University Extension in developing corporate executive programs, and later, working with community and private sector leaders, promoted networking activities for high-technology business and industry. The networking activities became a more formalized program — CONNECT — which has grown into an impressive program aimed at networking, advocacy, assistance to and promotion of technology firms. Dr. Atkinson charged Dr. Mary Walshok, Dean of Extended Studies and Public Program, with developing the corporate programs including CONNECT, and subsequently recruited a well-respected business leader, William Otterson, to direct the program. The CONNECT program and the San Diego Computer Center are described in the next section.

INTERVIEW WITH DR. RICHARD C. ATKINSON, PRESIDENT, UNIVERSITY OF CALIFORNIA

In September 1998, Innovation Associates' President met with Dr. Richard Atkinson to discuss his philosophies on the role of the university in stimulating high-technology economies. The following is derived from that meeting.

Dr. Atkinson's philosophies on university-industry cooperation are rooted in his experiences as a professor at Stanford University. At Stanford, he witnessed Dr. Fred Terman, Dean of Engineering, actively encouraging university-industry cooperation and promoting spin-offs of high-technology industries from the University. Dr. Atkinson carried this philosophy with him to the National Science Foundation (NSF), where, as Director, he began to build bridges between universities and industries. At the NSF, Dr. Atkinson started the Industry-University Cooperative Research Program (IUCRP), which required university R&D projects funded by the IUCRP to involve industrial partners. In the late 1970's, Dr. Atkinson promoted the idea of university-industry cooperation at the NSF when there was not much interest in this type of cooperation. At first, the idea of requiring industries to partner with universities to receive grants met with opposition, but eventually the concept became accepted and institutionalized. Dr. Atkinson promoted the importance of university R&D and the role of university-industry collaboration at the NSF:

- By initiating formal analysis to measure the economic results of R&D investments;
- By promoting technology transfer policies aimed at moving intellectual property rights from government to universities (which later was mandated through the Bayh-Dole Act);
- By institutionalizing engineering as an integral part of NSF activities, and underscoring the relationship between science and engineering; and
- By encouraging university-industry relationships in R&D through the IUCRP.

Dr. Atkinson said that, prior to the "Sputnik era," universities and industries had strong relationships in science and engineering. Universities cooperated with industries because it was economically beneficial for them to do so. But the bonds between universities and industries weakened during the Cold War when the federal government provided extensive funding for university research, lessening the need for university-industry cooperation. As the "Sputnik era" was coming to an end, Dr. Atkinson believed it was time to renew the once strong relationships between universities and industries. The IUCRP, and other activities that stemmed from Dr. Atkinson's tenure at the NSF, laid the groundwork for national policy and provided a model for state technology programs. Programs such as the Ben Franklin Program in Pennsylvania, and the Thomas Edison Program in Ohio, followed NSF's lead by focusing resources on university-industry collaboration in R&D and university-centered technology transfer.

As Chancellor of UCSD from 1980 to 1995, Dr. Atkinson drew on his Stanford and NSF experiences to position UCSD as a key technology generator in the San Diego region. During his tenure, the University played a central role in creating an entrepreneurial climate by attracting federal research dollars and helping bring research to market. Dr. Atkinson believed that it was part of the University's mission, as a state-funded institution, to give something back to California by creating a more favorable environment for attracting and developing technology-based industries around the University and in the community.

Dr. Atkinson promoted his ideas of university-industry collaboration at a critical time in San Diego's economic development. In the late 1980's and early 1990's, when the region experienced defense cutbacks, Dr. Atkinson worked externally, with community organizations, and internally, with the University's department heads, to forge a relationship between the University, the community, and the private sector. He believed that it was natural that small, high-technology enterprises would fill the gap left from reductions in defense contracts to major corporations.

In order to promote the development of high-technology enterprises in the San Diego region, Dr. Atkinson's initiatives at UCSD aimed:

- To increase the University's basic and interdisciplinary research capacity,
- To increase the University's computer and engineering education and research through new schools and centers,
- To encourage the transfer of the University's technologies to the private sector and into the market place,
- To support the development of new technology enterprises, and
- To develop national credibility and visibility for the University and the region's technology community.

Dr. Atkinson believed research was the key to economic progress, and that university-industry collaboration was essential to transfer research into the market place. Citing principals set out by President Truman's Science Advisor almost 50 years ago, Dr. Atkinson said that (1) basic research should be funded by the federal government, (2) basic research should be carried out in research universities, and (3) funding should be made available to individuals not institutions. Dr. Atkinson's active pursuit and success in obtaining federal funding for research, and his active courtship of private funding, were prerequisites to building UCSD as a nationally prominent research university.

Dr. Atkinson believed in greater freedom for academics to carry out their own research programs. He also believed horizontal, non-hierarchal structures encouraged "academic entrepreneurs." Under Dr. Atkinson's direction, UCSD professors were expected to spend about half of their time conducting research. Dr. Atkinson said, despite the emphasis on research, that teaching quality remained high. This was demonstrated by consistently high satisfaction ratings from undergraduate students.

Industries, he said, primarily want two things from research universities: access to students, and a window on science and technology. In San Diego, Dr. Atkinson helped provide the window on science and technology by instituting university-industry cooperative programs, executive fora, and programs that networked high-technology firms in the region.

Dr. Atkinson believed, although direct technology transfer to industries was important, perhaps even more important was the indirect technology transfer which resulted from students taking jobs with local industries and starting businesses. This indirect technology transfer benefitted growing local industries as well as the University's ability to attract top students.

Dr. Atkinson stressed the difference between the university being an "engine that drives the economy" and a "job shop." As an "engine," the university provides technology firms with research and development and technology transfer. Moreover, Dr. Atkinson said that not every university should be engaged in research, for different universities serve different purposes in the community and the state.

Dr. Atkinson believed the most important asset for any university was to employ the best people. He actively involved the private sector in recruiting top national scientists and engineers to the San Diego region. He said, "you cannot create intellectual talent, you must go after it and reduce the constraints in attracting the best people." He contended that a public university is presented with greater challenges than a private university in attracting the best people, but that this could be overcome, in part, by involving the private sector.

In terms of the national economy, Dr. Atkinson said that the application of knowledge may be (the United States') best strategic advantage in an international market. In order to apply knowledge and increase the U.S. competitive position, he believes two factors are key: (1) increasing productivity of the American workforce, and (2) increasing investments in research and development (which ultimately leads to increased productivity). He referred to a report by the Council of Economic Advisors which stated that 50 percent of all U.S. economic growth in the past 50 years has been due to investments in research and development (R&D). He said that research universities have been, and continue to be, a valuable source of that R&D. Dr. Atkinson expressed concern about declining federal R&D funding to research universities, and suggested that this could weaken future economic growth.

In 1995, Dr. Atkinson assumed the Presidency of the University of California, where he is applying experiences from Stanford University, the National Science Foundation, and the University of California at San Diego. He has already increased the University of California's university-industry efforts in biotechnology, and is expanding that collaboration to other fields. If the State of California benefits from Dr. Atkinson's leadership, as San Diego has benefitted, the State is indeed fortunate to have him at the helm of its university system.

The CONNECT Program

> The capacity we are adding is a set of organizations and activities that harvest the best and most useful knowledge that we find, and then organize and deliver it to people who can use it; whether they are scientists in industry, engineers in telecommunications, or middle school teachers of mathematics.
>
> - Mary Walshok, Dean, Extended Studies and Public Programs, UCSD

CONNECT was started in 1985 to foster university-industry cooperation and promote the growth of high-technology industries. It is part of the University's Extended Studies and Public Programs (University Extension), but operates somewhat independently from the University. CONNECT is a self-sustaining membership organization that provides to its members and the business community advocacy, networking, seminars, financial match-making fora, corporate partnering fora, and awards. CONNECT has grown rapidly. In 1985, CONNECT started with 17 company sponsors; by the end of 1998, there were over 540 sponsors. The organization has a staff of 12, several of whom are volunteers. CONNECT draws heavily on an active community of corporate leaders and service providers to conduct various activities. These activities include reviewing business plans, critiquing business presentations, conducting seminars and promoting public policy positions. In interviews with the Mayor of San Diego and CEO's of major corporations, UCSD and CONNECT consistently were cited as major forces in San Diego's rapid high-technology growth.

Early in its history, CONNECT brought together corporations for the common purpose of advocating public policy positions concerning water rights and environmental issues. CONNECT continues to advocate and lobby public policy issues. Recently, CONNECT has focused on reforming U.S. Food and Drug Administration regulations which may hamper progress in biotechnology industries. CONNECT also has advocated increasing the number of visas to permit recruitment of foreign engineers.

CONNECT conducts seminars and classes for high-technology CEO's and entrepreneurs. Seminars are given on how to market a high-technology product, how to write a business plan, intellectual property, marketing, and other topics central to developing and managing a high-technology business. CONNECT's former Director, the late William Otterson, said that a major difference between CONNECT's seminars and those given by other organizations is that CONNECT's seminars are taught by practitioners and not professors. Seminar leaders are service providers, seasoned managers, CEO's, and venture capitalists. Classes for entrepreneurs also are given through the University Extension. The most popular class, "How to Start and Manage a High-Tech Company," runs for 10 weeks. In this class, entrepreneurs form business teams, develop business

strategies, and present their business plans to venture capitalists. The course is taught by successful entrepreneurs from the community. CONNECT also operates a television show that is aimed at entrepreneurs. The show, which is produced and broadcast through the University, highlights successful entrepreneurs who discuss their business experiences. CONNECT also provides newsletters, business advice, financial match-making, and corporate partnering. CONNECT is funded entirely by sponsor and member fees and program revenue, and receives no University funds.

Entrepreneurial Development and Investment Activities. — CONNECT has organized five major activities — Meet the Researchers, the Springboard Program, the Technology Financial Forum, the Corporate Partnership Forum, and the Most Innovative New Product — to assist and promote high-technology entrepreneurs and corporations.

- Meet the Researchers: The "Meet the Researchers" series, which received an award in 1992 for Innovative Programming from National University Continuing Education Association, brings together scientists and business people from various sectors to learn more about technologies, technological developments and technology transfer. This program pairs a researcher from the University with a researcher from industry to discuss scientific and engineering issues of mutual interest. Program participants include UCSD faculty, students, researchers, and executives from industry and service providers.

- Springboard Program: The Springboard Program assists entrepreneurs with developing marketing and financial plans, hiring consultants, introducing them to investors, and other services. This program was initially funded under a U.S. Economic Development Administration (EDA) defense adjustment grant. CONNECT now operates the program using private funds.

  Through the Springboard Program, entrepreneurs make a 15-minute presentation to a panel of business experts who meet weekly at the University's faculty club for breakfast. The panel may involve venture capitalists, private venture capital angels, insurance brokers, investment and commercial bankers, high-technology CEO's, business development specialists, and marketing and public relations consultants. Springboard gives technology companies intensive hands-on counseling to prepare them for meeting investors. At the Springboard meeting, the panel helps the entrepreneur refine business strategies by honing in on key issues, identifying obstacles to growth, and developing strategies to overcome the obstacles. The panel concentrates on assisting the entrepreneur with the "3 M's": money, management, and marketing.

  Since Springboard's inception, it has helped about 150 companies. Participants tend to be from life science, pharmaceutical, medical device, telecommunication, software, semi-conductor, and test equipment firms. Investments normally range from $500,000 to $2 million per company. Each August, a special Springboard luncheon is held in which four to five of the best firms make presentations. At this

function, one company raised about $3 million.

- Technology Financial Forum: The Technology Financial Forum is a major annual event that brings together entrepreneurs and high-technology firms with potential investors. The Forum originally was part of an effort by private sector providers to expose San Diego entrepreneurs to venture capital, which tended to be restricted to California's Silicon Valley. The Technology Financial Forum was incorporated as part of CONNECT's activities in 1988 and has become one if its most successful efforts.

  Through the Forum, 40 to 50 firms annually make presentations to potential investors and corporate partners. To select firms, CONNECT conducts a rigorous screening process by private sector representatives who review the firms' business plans. Each year, over 45 business, financial, legal, and corporate representatives volunteer to be reviewers.

  CONNECT provides extensive assistance to firms participating in the Forum. Each firm must participate in a "dry run" prior to the actual presentation. Expert panelists, including CEO's, university regents, and financial representatives tend to be quite critical during the practice. But, entrepreneurs usually express how helpful this activity is in correcting weaknesses before their formal presentations.

  The Forum lasts two days; one day is devoted to life science firms and one day to technology firms. Presentations are given on the morning of each day. In afternoon break-out sessions, potential investors meet individually with entrepreneurs. By the end of 1998, CONNECT had held 10 Technology Financial Fora. Investments in firms participating in the Forum tend to be larger than those participating in Springboard activities. In 1998, over 100 venture capitalists attended the Forum. CONNECT claims that firms which have participated in the Technology Financial Forum have raised over $1 billion in new capital. Although CONNECT does not directly attribute the investments to the firms' participation in the Forum, they feel that they can make legitimate claim to providing some of the contacts and networking opportunities that have contributed to these new investments.

- Corporate Partnership Forum: This annual Forum provides the opportunity for potential investors and large pharmaceutical companies to invest, license or partner in other pharmaceutical companies. Although CONNECT does not track investments; CONNECT claims that several hundred million dollars have been negotiated as a result of this Forum.

- "Most Innovative New Products" Award: Each year, CONNECT sponsors a contest to select the most innovative new product in six categories. The award provides visibility and prestige to winners. The annual luncheon, in which the award is

presented, is sponsored by local corporations, and is a major community event. In 1998, the luncheon was attended by over 800 people.

Defense Conversion Activities. — In the late 1980's and early 1990's, CONNECT conducted entrepreneurial training programs aimed at helping dislocated defense workers start their own businesses. As part of the original program, CONNECT trained 19 dislocated defense workers, 14 of whom started businesses, most of which were high-technology businesses. Three of those businesses are still in operation, and the eleven other entrepreneurs took jobs in high-technology industries.

CONNECT also hosted a series of roundtable discussions on defense conversion. CONNECT brought together senior level executives from defense firms and others to discuss ways in which the defense companies could expand into high-technology civilian markets. The roundtables were intended to help businesses make a transition from defense to commercial markets, and provide networking for these firms. CONNECT's experience with these roundtables helped the organization design and implement later programs such as Springboard.

SAN DIEGO SUPERCOMPUTER CENTER

The San Diego Supercomputer Center (SDSC) was founded in 1985 as one of five national Supercomputer Centers funded by the National Science Foundation (NSF). The most recent NSF competition in 1996, funded the SDSC as a member of one of two national consortia. The SDSC's aim is to advance scientific research by developing key enabling computational technologies and supporting technology transfer to industry.

For over ten years, the SDSC was operated by General Atomics under an NSF contract. It was located at UCSD, and the University contributed funding for the building that houses the Center. In 1997, NSF directly contracted with UCSD to operate SDSC. This was part of a move by NSF to contract Supercomputer Center operations directly to universities. The Center now operates as a department of the University, and UCSD subcontracts with General Atomics for specific services.

The SDSC is the result of a $250 million investment by the NSF in state-of-the-art, high-performance computing technology. The Center has the most powerful vector and parallel computers available in the U.S., a 20-terabyte archival storage system, and a recently upgraded scientific visualization laboratory.

The SDSC supports unclassified, nonproprietary research in academia, government, and industry. Its research staff concentrates on scientific applications in biology, chemistry, and environmental

science, as well as enabling technologies such as scalable parallel computing, high-speed networking, archival storage, scientific visualization, and security. The SDSC's major activities are:

- Conducting research in scientific applications and enabling computational

technologies with partners from academia, government, and industry.

- Providing access to high-performance computing and visualization resources.
- Developing tools to integrate computing resources and enhance researchers' productivity.
- Developing undergraduate and K-12 curricula, and conducting educational programs to disseminate knowledge on the use of high-performance computational tools.
- Integrating computational technology into commercial research, design, and manufacturing processes through partnerships with industry.

The SDSC has provided important opportunities to UCSD's faculty and students by giving them access to the most advanced computers in the nation. Students from UCSD can use the laboratories, for a fee, and other students nationally have access to the computers through special work station accounts. The Center also hires university students as interns and employees. In addition, the SDSC gives school teachers two-week training sessions on computers. The Center hosts tours for over 3,000 school children annually to demonstrate high-performance computing and communications resources.

Through the SDSC's Industrial Partners Program, industry can access, for a fee, the computational technologies available at the Supercomputer Center. Those technologies include SDSC's computing systems, information repositories, and visualization resources. The Center provides training and consulting to industries in areas such as computational modeling and visualization. About 15 to 20 industrial customers annually buy time on the Center's computers, and additional firms buy storage space. Few small businesses use the facilities, but the Center's Deputy Director, Jack Donegan, said that the Center is trying to increase small business usage. Promotion of SDSC to small businesses is being encouraged, and financially supported, by the NSF. The SDSC also collaborates with CONNECT to plan conferences, and review and judge technical papers; and its Director and staff serve on CONNECT committees to give the Center additional exposure to industry.

UNIVERSITY "RETURN ON INVESTMENT" FROM COOPERATION WITH INDUSTRIES

> You will not find another high-tech community as closely associated as in San Diego ... And it started with the University.
>
> - The late William Otterson, Director, 1986-99, CONNECT, UCSD

Strong cooperation between UCSD and industries is widely recognized in San Diego as a major force in San Diego's economic development. University-industry cooperation has benefitted the business community and contributed to the region's economy, and also has benefitted the University. According to Dr. Mary Walshok, Dean of UCSD's University Extension, when UCSD's CONNECT program was created it did not shift the focus of the University away from teaching, as was feared, but "added capacity to the University." The contacts and networking that have been fostered by CONNECT increased the number of endowed chairs, brought substantial financial contributions, and enhanced the University's prestige. Several of the region's technology firms, including SAIC and QUALCOMM, have endowed chairs, provided scholarships, and contributed research grants. One of the largest endowments came from Dr. Irwin Jacobs, founder of QUALCOMM, and his wife, who gave UCSD $15 million for a new School of Engineering named in their honor. Their strong relationship with the University was promoted by the former Chancellor Atkinson and later fostered by the CONNECT program.

At first reticent, the faculty at UCSD now has embraced the idea of university-industry cooperation. The faculty have benefitted because of increased opportunities for themselves and their students. Some professors regularly provide consulting to local industries, and students perform internships and are employed by these industries. Corporations have also increased contributions for graduate student scholarships. Moreover, an increasing number of graduates (60 percent) now stay in the San Diego area after graduation because of the increasing opportunities in technology industries.

Industry funding of research at UCSD has increased, and the business community has been mobilized to promote research funding through letter-writing campaigns and lobbying of the State Legislature. According to the late William Otterson, San Diego has the only university-based group in the State that has mobilized their business community to promote university research. Recently, the State Legislature approved over $20 million to be directed to university-industry collaborative efforts through centers-of-excellence in the University of California system. UCSD's efforts have been cited by State Legislators as having contributed to this increased funding.

Although there is no empirical research to support the notion that the University has directly impacted the growth of the high-technology industries in the region, prominent members of the

business community cite the universities, particularly UCSD, for being a major driving force in San Diego's economic growth. In interviews with CEO's of high-technology industries, they cited the presence of UCSD, and the community leadership through the CONNECT program, as primary reasons for developing their businesses in the San Diego area. Moreover, these CEO's stated that UCSD was one of the main reasons that they have stayed in the San Diego region as their businesses have grown. The University has tapped the community spirit of high-technology firms in San Diego, and has fostered a close-knit community among small and large, high-technology firms.

CENTER FOR APPLIED COMPETITIVE TECHNOLOGY

The Center for Applied Competitive Technology (CACT) at San Diego City College (SDCC) is one of 12 applied technology centers in California. The purpose of the centers is to help firms, particularly small firms, upgrade their production techniques and worker skills. CACT focuses on a critical element often overlooked in high-technology development; that is, the training of technicians for high-technology firms. CACT also assists high-technology firms to upgrade their production processes, and operates one of the few incubators in San Diego.

The CACT incubator houses and provides business assistance to 12 to 15 technology firms. The incubator is located on the campus of SDCC and gives firms access to high-speed computer connections, audio-visual conferencing, and light manufacturing space. CACT offers incubator tenants a range of technical assistance and free classes on financing, technology, marketing, and other topics. In addition, several incubator firms have benefitted from the services of SDCC student interns. The incubator, which started in 1995, has successfully graduated five firms, including a video conferencing company and a prototyping firm. The incubator was originally funded by the U.S. Economic Development Administration, as part of a defense-adjustment grant to the City of San Diego. In 1998, there were plans to expand the high-technology incubator, and additional space was being allocated for that purpose.

CACT provides effective support to high-technology businesses by keeping pace with their skill needs. Many of the high-technology start-ups and other corporations in the region that provided products and services for defense, have diversified into other fields such as communications, and biomedical devices and instrumentation. As a result, the corporations' skill-needs changed, and some were unable to fill critical technical positions. To help local industries meet those needs, CACT provides a variety of training courses aimed at helping technicians service and maintain sophisticated equipment used in these new technology firms. Training courses include flexible manufacturing, robotics, bioscience, automated equipment, advanced computer programming, machine tools, metals technology, three-dimensional design software, semiconductor manufacturing, and modern manufacturing. CACT, in conjunction with five other community colleges, also recently developed a "technology masters project." This national program will provide advanced technology training on-line. The program, in part, is being supported by NSF.

CACT is building its demonstration and training capabilities in the biosciences area. In order to identify industry needs in this area, the CACT Director, Joan Stepsis, has worked with BIOCOM's Workforce Development Committee. Through the Committee, CACT interviewed numerous biotechnology companies to determine their projected hiring needs and skill requirements for technicians. To meet the growing biotechnology needs, CACT is developing a "biolab," which will provide training and demonstration on advanced equipment in biosciences. Firms using the laboratory also will have access to a DNA sequencing computer housed at SDCC. In a related project, NSF is providing funding to CACT for "Biolink," which will disseminate CACT's biosciences program through the Internet to other colleges across the country. The U.S. Department of Energy additionally is funding a training program in bio-processing, as well as development of a model training program in small-batch manufacturing. In the bio-sciences area, CACT currently provides technical training on a variety of subjects such as "clean room" technologies, and it is additionally developing curriculum for servicing new types of biosciences equipment in hospitals and industries.

CACT encourages firms to demonstrate new equipment at the Center; and in 1998, 20 firms provided demonstrations and training there. In addition, CACT's staff and a cadre of consultants provide technical assistance to firms on production, quality management, and other important areas to these firms. CACT specialists visit firms, particularly small, technology-firms, and provide recommendations on equipment and processes. Recently, CACT signed a formal agreement with the San Diego Manufacturing Extension Center to provide training in management of manufacturing and production technologies. The National Institute for Standards and Technology also has funded a CACT project to help small part suppliers meet international corporate standards. CACT additionally partners with NASA's Far West Technology Transfer Center, to give firms access to federal laboratory technologies.

As part of regional efforts to diversify industries in the early 1990's, CACT also administered a U.S. Department of Labor program to train engineers who were displaced by the aerospace industry. CACT designed and implemented curricula to retrain the workers and helped them find employment in new high-technology industries in the San Diego region.

CACT is providing an important part of San Diego's technology development. Dr. Stepsis, commented that community colleges have not received the attention of research universities, nor the same level of federal and state support. Each type of educational institution plays an important role, with community colleges filling the technical training and support needs of high-technology firms. As technical labor shortages grow, Centers such as CACT, fill a critical void in the education and training of a high-technology workforce.

VI. THE ROLE OF COMMUNITY-BASED ORGANIZATIONS

INTRODUCTION

Community-based organizations have made a significant contribution to the development of high-technology firms in the San Diego region. The San Diego Regional Economic Development Corporation led development initiatives in the 1980's, encouraging the participation of the universities and the private sector. The San Diego Chapter of the MIT Enterprise Forum, as UCSD-CONNECT, has provided a platform for budding entrepreneurs. The San Diego Association of Governments contributed to technology development by identifying and tracking economic trends, and by initiating major infrastructure improvements. The Regional Technology Alliance, which is a state-sponsored program, has promoted technology industries in the San Diego region. BIOCOM, a local association representing biotechnology, pharmaceutical and medical device industries, has provided an advocacy and networking forum for those industries. The San Diego Manufacturing Extension Center, supported by federal and state funds, has helped small manufacturers upgrade technologies.

In this chapter, we provide details on each of these organizations. A few organizations, not included in this chapter, also have contributed to high-technology development in the San Diego region. The Software and Internet Council provides advocacy and networking for software industries, and the local Chambers of Commerce have contributed to development of technology industries.

MIT ENTERPRISE FORUM

The San Diego chapter of the Massachusetts Institute of Technology (MIT) Enterprise Forum offers advice, support, and education services for local emerging technology-based companies. Programs include professional seminars, startup clinics, case presentations, and business plan workshops. Among the most valuable uses of Forum activities is the opportunity for entrepreneurs to network with a variety of business professionals including: venture capitalists, private investors, industry experts, and other successful entrepreneurs. Each month, the MIT Enterprise Forum draws about 300 entrepreneurs, service professionals, and financiers.

The MIT Enterprise Forum was founded by local business leaders who knew of the program's success in other areas of the country. The initial Chairperson, George Chandler, was the District Director of the U.S. Small Business Administration (SBA). He had learned of the program's value from his work at the National Aeronautics and Space Administration and his participation in the Sloan School of Management at MIT. As the founding Chairperson of San Diego's MIT Enterprise Forum in 1985, Mr. Chandler supported close cooperation with UCSD's CONNECT program, which started a few months after the Forum. The cooperative and collaborative relationship between the two programs included joint sponsorship and marketing of the programs. The partnership formed an important precedent in the region for collaboration between trade and industry organizations.

> San Diego has an advantage over many areas because of the cooperative and collaborative nature of the region. From the beginning, the MIT Enterprise Forum and UCSD's CONNECT program worked together to support the small technology firms in our area.
>
> - George Chandler, District Director, SBA San Diego

MIT Forum panelists and moderators often enjoy international acclaim in high-technology industries, such as telecommunications, semiconductors, biotechnology, and wireless communications. Over the years, Forum sessions have featured such prominent names as QUALCOMM's Chairman & CEO Irwin Jacobs in 1985, and Wireless Knowledge President & CEO John Major in 1999. Prominent presenter firms who have reaped extraordinary benefits from their San Diego Forum experience include Peregrin Semiconductor, Inc., Bien Logic, Inc., Mail Boxes, Etc., Extar, Neural Semiconductors, Energy America, REMEC, and Stratagene.

A number of presenter firms credit the Forum for attracting millions of venture capital dollars to their companies, and facilitating contacts that have led to major license and company purchases. For example, the founder of Doctor Design credits the Forum for introducing him to capital resources that resulted in a merger which ultimately contributed to his company's $40 million success. Forum panelist Lee Stein credits the Forum with making it possible for his company to grow to over $300 million. And Simplenet CEO and President Bob Bingham attributes much of the success of his company to Forum guidance and experience. Two months after the Simplenet CEO was a presenter at the Forum, his firm was acquired by Yahoo.

CITY OF SAN DIEGO SMALL BUSINESS ADVISORY BOARD

The Small Business Advisory Board (SBAB) was established by the City of San Diego in July 1982 to encourage a cooperative and supportive atmosphere between the business community and the City. The Board advises the Mayor, City Council, and City Manager on matters that enhance the capability of small businesses in San Diego to prosper. Those matters often involve the formulation of laws, policies, and procedures that affect the management, operation or financial stability of small businesses. The District Director of the U.S. Small Business Administration (SBA), George Chandler, assisted in development of the City ordnance that created the SBAB, and in 1999 he was serving as the SBAB's Chairperson.

The nine-member Board is appointed by the Mayor and confirmed by the City Council. It is composed of the SBA District Director, a representative of the Greater San Diego Chamber of Commerce, a representative of the United Federation of Small Businesses, and small business owners. The City's Office of Small Business provides staff support to the Board and carries out

projects initiated by the Board.

The SBAB was established by the City at a time when not much importance had been placed on small business problems and opportunities. By supporting creation of the SBAB, the City made a strong statement about the importance of San Diego's 55,000 small businesses to the region's economic development. The City's creation of the SBAB has prompted other cities to establish similar initiatives.

The SBAB has undertaken numerous activities to promote small business interests in the region's development. The Board was instrumental in reducing and streamlining fees and taxes. Partly as a result of their efforts, the City's business license tax was reduced from $135 to $34 for businesses with 12 or fewer employees. In addition, SBAB representatives testified before the California State Legislature's Revenue and Taxation Committee in support of reducing, by 25 percent, the Minimum Franchise Tax (MTF) for corporations with gross receipts of one million dollars or less.

The Board helped the City leverage $1.2 million in matching grants needed to establish the Bankers Small Business Finance Corporation Community Development Corporation (CDC). The CDC is a consortium of more than 30 San Diego lenders that provide micro-loans to women- and minority-owned enterprises. The Board also supported establishment of the Equal Opportunity Contract Program to assist women- and minority-owned enterprises in securing City contracts.

The SBAB helped develop the Small Business Enhancement Program, which earmarked one million dollars for small business development activities. The Board supported matching Seed Capital Grants of $130,880 for chambers of commerce and non-profit organizations to provide small business assistance, and helped identify and conduct outreach to potential program recipients.

The SBAB worked with the business community to form 18 Business Improvement Districts (BIDs). San Diego BIDs represent about 20,000 small businesses that work together to revitalize the City's neighborhoods. As part of the effort, the Board has coordinated neighborhood "clean-ups" to make neighborhoods more attractive for business investment.

The SBAB has been active in making zoning regulations, and other regulations and ordinances more small business "friendly." For example, the Board worked with the Fire Department to relax rigorous fire codes affecting owners of hotels, motels, and apartment buildings built before 1975. These code relaxations were important in preserving available and affordable housing, which was in short supply in San Diego. The Board was instrumental in changing sign code ordinances to promote sign usage by small businesses and improve the environmental impact of business signs. The SBAB worked with the community and the City government to develop regulations enabling the expansion of sidewalk cafes in San Diego. The Board also worked with the City and Police Department to improve regulations and reporting requirements in support of street vendors, and to encourage cabaret businesses. The SBAB coordinated a City and County Joint Committee on Hazardous Materials Management, which reduced administrative duplication and simplified inspection requirements governing hazardous materials. Lastly, the Board developed and helped the City publish and disseminate the "Small Business Resource Directory" for San Diego, a

comprehensive directory of small business resources.

SAN DIEGO REGIONAL ECONOMIC DEVELOPMENT CORPORATION

The San Diego Regional Economic Development Corporation (EDC), founded in 1965, played a leading role in the development of small, high-technology businesses in San Diego. Since 1993, the EDC has been funded by TEAM SAN DIEGO, a coalition of 229 private sector investors, the City of San Diego, the County of San Diego, the San Diego Unified Port District, and several of the region's incorporated cities. Julie Meier Wright assumed the post of President and Executive Director in August 1997, having previously served as the California Secretary of Trade and Commerce. Ms. Wright replaced Daniel Pegg, who had held the position for 14 years.

During the 1980's, the EDC's efforts focused on attraction of industries and major research centers, such as the Microelectronics and Computer Consortium. Although unsuccessful in winning the major research centers, the EDC's efforts brought together public, private, and academic sectors to bid for these centers. This effort helped bridge the gap between these three sectors.

As part of an effort to promote high-technology industries, the EDC led the way in establishing UCSD's CONNECT program. Daniel Pegg, EDC Board members, former UCSD Chancellor Richard Atkinson, and other community leaders formed the organization to coordinate public and private sectors, and enable entrepreneurs to take advantage of UCSD's research. The EDC was supportive of other associations, such as BIOCOM and the Software Industry Council (now the Software and Internet Council), that promoted growth in specific technology clusters.

In the wake of defense cuts in the early 1990's, companies were leaving San Diego and the unemployment rate climbed to seven percent. In response to the downturn, the EDC in conjunction with local government and private industry, launched a five-year strategic plan. The plan called for creating 15,000 direct jobs in manufacturing and high-technology industries, and creating 25,000 indirect additional jobs in service industries. In order to create these jobs, the plan outlined three major strategies: (1) promoting the growth of maquiladora industries, (2) increasing trade opportunities with the Pacific Rim, and (3) promoting the formation of high-technology industries.

Through the EDC's efforts, a number of electronic and electrical machinery industries established maquiladora plants across the border in Mexico. The success of these factories helped fuel San Diego's economic rebound. To fulfill its international trade objectives, the EDC helped local companies export products by sponsoring trade missions, publishing trade directories, and conducting international marketing campaigns. One activity, the Mexport Buyer & Seller Trade Show, has successfully showcased trade opportunities to Mexico for over ten years. The EDC has identified and marketed to foreign companies potentially interested in operating in the San Diego region, and recently has opened a trade office in Hong Kong.

The EDC also provided free confidential business assistance to help new companies locate in San Diego and help existing companies stay in San Diego. Among the services offered to firms were site assistance, help with permit processing, technology assistance and import/export assistance.

The EDC and TEAM SAN DIEGO leadership advocated public policy changes to support and nurture a competitive business environment. They organized trips to Washington, D.C. and Sacramento to promote policies which supported San Diego's economy. The EDC garnered significant legislative support to create a fund within California's Infrastructure Bank to help high-technology companies obtain debt financing for costly equipment and facilities. The EDC played a major role in securing state funding for freeway construction to help alleviate commuter congestion. The EDC also worked with the City government to implement infrastructure policies that favored a pro-business environment.

One of the most effective services that the EDC instituted, along with other community organizations and the City, was a free, one-stop shop for companies. This center coordinated services in ten areas: (1) site assistance, (2) utility assistance, (3) permit processing, (4) financing, (5) labor/hiring, (6) training, (7) technology assistance, (8) import/export, (9) business alliances, and (10) business incentives. The EDC partners with the other community organizations to provide these services.

Other EDC efforts have focused on enhancing the region's image through marketing and advertising campaigns. Recently, the EDC has produced advertising supplements for several national business magazines. The EDC also has held conferences to promote San Diego and San Diego companies, and has conducted recruiting efforts, often in concert with UCSD-CONNECT.

Another major effort has aimed at encouraging K-12 students to pursue careers in science and engineering. Spearheaded by the EDC, this special collaboration has involved industries, universities, and the San Diego Unified School District. Activities have included tours of R&D facilities, training, and lectures from corporate leaders and university representatives.

By1998, the EDC had reached its first five-year goal of creating 40,000 jobs. That year, the EDC's Board of Directors approved a second five-year plan covering 1999 to 2003. In this plan, the EDC focused on developing and supporting high-technology, high-wage industry clusters. The new plan stressed:

- Supporting the expansion of technology-driven companies and solidifying San Diego's image as a high-technology center.
- Promoting San Diego as a global hub between Asia and Latin America.
- Spearheading regional collaboration.

In 1999, the EDC planned to concentrate its efforts on the high-growth industry clusters of biotechnology, telecommunications, defense and space, and software.

SAN DIEGO ASSOCIATION OF GOVERNMENTS

The San Diego Association of Governments (SANDAG) is a forum for regional decision making for 18 cities and San Diego County government.[5] Its mission is to build consensus, develop strategic plans, obtain and allocate resources, and provide information on a broad range of topics pertinent to the San Diego region's quality of life. SANDAG is legally a joint powers agency established under State of California law by a formal agreement signed by each of the local government members. Over its 40-year history, SANDAG has played an important role in the region's economic development.

SANDAG is governed by a Board of Directors, which is composed of two elected officials from each of the 18 city members, and the San Diego County government. Also on the Board as advisors are representatives from Caltrans, the San Diego Port District, the San Diego Water Authority, and Tijuana/Baja California. The U.S. Department of Defense also serves on the Board as a liaison member. The Board holds open meetings every month on significant regional issues such as growth, transportation, environmental management, housing, open space, air quality, energy, fiscal management, economic development, and criminal justice. The Board is supported by a professional staff of planners, engineers, and research specialists.

In May of each year, the Board adopts an "Overall Work Program." Many of the priorities set forth in the 1998 work program involved strategies to strengthen small, high-technology businesses. Some of the 1998 activities were:

- Regional economic planning and research, which involved evaluation, monitoring, and development of reports on issues affecting the fiscal stability and economic prosperity of the region.
- Regional growth and environmental management planning.
- Regional transportation planning, development, and administration.
- Intergovernmental relations and program management.

SANDAG has played an important role in keeping watch on the economic "big picture." Its research and analysis have laid the groundwork for regional development strategies. SANDAG collects, analyzes, and publishes critical economic information on the San Diego region. It recently published an economic strategy on the region and has published various analyses of the region's high-technology clusters. In addition, SANDAG's nonprofit corporation, SourcePoint, offers specialized information and data services to private sector businesses, individuals, and organizations. SourcePoint provides regional data on demographics, economics, transportation, land use, public facilities, and communications. SourcePoint's staff can tailor information for use in business plans,

[5]The member agencies are the Cities of Carlsbad, Chula Vista, Coronado, Del Mar, El Cajon, Encinitas, Escondido, Imperial Beach, La Mesa, Lemon Grove, National City, Oceanside, Poway, San Diego, San Marcos, Santee, Solana Beach, Vista, and the County of San Diego.

marketing and feasibility studies, site analysis, and public presentations.

> Information, information, information has been the most important, the most appreciated, and the most used product delivered by SANDAG. With its regional perspective, SANDAG has provided a vital foundation for all.
>
> - Kenneth E. Sulzer, Executive Director, SANDAG

From its earliest days, SANDAG has been involved in regional transportation planning. In 1992, SANDAG adopted a $24.6 billion Regional Transportation Plan, that encompasses transportation programs, projects and services in the region through the year 2020. In 1998, it adopted a $3.65 billion, six-year Regional Transportation Improvement Program encompassing highway, transit, street and bicycle projects. In addition, the organization operates several programs related to travel including the I-15 FasTrak to improve traffic flow, and expand bus and ride sharing services.

SAN DIEGO REGIONAL TECHNOLOGY ALLIANCE

The San Diego Regional Technology Alliance (SDRTA) is a nonprofit corporation that assists San Diego's high-technology industries. Its mission is to "empower businesses and entrepreneurs in developing emerging, competitive technologies" using San Diego's resources. It coordinates other regional resources and services to help support technology firms. The SDRTA is one of several Regional Technology Alliances established by the State Legislature to foster and support technology-based economic development. The Alliances were created in the wake of cutbacks in the defense industry to help reverse economic downturns.

In 1994, the City of San Diego was awarded $5.8 million from the U.S. Economic Development Administration (EDA) for defense conversion. These initiatives included (1) creating a technology incubator at San Diego City College, now the Center for Advanced Competitive Technologies, (2) an entrepreneurship program through UCSD-CONNECT, (3) a dislocated worker training program at San Diego State University, and (4) creation of a high-technology resource center.

As the local link with defense conversion activities, SDRTA recommends administrative actions and

programs that can assist San Diego's defense-dependent industries to successfully convert to commercial markets. It helps identify businesses that can benefit from defense conversion programs and locate defense industry workers who can benefit from employment and training opportunities. The SDRTA coordinates and identifies job opportunities within, and outside of, the defense industry for which displaced workers can be trained and placed. It assists individual businesses and industry consortia in applying for state and federal defense conversion funds.

In 1998, the SDRTA had three goals: (1) to provide technology, business, and financial assistance to technology-based entrepreneurs and small businesses; (2) to offer technology-based services to the greater San Diego community, and (3) to conduct analytical studies on technology sectors in the San Diego region. The SDRTA's Executive Director reported that the organization had reached over 1,000 clients in 1998 through its activities including workshops, conferences, and information services.

"Project Mercury" is one of the SDRTA's major activities. It is designed to help entrepreneurs and companies by providing business and financing assistance, including referrals and introductions to public and private financial institutions. The Project staff assist businesses seeking financing and assist prospective investors screen applicants. The Project Mercury's web site lists local services available to businesses and profiles businesses seeking financing.

The SDRTA also helps businesses access federal research and development programs, especially the Small Business Innovative Research (SBIR) and Small Business Technology Transfer (SBTT) programs. SDRTA locally manages the California Technology Investment Partnership Program (CalTIP). CalTIP is a state-funded program designed to promote technology transfer of federal research and development. SDRTA awards CalTIP grants through a competitive, merit-based selection process, monitors performance of CalTIP grantees, and puts grantees in contact with sources of technical assistance.

SDRTA's Techtropolis 2010 program provides information and activities in support of technologies important to the San Diego region. Techtropolis 2010 encompasses four community-based projects:

1.) Community Centers: the SDRTA gives support to community-based organizations that provide public access to computers.

2.) Tech-Museum: the SDRTA is working with the City and other organizations to develop a museum that will showcase technologies developed in the San Diego region.

3.) Teaching Technology: the SDRTA provides speakers who discuss technology-based topics at local schools. The project is designed to encourage science and technology careers.

4.) Technology Tours: the SDRTA sponsors school and community visits to local

technology centers.

In conjunction with SANDAG, SDRTA has funded a regional economic development information system to improve the region's collection and analysis of industry cluster data. The SDRTA and SANDAG also jointly conduct analytical studies on technology-related issues. In addition to a close working relationship with SANDAG, SDRTA has formed strong relationships with other San Diego groups that work with high-technology companies. This includes UCSD-CONNECT, SDSU's Entrepreneurial Management Center, and the Center for Applied Competitive Technology.

BIOCOM

BIOCOM is a membership association for the biotechnology, medical device, medical equipment, and bio-agriculture industries in the San Diego region. BIOCOM's 240 members include R&D companies, manufacturers, service providers, universities and colleges, research institutions, municipalities, and state and local organizations. Two-thirds of its members are from biotechnology industries, and one-third from biodevice industries. BIOCOM, in recent years, has made an effort to expand its membership in the biodevices area.

> Coalitions present a paradigm for San Diego's economic future. By working together on issues of mutual concern, we can accomplish far more than we can as individual organizations.
>
> - Ann Randolph, Executive Director, 1995-99, BIOCOM

In 1991, San Diego architect James McGraw, and UCSD-CONNECT's former Director William Otterson, organized a group of service providers to the biotechnology industry into a trade association called BIOCOM. At the same time, a group of CEO's from bioscience firms banned together to form the Biomedical Industry Council (BIC). These two groups worked closely together to address city, state and federal issues relating to the life sciences industry. BIC subsequently merged with BIOCOM.

As an advocacy group, BIOCOM collects and provides information about the needs, concerns, and potential of biocommerce in San Diego. BIOCOM works with other regional, state, and national organizations with similar agendas to advance the public policy concerns of its members. On the federal level, BIOCOM has advocated for (1) Food and Drug Administration reform, (2) pro-industry patent legislation, and (3) the transfer of land at Ward Valley, from the federal government to the State of California, for use as a low-level, radioactive waste storage site.

> (Commercializing) a biotechnology takes 10 to 12 years, and costs over $300 million to get a product on the market. It is an industry with special needs — the cost of living, traffic patterns, modes and ease of transportation — all affect the industry. Therefore, BIOCOM is involved in all county efforts, from airport master planning, to regional prosperity, to land use, to education.
>
> - Ann Randolph, Executive Director, 1995-99, BIOCOM

On the state level, BIOCOM has lobbied for tax and economic incentives that support the growth of the biomedical industry in California. BIOCOM members chaired the San Diego Taxpayers Against Frivolous Lawsuits coalition and raised more than $500,000 from San Diego industries to help defeat a state initiative (Proposition 211) allowing unrestricted law suits against industry. BIOCOM also works closely with the California Health Care Institute and other state groups on specific issues, as they arise.

In October 1992, BIOCOM sponsored "CalBioSummit," the first statewide conference for biotechnology and related industries. BIOCOM continues to host an annual statewide CalBioSummit, which now serves as a forum for biocommerce legislative and business issues. CalBioSummit raised the profile of BIOCOM and facilitated BIOCOM's relationship with former Governor Wilson's office and the Secretary of Trade and Commerce. As a result of these activities, seven CEO's from San Diego were appointed to a biotechnology council established by the former Governor.

BIOCOM also has had a strong interest in local government. The organization took the lead in forming a coalition of community leaders to secure land for the expansion of the airport. BIOCOM members testified before the City Council and, due in part to BIOCOM's efforts, the City Council voted to provide more land for the airport.

In addition to its advocacy activities, BIOCOM offers an array of membership services. It holds monthly breakfast meetings that feature speakers on topics pertinent to the biotechnology industry. These meetings are open to the public and offer networking opportunities. BIOCOM also holds half-day seminars on topics such as market development, design of clinical trials, contract development, purchasing, and project management. Sometimes, BIOCOM partners with local universities to develop courses of interest to the biotechnology community.

BIOCOM is active in education efforts. BIOCOM has provided industry-wide, community-wide, and state-wide education programs to raise skills in the work force and create public awareness about the biotechnology industry. BIOCOM helped develop a curriculum for grades K-12, which has been adopted in the local schools. In addition, BIOCOM has identified basic skill sets for students and

others who seek biotechnology jobs. BIOCOM representatives have made presentations to parents and students about the importance of skills in math, science, computers, communications, and other skill areas needed for jobs in biotechnology.

In 1998, BIOCOM launched an internship program, placing 50 students from high schools and community colleges in member companies. BIOCOM is expecting to expand this program in 1999. BIOCOM also brings middle school children into member companies to learn about the industry.

BIOCOM maintains close ties to local universities. UCSD and BIOCOM have jointly developed executive training courses, and seminars in biotechnology and biocommerce. BIOCOM members are also active on UCSD's Science and Technology Council, and BIOCOM maintains a strong relationship with UCSD's CONNECT program. BIOCOM's former Executive Director, Ann Randolph, said that the organization's relationship with UCSD is important since many of the biotechnology firms in San Diego have some affiliation with the University. She said that technology transfer from the University has been critical to the development of the industry in San Diego. BIOCOM also has worked with the San Diego City College to develop a manufacturing training program in biotechnology at the College's Center for Applied Competitive Technologies. BIOCOM additionally maintains close working relationships with the EDC, SANDAG, and SDRTA.

SAN DIEGO MANUFACTURING EXTENSION CENTER

The San Diego Manufacturing Extension Center (SanMEC) is a private, nonprofit organization established to provide technical and business consulting services to small- and medium-sized manufacturing firms. Its goal is "to increase the productivity, profitability, and global competitiveness of San Diego manufacturers."

SanMEC began as a spin-off and later, a successor to San Diego's High-Technology Resource Center. SanMEC formally began in March 1996 under a cooperative agreement from the National Institute for Standards and Technology (NIST), and is part of NIST's Manufacturing Extension Partnership (MEP) program. SanMEC's budget comes from NIST, state "matching" funds, and about one-third from fees for service. SanMEC is governed by an independent, voluntary Board of Directors from business, industry, government, and academia.

Most of the firms that SanMEC serves are in telecommunications, electronics, biotechnology/health care, and software. SanMEC offers firms technical support in four areas: (1) manufacturing modernization, (2) business planning, (3) finance and capital acquisition, and (4) workforce development. It provides services in new product development, marketing and distribution planning, and development. Manufacturing assistance that SanMEC has provided to firms include productivity improvements, technology upgrades, materials management, cellular manufacturing, standard costing, automation, plant layout, and process improvement. One example of SanMEC's efforts has been its work in assisting companies to adopt ISO, the international quality-control standard for manufacturing. SanMEC organized a users' group for ISO 9000 that facilitated discussion among

representatives from small manufacturing companies about compliance with international standards and specification requirements of large manufacturers.

SanMEC uses business specialists to provide small manufacturers with engineering and other assistance tailored to meet the needs of individual clients. The business specialists have proven track records and hands-on manufacturing experience. In addition, SANMEC refers businesses to private consultants through its extensive network.

Through its affiliation with MEP, SanMEC also gives clients access to manufacturing solutions and technologies from federal laboratories and other MEP programs. Prominent among its local partners are the Center for Applied Competitive Technologies, UCSD-CONNECT, Small Business Development Centers, and the Southwest Technology Transfer Center.

In its first two years of operation, SanMEC has helped 126 companies, more than two-thirds of which employed 10 or fewer employees.

VII. PUBLIC POLICY INITIATIVES TO SUPPORT SMALL, HIGH-TECHNOLOGY BUSINESSES

INTRODUCTION

Public policy changes and investments in infrastructure contributed to a more business-friendly environment in San Diego. In this chapter, we describe how local government policies contributed to the growth of small technology businesses. We also discuss the infrastructure challenges that San Diego has faced and, in some cases, continues to face as it approaches the next decade.

LOCAL GOVERNMENT POLICIES

> In order to grow and attract the kind of high-tech industries we wanted, we had to make dramatic improvements in San Diego's local business climate.
>
> - Mayor Susan Golding

In the 1980's, San Diego experienced a population boom that added pressure on an already burdened infrastructure, particularly on land, housing, and water resources. At the time, the community's prevailing attitude was that too much economic growth would hurt the environment. As a result, San Diego and surrounding local governments pursued limited growth policies.

In an attempt to control growth, the City government imposed complex and burdensome regulations on firms. San Diego became known, nationally, for its anti-business attitudes. The economic recession that began in the 1990's provided a wake-up call that prompted the City to change its attitude toward business.

In 1992, the City government created an Economic Development Task Force, composed of community and business leaders, to provide advice on the worsening recession. The Task Force concluded that many local high-technology businesses in San Diego were on the verge of commercializing new products, but that long delays and paperwork needed to obtain permits were hindering development and causing some firms to go elsewhere. Moreover, the Task Force said that aggressive attraction efforts of other cities and states were causing high-technology firms to locate in other areas. The Task Force also found that many regulations were out-of-date, irrelevant, or in conflict with other regulations. Businesses and individual citizens were encouraged to identify and report to the City government outdated laws, regulations, and policies.

The Task Force issued recommendations targeted at improving the business climate of San Diego. A major recommendation, which was carried out, was to appoint an ombuds person to help high-technology businesses traverse the City's permitting process. According to the Mayor's office, from 1991 to 1996, the ombuds person helped retain over 300 businesses in San Diego.

The Task Force's recommendations were supported and many were implemented by incoming Mayor Susan Golding, who was elected in 1992. In an interview with Mayor Golding, she said that prior to her election, the City had become disinterested in, and sometimes hostile to the business community. In an attempt to reverse this anti-business attitude, Mayor Golding and the City Council reached out to the business community, eliminated burdensome regulations, and streamlined bureaucratic processes.

The ombuds person, with help from the San Diego Regional Economic Development Corporation (EDC), organized a one-stop-shop permit processing center, which helped cut permit processing time in half. The EDC also established a One-Stop Early Assistance Program to advise companies on permits covering 12 local, county, and state government agencies.

Businesses also were required to pay high utility usage fees. The highest fees were levied on water and sewer usage. In 1994, the City Council reduced water and sewer capacity charges by 55 percent for major development projects, (e.g. those projects that created 200 or more quality jobs, provided new or expanded research facilities, or generated annual sales or other tax income to the City of at least one million dollars). These reductions paved the way for major expansions of manufacturing facilities, such as those of Sony and QUALCOMM, and numerous biotechnology research firms. Recognizing that the reductions had made a significant impact, the City Council reduced the fees for all development projects and further reduced the fees for major development projects.

According to the Mayor's office, San Diego in 1998 had the lowest local business tax of any big city in the United States. Under Mayor Golding's leadership, the City Council reduced business taxes by 80 percent. In 1998, a business with 12 employees or less paid a flat rate of only $34 per year. "Housing impact fees," assessed on local businesses also were cut in half. These fees, enacted prior to Mayor Golding's administration, were designed to subsidize low-income housing programs based on an assumption that high-paying industries would increase the price of housing. Additionally, this fee is now waived entirely in San Diego enterprise zones. The personal property tax rebate also allows the City to rebate up to 17 basis points to San Diego businesses on the assessed valuation of personal property.

The Business Cooperation Program, enacted by the City Council in 1996, enables businesses and non-profit corporations to receive a cash rebate or business tax/development fee tax credit for reporting and filing their business to business sales taxes to the State using a method that allows the City of San Diego to claim its share of locally generated revenues. The Business Cooperation Program, in 1999, was used in a package of incentives to attract Novartis, the Swiss pharmaceutical giant, which is making a major investment in San Diego.

The City established two enterprise zones to attract businesses, one in Southeast San Diego, an older urban area with a low average income, and one in an area near the Mexican border. The City offered businesses located in the zones sales and usage tax credits on certain machinery purchased for use in the zones, employee wage tax credits, business expense deductions, and carryover from net operating losses.

A Foreign Trade Zone also opened in San Diego. Companies located in the zone could eliminate, defer or reduce U.S. customs duties. Companies eligible to locate in the zone were those that manufactured, assembled, packaged, tested, labeled, or re-exported merchandise composed of imported material. Two Recycling Market Development Zones also were opened. These zones provided recycled product manufacturers special incentives.

STATE GOVERNMENT POLICIES

During the 1990's, the State of California enacted legislation that provided development incentives to businesses, particularly high-technology businesses. These incentives helped San Diego's high-technology development along with other regions in the State. They included:

1.) An R&D tax credit for corporations, covering a portion of in-house research, and covering a greater portion for research contracted to universities.
2.) An investment tax credit of six percent for companies purchasing qualified manufacturing equipment. This credit can be carried forward and used for five years.
3.) A reimbursement from the State's Employment Training Panel to cover the cost of training workers. The State reimburses companies on average between $1,000 and $3,000 per employee, depending upon the number of hours and type of training.
4.) The issuance of Industrial Development Bonds (IDBs) that could be used by corporations to finance the cost of land, buildings, equipment, and tenant improvements for a facility that is predominantly used for manufacturing.
5.) A rebate to businesses of the city's and county's portion of the personal property tax levied on machinery. The legislation authorizing the rebate allows a city or county to require that a certain number of jobs be created, or investments be made, in order to qualify for the rebate.

NATURAL RESOURCE AND INFRASTRUCTURE ISSUES

San Diego has faced, and continues to face, some natural resource and infrastructure challenges that have affected business expansion. Limited water, restricted land, environmental and related growth issues, have tended to restrict the region's business expansion. Ironically, at the same time that limited natural resources have inhibited business growth, the beauty of the San Diego area has also

attracted and retained many of San Diego's businesses. We discuss some major issues — water,

environment, communications, transportation, housing, and land use — that affect the area's economy.

Water

Water is essential to San Diego's economic survival. Annually, 80 to 95 percent of the region's water supply is imported, mainly from the Colorado River. Because San Diego relies so heavily on imported water, local policies and efforts to insure a secure water supply are critical to long-term business expansion.

The San Diego City Council and the San Diego County Water Authority adopted a Water Resources Plan in an attempt to diversify the region's sources of water. The most important element of the plan was an agreement to purchase water from the growers in the Imperial Valley beginning in 1999. The San Diego County Water Authority expects that water from this source will represent 25 percent of the region's total water supply by 2015. To ensure cleaner water, the County Water Authority is holding meetings with Mexico through the Tijuana/San Diego Border Water Council.

The Guaranteed Water for Industry Program, enacted in 1998, was designed to assist water-reliant biotechnology companies. The program allows R&D and manufacturing firms to be exempted from mandatory water reduction measures imposed in times of drought. To qualify for the program, firms must use reclaimed water to the extent feasible, and implement "best management practices" for water conservation of potable water.

Environmental Issues

Hazardous waste is a serious problem in the San Diego region. It is especially critical because some of the region's high-technology and healthcare businesses generate low-level radioactive waste. Currently, there is no central disposal site for low-level radiation waste in the region. Firms store low-radiation waste on site. By 1998, there had been hundreds of state-permitted "temporary" low-radiation waste storage sites across the region. The issue of radiation storage has become a hotly contested battle between environmentalists and pro-business developers in the San Diego region.

SANDAG proposed two solutions to the radiation storage and disposal problem. The first proposal was to create a centralized and secure state-of-the-art waste storage facility. The second proposal was to transfer control of Ward Valley, a federally protected area near San Diego, from the U.S. Department of Interior to the State of California, in order to use the land as a disposal site. Recently, the State has decided that Ward Valley will not be used as a disposal site and it will seek alternative solutions.

Additional environmental issues have arisen in the San Diego area because of its location on the Mexican border, and because environmental standards in Mexico are not as strict as those in the United States. One major environmental problem is caused by the pollution in Mexico's New River, which flows into the San Diego region. Maquiladoras in Mexico illegally dump lead and other toxic substances into this river, making the New River one of the dirtiest rivers in the world. Air pollution

from dangerous pesticides and crop burning in Mexico also travels across the border and results in poorer air quality in San Diego.

In response to these cross-border environmental issues, the Consuls General of the United States and Mexico have established the San Diego Tijuana/Tecate Border Liaison Mechanism (BLM) to help resolve border-related issues, including environmental problems. In addition, the Border Environmental Cooperation Commission, a binational institution developed as a result of NAFTA, is planning environmental infrastructure projects.

Communications

Fiber optics infrastructure is key to supporting San Diego's burgeoning high-technology industries. Under the management of Pacific Bell, the San Diego region's fiber optic infrastructure encompasses more than 184,000 miles. Regional fiber optic infrastructure is capable of handling more than 8.5 million calls per hour. In addition, 70 digital switching stations are positioned strategically throughout the region to maintain two million access lines.

Transportation

The Airport. **—** San Diego's Lindbergh Field is located near the central city and currently handles 14 million passengers per year. In 1997, the airport completed a $237 million expansion that included enlarged storage facilities, and a new commuter terminal able to service 25,000 passengers per day. In 1999, a major expansion of the West Terminal also was completed.

The airport's weakness is its strength. The airport is located in the downtown area, and the convenience of a downtown airport adds to the City's desirability. But because of the airport's location, its hours of operation are limited, its ground access is inadequate, and its runways are too short to accommodate major international air traffic. Large fully loaded intercontinental aircraft cannot be accommodated at Lindbergh Field. Businesses that rely on this form of transportation must export their goods from Los Angeles. Moreover, the airport's future capacity is inadequate to meet projected demand for service. This issue had been discussed for over a decade, with plans and recommendations from regional development groups still under consideration. One plan, the development of a state-of-the-art air cargo airport facility at Brown Field, South of San Diego near the Mexican border, was in an environmental evaluation stage in late 1999.

The Water Port. **—** The San Diego Unified Port District, which operates the Port of San Diego, recently spent $17 million on seawall projects and dredging to expand the maximum cargo capacity by 35 percent. The Port also has a new cold storage facility, the only such dockside facility on the West Coast. There also are plans to construct a bulk storage silo, which will provide better dockside storage capacity and loading and unloading capabilities. But despite these improvements, the Port is still smaller than the nearby, larger Ports of Long Beach and Los Angeles. As a result, the Port Authority concentrates on a niche market — importing vehicles from Asia — which now provides the largest revenue source to the Port's maritime operations.

Railways. **—** Rail service is a weak link in the San Diego region's transportation infrastructure. Rail freight service for the San Diego region is now provided by a single railroad, the Burlington Northern & Santa Fe Railroad, with service via Los Angeles. SANDAG has suggested that the Desert Line of the San Diego & Arizona Eastern Railway restore freight service between San Diego and Imperial County, and link with the Southern Pacific Railroad, providing a greater access to markets. SANDAG estimates the cost for repairing and improving the Desert Line to be $124 million, including costs to enable the railroad to share the new Port of San Diego facilities with the Burlington Northern & Santa Fe Railroad. The existence of an improved freight service would provide valuable access for the region.

Roads. **—** San Diego has an extensive, uncongested network of freeways and roads. Freeways easily connect towns and neighborhoods from the Mexican border to Los Angeles. According to the EDC, the average drive commute time in the San Diego region is 24 minutes. This commute time is the fifth best among the 20 largest metropolitan areas in the nation.

Housing and Land Use. **—** San Diego's housing costs are among the highest in the country, but lower than housing costs in Silicon Valley or the Los Angeles area. From 1990 to 1995, housing prices declined, dropping below the national average; but by the first quarter of 1999, the average price of a house in San Diego had risen to $203,000 well above the national average. The demand for housing increased rapidly in the 1990's and prices correspondingly rose as demand exceeded supply. The Chamber of Commerce reported that, in 1998, more than 200 new subdivisions were being developed throughout the county to help alleviate some of the demand for housing. However, the rise in housing prices is expected to continue.

VIII. CROSS-BORDER COOPERATION

> Three years ago we found Mexicans were spending almost $3 billion dollars a year in San Diego. That's more than the Convention Center brings in plus the Superbowl!
>
> - Charles Nathanson, Executive Director, San Diego Dialogue

A DRIVING FORCE IN SAN DIEGO'S ECONOMY[6]

San Diego's economic and cultural ties to Mexico/Baja California are important to an understanding of the area's high-technology growth and economic prosperity. The City of Tijuana, Mexico is located only 14 miles from San Diego, and because of the close proximity, the economies of the two regions have become so closely aligned that the region is sometimes referred to as the "San Diego/ Tijuana Corridor."

Until recently, economic developers placed little emphasis on San Diego's close proximity to Mexico. Different statistical methodologies, languages and forms of government made it difficult for planners to fully assess Mexico's impact on San Diego's economy. But as the regions have become increasingly inter-dependent, economists and planners are recognizing the importance of economic linkages between the two geographic areas.

The economies of the San Diego region and Tijuana/Baja have become increasingly inter-dependent. Mexico is the home of many maquiladoras, creating jobs on both sides of the border. Moreover, trade between Tijuana and San Diego is steadily increasing. San Diego is a shopping mecca for Tijuana residents who contribute about $3 billion in sales to the San Diego economy. Mexico also imports over $4 billion in products annually from San Diego, making it San Diego's largest export market.

The region also is becoming increasingly bi-cultural. Residents from both the United States and Mexico regularly cross the border to shop, visit friends, and vacation. Many San Diego residents

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[6]Data that appear in this section were supplied by San Diego Dialogue, University of California, San Diego. Primary data sources are: San Diego Dialogue, California Employment Development Department, U.S. Census Bureau, U.S. Bureau of Labor Statistics, U.S. Immigration and Naturalization Service, U.S. Department of Transportation, (Mexico) *Instituto Nacional de Estadistica, Geografia y Informatica*, (Mexico) *Instituto Mexicano del Seguro Social*, and *Banco de Mexico*.

are bilingual as a result of their Latin heritage. These factors have helped integrate the two cultures and improve the harmony of the region.

Manufacturing Jobs and Maquiladoras

During the 1960's, the Mexican government devised an industrial development plan, called the maquiladora program, to maximize manufacturing capabilities in Mexico and offset high unemployment. The system allows for manufacturing inputs, such as raw materials and parts, to be imported and retained, free from import duties, for up to one year. These inputs are then manufactured or assembled into final products by Mexican factories. The final products are exported by the Mexican factories with duties being applied only on the value-added by labor and manufacturing. This form of manufacturing and assembly allows foreign businesses to avoid Mexico's historically protectionist duties and take advantage of the lower wage rates of Mexican workers. This system has created an important economic synergy between the San Diego and Tijuana regions. San Diego's high-technology firms provide the technological inputs and Tijuana firms manufacture the products. The result is that San Diego and Tijuana firms both benefit.

In 1995, the Tijuana region was home to about 500 maquiladora operations. By early 1997, the number had almost doubled. By the end of 1998, the Tijuana region was home to almost 1,000 maquiladoras employing 201,000 workers. In the Tijuana region, 41 percent of all maquiladoras were involved in electronics or textile manufacturing. The region now has become the largest manufacturing center of television sets in the world. In fact, manufacturing employment in Tijuana now surpasses manufacturing employment in San Diego.

Between 1991 and 1996, Tijuana's private sector employment grew 32 percent, with employment in the maquiladora plants accounting for 40 percent of the total formal sector employment, and 70 percent of the job growth. In 1998, 81 percent of the workers employed in the maquiladoras were general laborers involved in assembly or manufacturing, 12 percent were technicians and 7 percent were administrative employees.

On the U.S. side of the border, there were 380 companies in Otay Mesa alone employing nearly 10,000 workers from San Diego. The presence of the thriving border commerce also indirectly supports thousands of additional jobs and businesses throughout the San Diego region.

In addition to the U.S. presence, there is a heavy Asian presence in the Tijuana area with many of the parent firms headquartered in Tokyo, Seoul, and Taipei. Sanyo's electronics factory, a maquiladora across the Mexican border employs 4,500 people, making it the largest factory in the Tijuana/San Diego area. In addition, Sony, Hitachi, Matsushita, Samsung and Hyundai employ over 1,000 people each in their Mexican maquiladora electronics plants.

The maquiladora program is undergoing significant changes in Mexico that will affect the economy of Tijuana, and indirectly affect the economy of San Diego. NAFTA will gradually eliminate all

tariffs on goods made or assembled in North America and traded between Mexico, Canada, and the U.S. This is expected to occur by 2004.

In 1998, Mexico's maquiladora industry purchased $4.7 billion in inputs for the maquiladora industry, mainly electronic components, plastics, machinery, metals, and paper products. About 50 percent of these maquiladora imports were purchased from Europe and Asia. Elimination of tariffs as a result of NAFTA should create additional opportunities for San Diego industries to replace inputs now provided by Europe and Asia.

Cross Border Employment

It is difficult to compare the workforce in Tijuana with the workforce in the San Diego region. The U.S. and Mexican governments use different statistical measures of their labor forces. Moreover, many Mexican workers are part of the "informal labor market" and are not registered with the Mexico's *Instituto Mexicano del Seguro Social* (IMSS). Given these caveats, the 1997 Mexican Survey (*Encuesta Nacional de Empleo Urbano*) showed that in 1995, 7.8 percent or approximately 50,000 workers who lived in Tijuana, worked in the U.S., many of them in the San Diego region.

Trade

Mexico is San Diego's largest export market. San Diego's largest exports to Mexico were in electronics, industrial machinery, and computers. The value of these exports to Mexico almost tripled between 1987 and 1995, accounting for $2.4 billion in 1995. San Diego's exports to Mexico represented over one-third of the State of California's exports to Mexico.

Not only has Mexico become San Diego's largest export market, the Tijuana region has been responsible for contributing billions of dollars to the local economy from Mexican residents who purchase goods and services in San Diego. In a typical month, there are 1.4 million border crossings between San Diego and Tijuana, 42 percent of which are for shopping. These shopping excursions add approximately $2.8 billion annually to San Diego's regional economy.

CROSS BORDER COOPERATION

The U.S./Mexico border is the busiest in the world. Two land ports of entry (San Ysidro and Otay Mesa) provide legal access between San Diego and Tijuana. The port of entry at San Ysidro is the busiest single port of entry in the United States. Almost all crossings at San Ysidro and Otay Mesa are made by residents of the San Diego/Tijuana metropolitan area, and about 60 percent of the people who cross the border do so frequently.

Illegal entrance has been a major problem in California. This is especially true in the San Diego area, which is the closest major city to the border. In the past, development of joint U.S.-Mexican strategies to deal with these issues has been a problem. Problems have arisen partly because of the

lack of coordination among local jurisdictions in the San Diego region and among county, state, and federal governments. Moreover, government and community leaders have not sufficiently recognized the importance of coordinating economic development with Mexico. San Diego City Council Member, Juan Vargas, commented:

> (Mexico and the San Diego area) didn't do much planning together. For example, our road system on the border doesn't hook up with the Mexican road system. When we opened the crossing at Otay Mesa, we didn't tell the Mexicans. This resulted in people crossing the border into dirt roads. Now we have monthly meetings. We coordinate. Mexico tells us what they are planning, and we tell them what we are planning.

In October 1998, the first border summit was convened by the Boards of Supervisors of San Diego and Imperial Counties. The summit provided an opportunity for local level officials to discuss community plans and ways in which the communities could jointly build more cooperative relationships with Mexico.

In February 1999, Tijuana Mayor Francisco Vega opened a government relations office in San Diego, a first in the history of Tijuana and San Diego. The purpose of the office is to ensure that Tijuana is represented within San Diego's municipal and business communities. "The new office in San Diego was possible because of improving cross border relations," said Mr. Luz Maria Dávila, Chief Liaison for Mayor Vega. "(The City of Tijuana) will now be present at meetings of the San Diego Chamber of Commerce, the San Diego Port Authority, SANDAG, and many other organizations." Mr. Dávila said the office will involve more than just official business: "It will make it easier to be in touch. We need a lot more involvement and closer relationships between the two cities."

A number of challenges remain. In addition to economic development issues, there are infrastructure issues related to pollution, water resources, and health. Communication between Mexico and the San Diego area also is complicated by telecommunication systems that need to be made more compatible. Migration, illegal immigration, and human rights remain thorny problems.

But cooperation between Mexico and San Diego has advanced quickly. Increasing trade, the inter-dependency of San Diego and Tijuana manufacturing, and the increasing Mexican contribution to San Diego's tourism industry, makes cooperation between the regions imperative. With increasing efforts on both sides of the border, the Tijuana and San Diego areas stand to mutually gain from improving relationships.

IX. SELECTED CORPORATE BRIEFS

INTRODUCTION

We provide brief case studies on six corporations that got their start, and continue to grow, in San Diego as part of the region's high-technology explosion. Two of the six corporations — Myelos Neurosciences, Inc. and ORINCON Corporation — are small technology firms. Four of the corporations — QUALCOMM, Inc., Science Applications International Corporation (SAIC), Stellcom Technologies and The Titan Corporation — now large corporations, were small technology start-ups as recently as the mid 1980's. Some of the corporations spun off from UCSD, others spun off from large defense industries.

Myelos Neurosciences, Inc., was started by a professor from UCSD who built the firm based on research that he conducted while at the University. The founder and President of the firm continues to work with UCSD as he develops his growing biotechnology business. ORINCON Corporation, also started by a professor from UCSD, developed and produced electronic equipment for antisubmarine warfare. Later, the corporation applied the DoD technology to develop diverse products for government and commercial purposes. QUALCOMM, Inc., grew from a start-up in 1985 to a $3.3 billion business in 1998. Employing over 11,000 workers, QUALCOMM became a national leader in wireless communication products and technologies. SAIC, which started 30 years ago when its founder left a major defense contractor, has become a $4 billion consulting business. SAIC not only managed to remain strong through the ups and downs of the defense budget upon which it depended, but has grown by increasingly aiming its products and services to meet the needs of new and emerging technology markets. Stellcom Technologies, a computer and engineering firm, grew into a $25 million business in fifteen years The Titan Corporation, started in 1981 to provide communication products and services to the defense sector, diversified in the 1990's by adapting some of its defense technologies to niche commercial markets.

MYELOS NEUROSCIENCES, INC.

> The San Diego area is supportive of technology firms by encouraging a critical mass of academic and research institutions. This draws tremendous talent to the area, and produces tremendous talent.
>
> - Dr. Elliot Parks, former President and CEO, Myelos Neurosciences, Inc.

Myelos Neurosciences Corporation (Myelos) is a young bio-pharmaceutical firm founded in 1994 by Dr. John O'Brien. Dr. O'Brien started the company while he was a professor of neuroscience at the UCSD's School of Medicine. The company is developing a therapeutic peptide compound to treat peripheral neuropathies, including those associated with diabetes, chemotherapy, nerve injury, and viral infections. Myelos is a privately held company, largely financed by venture capital.

Growth and Evolution of Company

Under grants from the National Institutes of Health (NIH), Dr. O'Brien discovered the primary enzyme deficiency for Tay-Sach disease in the early 1970's. While working on another NIH grant at UCSD in the 1980's, he recognized that a naturally occurring molecule had an effect on the human nervous system. Dr. O'Brien presented his findings to the University and suggested that the University patent the technology process. UCSD declined the patent, but permitted Dr. O'Brien to obtain his own patent. Dr. O'Brien subsequently tried to license the technology to pharmaceutical companies, but ultimately decided to establish his own company to develop the technology. In order to finance the operation, he approached several venture capital companies and also worked with UCSD's CONNECT program to help him identify and market the business to additional investors.

Initial funding came from two venture companies located outside of San Diego. Myelos subsequently leveraged this capital to attract additional funding from other venture capital companies. Through venture capital investments, the company grew from $250,000 in December 1994 to $3 million six months later.

The company's strategy shifted as its product/process development matured. The major shift occurred as the company's technology moved from research to application stages. As Myelos' products/processes entered later stages, it became easier for the company to attract partners and accelerate business growth. Dr. Elliot Parks, former President and CEO, explained:

> We have had a value change where, the further you go down the process of taking the product to market, the more risk you remove. It's very slow getting partners in the beginning, then its like a fire hose.

Dr. Parks said that Myelos' ability to attract strategic partners provided external validation of the company's potential to commercialize its products/processes.

Based on earlier research, the company now is developing therapeutic peptides for use in the treatment of neurologic, immunologic, and hematologic disorders. Myelos owns the patents to this technology and has exclusive licenses to additional technology through contracts with UCSD. Myelos' commercialization strategy involves partnering with major pharmaceutical companies that will license the therapeutic products/processes as well as market other products/processes in niche biomedical areas. Several major pharmaceutical firms have expressed interest in potential partnerships.

Myelos has grown from two part-time employees in 1994 to fifteen employees and contractors in 1998. Myelos planned to hire an additional 20 people in 1999. Because the company is privately held, revenue and earnings figures were not available.

Linkages to Universities and Community Organizations

Dr. O'Brien started Myelos as a result of research conducted at UCSD, where he is still an academic researcher. Myelos provides a grant to the University to support Dr. O'Brien's laboratory, and has an arrangement with the University that gives the firm "first right of refusal" for technologies arising from the research. Myelos' grants support the research of 15 students at the UCSD laboratory and additional UCSD research in neuropathology and biotechnology. The relationship between Myelos and UCSD provides critical support for the company, by giving Myelos access to university resources, and at the same time, benefits UCSD by funding research and supporting students.

UCSD's CONNECT program served as Myelos' first link to the venture capital community and it has been instrumental in helping Myelos grow. Dr. Parks said that the support provided by CONNECT and its former Director, the late William Otterson, was crucial to Myelos' development. Dr. Parks commented that the company is a strong supporter of CONNECT because of "the program's access to people, products, and opportunities." The CONNECT program links Myelos to large pharmaceutical companies, other high-technology and biotechnology companies, and service providers.

Myelos is active in San Diego's biotechnology community. Dr. Parks was one of the founders of BIOCOM, and Myelos is an active participant in BIOCOM's activities. Dr. Parks said that the networking opportunities, industry surveys, and economic forecasts conducted by BIOCOM have been particularly helpful to Myelos. Myelos also participates in the activities of the California Health Care Institute, an advocacy group that represents hospitals, clinics, large pharmaceutical firms, and biotechnology firms.

Another group in which Myelos is an active participant is the San Diego Venture Group. This group holds monthly breakfast meetings, which Dr. Parks finds useful for networking. Members of this group are service providers to the biotechnology and high-technology communities, entrepreneurs, and venture capitalists.

Dr. Parks believes that these industry and community organizations provide important sources of networking and information, each with its own domain and purpose. Dr. Parks commented that "the reservoir of talent in San Diego breeds a very productive environment." This is supported and fostered by the universities, research institutes, and various networking organizations.

Future

By late 1998, Myelos was seeking additional equity financing to advance clinical development, including human and animal efficacy studies. The company also was seeking corporate partners to

assist in completion of human clinical trials, to obtain regulatory approval, and to market the peptide drugs. Myelos intends to enhance in-house product development capability, expand technical staff, continue research collaborations with commercial and academic laboratories, and establish joint ventures and strategic partnerships with major pharmaceutical firms.

ORINCON CORPORATION

ORINCON Corporation (ORINCON) is a signal imaging and information processing firm, that started 22 years ago, as a developer and producer of antisubmarine warfare technology. Since the end of the Cold War, the company diversified its products, which now are used to detect impending crashes at airports, prevent small children from falling into swimming pools, and identify cancer cells in blood.

ORINCON is a privately-held corporation composed of ORINCON Industries, Inc., which is a holding company, and ORINCON Technologies, Inc., which pursues commercial opportunities through joint ventures, licensing, and corporate partnerships. The company has 150 employees at its headquarters in San Diego and its offices in Ballston, Virginia and Kailua, Hawaii.

Growth and Evolution of Company

In 1973, Daniel Alspach a professor at UCSD, and two engineers from the industry founded ORINCON Corporation. Corporate operations began in 1975 after the company was awarded three U.S. Department of Defense (DoD) contracts to design a tracking system for Soviet ballistic missile submarines. From the beginning, the company focused on the application of signal imaging and information processing to real-time problems.

In the 1980's, as DoD increased funding for antisubmarine warfare contracts, ORINCON's business grew rapidly. In the 1990's, DoD drastically reduced contracts in the anti-submarine warfare area, which represented 95 percent of the company's work. What could have been a disaster for ORINCON turned into a successful transition. Dr. Alspach, President of ORINCON, said that the company survived because it quickly recognized the need to diversify.

ORINCON broadened its base of customers and began contracting with the U.S. Department of Transportation, National Cancer Research Institute, Federal Aviation Administration, Federal Highway Administration, and several companies in the United Kingdom. Although DoD was still ORINCON's largest client in the 1998, the company had diversified its product base in anticipation of future DoD cutbacks. The rapid diversification paid off. From FY 1990 to FY 1998, ORINCON increased its revenues by 28 percent. In FY 1998, the company's revenues totaled over $20 million. (See Table 17.)

TABLE 17
GROWTH OF ORINCON CORPORATION
(1990-98)

Year	Revenue (in $ thous.)	Net Profit (in $ thous.)	Number of Employees
1990	15,791	145	164
1991	22,938	676	209
1992	22,442	705	196
1993	19,653	771	161
1994	16,291	341	139
1995	16,088	201	144
1996	19,003	305	158
1997	17,240	415	153
1998	20,196	599	153

Source: ORINCON Corporation.
Note: Fiscal years end June 30th.

Dr. Alspach said that one key element to ORINCON's survival has been the receipt of Small Business Innovation Research (SBIR) contracts. The company has been awarded approximately 100 Phase I SBIR grants and contracts. Dr. Alspach commented that "the SBIR contracts kept ORINCON from going out of business during defense cutbacks and facilitated product diversification." The company has used SBIR contracts to design and test new products. These products were based on ORINCON's technologies in submarine warfare, and were adapted for dual-use purposes.

With the support of SBIR contracts, the company developed a new Intelligent Vehicle Sensor (IVS). The IVS was installed at Long Beach Airport, as part of ORINCON's airport classification and tracking system. This sophisticated system is used to avoid runway crashes. It identifies aircraft and ground vehicles, displays them as icons on a computer monitor, and sounds an alarm when it "recognizes" vehicles that should not be on the runway. ORINCON has a major contract pending to install this system in a foreign airport, and expects the IVS to be a growing part of its business. ORINCON spent eight years and over $35 million to commercialize the IVS technology.

Other development and commercialization efforts involve traffic monitoring and control, software development productivity tools, manufacturing productivity enhancement, software for financial analysis, and environmental modeling. The company also is investing in Internet applications, medical signaling, and image processing tools.

Linkages to Universities and Community Organizations

> We would not be here if it were not for UCSD . . . The money that we spend working with the University is the "cheapest money" we spend.
>
> - Daniel Alspach, President, ORINCON Corporation

ORINCON has strong linkages with UCSD. About 25 percent of ORINCON's employees are UCSD graduates, and the company pays a fee to gain access to student resumes. ORINCON contributes $15,000 annually to UCSD, not including tuition paid for employees. Dr. Alspach, a former professor at UCSD, was one of the founders of the Dean's Council Alliance at the University.

The company maintains close ties with faculty members, who conduct employee seminars and provide consulting. ORINCON is working on several collaborative research projects with the University, including projects with the University's Aerospace Department, and Engineering Design Department. ORINCON received assistance from UCSD's CONNECT program, to help them identify potential financial sources. The company continues to be an active member of CONNECT.

Future

ORINCON will continue to produce innovative engineering solutions for military and government agencies, as well as foreign and commercial customers. The company expects to receive increasing defense contracts as defense budgets rise. ORINCON also anticipates greater commercial sales, and expects that commercial markets will account for an increasing share of its total revenues. ORINCON's R&D investments have begun to pay off as several of its development projects enter commercialization stages. Sales and revenue from royalties are expected to continue increasing at similar rates to those over the last couple of years.

QUALCOMM, INC.

QUALCOMM, Inc. (QUALCOMM) is a leading supplier of digital wireless communication products and technologies. The company specializes in the design, development, manufacture, service, and support of advanced communication systems for commercial and government users.

Founded in 1985, the company in 1998 employed over 11,000 workers at its San Diego headquarters, its 11 offices in the U.S., and its offices in 18 countries. QUALCOMM's stock has been publicly traded since 1991 on the NASDAQ and was one of the fastest growing stocks traded on the NASDAQ in 1999. In 1998 and 1999, QUALCOMM was on *Fortune* magazine's list of the

100 fastest growing companies.

Evolution and Growth of Company

In 1968, Andrew J. Viterbi, a UCLA professor; Irwin M. Jacobs, a professor from UCSD's Department of Applied Electrophysics; and Harvey White formed Linkabit Corporation to provide consulting in defense communication technologies. Dr. Jacobs left UCSD in 1971 to become Linkabit's President and CEO, and guided Linkabit from a start-up in the field of satellite communications to a corporation of over 1,400 employees.

In 1985, Linkabit was sold, and forty days later Dr. Jacobs and Dr. Viterbi started QUALCOMM. With the experience gained from Linkabit, the new company focused on developing new digital wireless technology. With a proven track record from the work at Linkabit, QUALCOMM received DoD contracts to develop advanced communication systems for military use.

QUALCOMM pioneered in developing Code Division Multiple Access (CDMA), which served as the platform for QUALCOMM's products and services. Initially, engineers and scientists scoffed at the technology. But the company persevered and today hundreds of CDMA digital cellular systems, personal communications services (PCS's) and wireless local loop (WLL) networks have been deployed in over 30 countries to millions of subscribers. This technology has been adopted as the U.S. digital cellular standard.

Building on digital wireless technology, QUALCOMM produces CDMA subscriber products, including a palm-sized folding "Q" phone, CDMA digital cellular phones, and PCS phones. QUALCOMM manufactures CDMA wireless infrastructure equipment to support cellular, PCS, and WLL networks, including base stations, test equipment, and network planning software. The firm manufactures the chips that are used in cellular, PCS, and WLL systems as well as direct broadcast satellite systems, small aperture terminals, radar systems, digital and mobile radios, synthesizers, voice storage systems, security systems, and instrumentation.

Another QUALCOMM product, sold in 33 countries, is the Omnitracs system, a two-way mobile satellite messaging and tracking system used primarily by commercial trucking fleets to provide data transmission, position reporting services, and information management systems to transportation companies.

QUALCOMM also produces an electronic messaging software, called Eudora e-mail, which is used by 18 million people for electronic communications over the Internet and corporate intranets. The company currently is expanding its suite of Eudora software with personal productivity programs and new applications to integrate wireless voice and data.

According to Mr. Daniel Pegg, a former Executive Director of the EDC and former Sr. Vice President of QUALCOMM, much of the success of QUALCOMM can be attributed to the drive and energy of the three founders. The founders had the foresight to recognize that the innovations developed in telecommunications for the defense industry could be adapted to burgeoning

commercial needs.

By 1998, QUALCOMM had become one of the three major corporations in the U.S. producing digital wireless phones. Mr. Pegg believed that one of the reasons for QUALCOMM's success has been "its ability to stay focused and its perseverance." He said that in the early days QUALCOMM's sales executives carefully selected key accounts and "went after them with a vengeance." They focused on accounts such as Sprint PCS and PrimeCo in the wireless industry, which would later provide a platform for growth.

Mr. Pegg said that QUALCOMM also invested heavily in public relations and marketing. As part of brand recognition efforts, the company acquired the naming rights to the San Diego sports facility, which is now known as QUALCOMM Stadium. In 1998, QUALCOMM Stadium was the site for the Super Bowl and the World Series, making QUALCOMM an internationally recognized name.

QUALCOMM also focused on developing international markets. It located plants around the world to support the growth of QUALCOMM products, emphasizing customer support and increasing brand recognition. In 1996 Sony Wireless Company, entered a joint venture with QUALCOMM to design and manufacture wireless products, based on CDMA. The plant also produces cellular telephones, wireless messaging products and other personal communication devices.

QUALCOMM's revenues have grown dramatically. The company's 1998 revenues were 60 percent higher than in 1997, totaling $3.3 billion. From 1994 to 1998, revenues increased by twelve times their original value. Table 18 shows the company's growth in the mid to late 1990's.

Table 18
Growth of QUALCOMM, INC. (1994-98)

Year	Revenues (in $ millions)	Net income (in $ millions)	Earnings Per Share (in $)	Employment
1994	272	16	.30	1,262
1995	387	30	.56	2,972
1996	814	21	.32	4,735
1997	2,096	92	1.37	6,926
1998	3,348	109	1.57	11,600

Source: QUALCOMM, Inc.

Note: The data are for years ending on September 30, but the company's fiscal year ends on the last Sunday in September. There were 53 weeks in fiscal 1996.

Linkages to Universities and Community Organizations

> The link with the community is not only good for the community, but it is good for QUALCOMM. It's an investment in the future.
>
> - Mr. Daniel Pegg, former Sr. Vice President, QUALCOMM, Inc.

Q U A L C O M M maintains close ties to UCSD. Not only did two of the three founders come from UCSD, but many of the employees were recruited from the University. QUALCOMM sponsors research at the University, contributes material for text books, and conducts student visits and seminars. Professors are encouraged to work alongside QUALCOMM executives in order to gain private sector experience and perspective. Most importantly, founder Irwin Jacobs and his wife contributed $15 million to construct an engineering building at UCSD. The UCSD's School of Engineering is now named in their honor.

The company maintains strong links to UCSD's CONNECT program. QUALCOMM founders have served on the CONNECT Board, and the company supports an engineering high-technology task force. QUALCOMM also underwrites the costs of publishing the directory. The company has won numerous awards from CONNECT's "Most Innovative Products" program.

QUALCOMM works with, and supports, the San Diego State University's Entrepreneurial Management Center and other efforts at that institution. QUALCOMM also is active in numerous community organizations and is a prominent supporter of community development. Founder Harvey White has served on the SANDAG Board, and Dr. Jacobs is active in numerous civic activities and charities.

QUALCOMM's executives also believe that it is important for K-12 education to keep pace with changing skill needs. The company actively promotes science and technology education to young people by providing computers to schools and sponsoring "job shadowing" programs for students.

Future

In 1998, QUALCOMM filed 146 new patent applications, which expanded its total portfolio to over 500 patents issued or pending. In addition to its proprietary products, QUALCOMM has licensed its technologies to over 60 manufacturers. QUALCOMM expects to continue its astounding growth as the number of wireless subscribers worldwide expands to a projected 440 million by the year 2000.

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Science Applications International Corporation (SAIC) is a research and engineering firm providing a wide range of services in most technology fields. It is the 41st largest private company, and the largest employee-owned company, in the U.S. As other companies that provided defense-related services, SAIC struggled during the early 1990's. SAIC not only maintained its earnings during that period, but also grew by aggressively seeking opportunities in diversified technology areas.

Evolution and Growth of Company

In 1969, Dr. Robert Beyster left General Atomic to launch the forerunner of SAIC. Thirty years later, the company has grown to 35,000 employees, with offices in over 150 cities worldwide. In the 1970's and 1980's SAIC built its consulting business mainly on defense contracts and other government contracts. SAIC's staff provided technical expertise to support cleanup efforts at Three Mile Island and Prince William Sound, and space missions such as Voyager and the Hubble Space Telescope.

SAIC has a history of successfully identifying and capitalizing on emerging technology areas receiving federal funding. For example, during the 1970's, the firm built an enormous energy research component. When energy funds decreased in the early 1980's, SAIC quickly shifted to other technical areas. In the early 1990's, SAIC was hit hard by reductions in defense spending. As a result, SAIC diversified its services, increasing its commercial and international business to reduce the firm's reliance on defense contracts. The firm broadened its expertise in technology development and analysis, computer system development and integration, technical support services, and computer hardware and software products. During the 1990's, SAIC also built expertise in the fields of energy, environment, health care, information technology, Internet, national security, space, telecommunications, transportation, and logistics. The most successful growth areas in the 1990's have been in information technology and health care services. SAIC, during the 1990's, was able to reduce the DoD share of its total revenues from over one-half to about one-fourth.

SAIC diversified and built expertise in other areas by aggressive hiring and acquisition of other companies. Its first major acquisition, in 1987, was AMSEC, a provider of ship engineering and maintenance services for the U.S. Navy. One of SAIC's most important recent acquisitions, in 1997, was that of Bellcore, the New Jersey-based research arm of the regional Bell operating companies. The purchase of Bellcore resulted in SAIC moving from the 55th to the 41st largest privately-held U.S. company.

From the beginning, Dr. Beyster's vision for the company was to build a cadre of ambitious, entrepreneurial employees who, through ownership in the company, would have a stake in the company's success. Employees are responsible for finding their own contracts and "growing their own businesses" within SAIC. In return, employees have an equity position in the firm and an opportunity to purchase stock in the company. As a result, employees own 90 percent of SAIC; the remaining 10 percent is owned by consultants and former employees.

SAIC revenues increased from $2.4 billion in FY 1997 to $3.4 billion in FY 1999. In 1998, SAIC generated about half of its revenues from commercial and international contracts, one-fourth of its revenues from defense, and one-fourth of its revenues from other federal and state contracts. SAIC's

revenues, earnings per share, net income, and number of employees during the 1990's is shown in Table 19.

Table 19
Growth of SAIC
(1990-99 Estimated)

Year	Revenues (in $ millions)	Earnings Per Share (in $)	Net Income (in $ millions)	Number of Employees
1990	1,022	.67	31	11.449
1991	1,163	.73	33	12,085
1992	1,285	.75	34	13,629
1993	1,504	.83	38	14,872
1994	1,671	.89	42	16,162
1995	1,922	1.01	49	17,853
1996	2,155	1.13	57	20,931
1997	2,402	1.23	64	24,209
1998	3,100	1.55	85	31,000
1999	3,400	2.11	117	35,000

Source: SAIC.

Note: 1999 figures are estimates based on performance in 1998. Fiscal years end January 31st.

Linkages to Universities and Community Organizations

According to SAIC Vice President, Dr. Stephen Rockwood, collaboration with UCSD and other universities has been important to SAIC's growth in San Diego, especially during the 1990's. Through its connections with UCSD, SAIC has access to students and professors, who provide consulting to the company. Dr. Rockwood said that the University is an important source of information on new technologies and a valuable source for recruitment.

SAIC supports UCSD's CONNECT program, and SAIC employees are active in CONNECT and in numerous industry-related organizations. In addition, the firm has established a Foundation of Enterprise Development to help other entrepreneurs around the world model companies based on the employee-owned SAIC.

In a 1998 interview, Dr. Rockwood said that San Diego has become more "pro-business." He added

that San Diego has an active community which encourages intellectual exchanges, business collaboration, interaction with the universities, and financing available to new firms.

Future

SAIC projections for future growth continue to be good. But Dr. Rockwood expressed concern about the firm's continuing ability to find qualified scientists and engineers. In the information technology area, for example, SAIC had 2,000 job openings in 1998, and had found it difficult to find qualified applicants to fill these positions. Dr. Rockwood said that as a result of unmet needs for skilled workers, companies are sending their software development offshore. SAIC and many other technology firms in San Diego support liberalizing U.S. immigration for technically skilled workers, to meet growing skill shortages. Additionally, SAIC provides in-house training to help overcome the shortage of trained workers.

Fiscal year 1999 represented SAIC's 30th year of continued revenue and earnings growth, a trend which the company is confident will continue into the 2000's.

STELLCOM TECHNOLOGIES

Stellcom Technologies (Stellcom) provides consulting services in computer applications and contract engineering. Stellcom's services encompass software, firmware, and hardware. It is a $25 million company, sustaining an average annual revenue growth of 50 percent. Stellcom is a privately held company that recently became employee-owned.

Growth and Evolution of Company

Mark Fackler founded Stellcom in 1984, after he left General Dynamics where he was a computer programmer. After Mr. Fackler resigned from General Dynamics, he briefly worked for a consulting firm to gain some small business experience, and then incorporated his own firm. Stellcom's first client was Mr. Fackler's former employer, General Dynamics.

Mr. Fackler said that when he founded Stellcom, he recognized that many companies no longer engaged in continuous product development and that product life cycles were growing shorter. Moreover, as technologies were rapidly changing, companies needed professionals who were trained in the latest technologies. This was at a time when the supply of engineers was getting tighter and the number of computer science graduates was dropping. Companies needed highly skilled engineers and computer professionals to optimize the effectiveness of their in-house staff and to provide short-term technical services. Stellcom addressed these needs by offering senior-level consultants and staff.

During the 1980's, Stellcom's clients were mainly defense-related. But in the early 1990's, Mr. Fackler recognized that there might be defense cutbacks, and in response diversfied Stellcom's client

base. Mr. Fackler said that in order to shift to commercial markets he had to take a pay cut before he was able to secure his first commercial client.

Since that time, Stellcom has provided services to commercial and government clients in: strategic planning, business needs analysis, technology/product evaluation, project planning and execution, system and software architecture, software development, application implementation, hardware development, systems integration, and infrastructure design and implementation.

Microsoft selected Stellcom as a Solutions Provider to serve Microsoft customers and partners. Microsoft Certified Professional Certifications were awarded to 33 Stellcom staff, and Stellcom has sent engineers to Microsoft to help develop the Customizable Starter Sites, and to assist in completing Microsoft's Site Server 3.0. In addition to Microsoft, Stellcom's clients include Hewlett Packard, QUALCOMM, GTE, Kingston Technology, Mobile Planet, San Diego Gas & Electric, Cubic Corporation, and Cooking.com.

In 1996, Stellcom became an employee-owned company, offering stock options to all employees. The employee-ownership plan is based upon the SAIC's model. In 1998, Stellcom employed over 200 engineers who have worked with more than 150 companies.

Linkages to Universities and Community Organizations

> We got together because we recognized that we needed to publicize the San Diego region as a technology giant ... When you hear San Diego, you think of Shamu! We are changing that.
>
> - Mark Fackler, President and CEO, Stellcom Technologies

Stellcom is very active in the San Diego Software and Internet Council, the Computer and Electronics Marketing Association, and the American Electronics Association (AEA). In 1999, Mr. Fackler became the Chairperson of the San Diego chapter of the AEA, and he is on the national board of the Association. Mr. Fackler also chairs the San Diego Manufacturing Extension Corporation Board. Stellcom is actively involved in UCSD's CONNECT program, and in 1997, Stellcom executives were featured on the monthly CONNECT television show.

The company is active in Technologies Perfect Climate (TPC), a local organization aimed at promoting San Diego as a high-technology region. TPC is composed of 14 organizations including

the San Diego Chamber of Commerce, the San Diego Regional Technical Alliance, Software and Internet Council, AEA and UCSD-CONNECT. With funding from Stellcom and other San Diego technology firms, TPC has produced a recruiting video aimed at attracting skilled workers to the area. Mr. Fackler feels that it is important for Stellcom and other technology firms to take an active community role, and to get the word out that "San Diego is a great place to work."

Future

According to Mr. Fackler, Stellcom's revenues were $25 million in 1998, and Stellcom is growing at over 50 percent per year. Stellcom projects growth at similar rates for the next few years. As the demand for computer services grows, and as outsourcing for these services continues to grow at increasing rates, Mr. Fackler believes that Stellcom is well positioned for rapid growth.

THE TITAN CORPORATION

The Titan Corporation (Titan) designs, manufactures, and installs high-technology information and electronic systems for commercial and government clients. These systems and services enable Titan's customers to cost-effectively generate, digitize, process, compress, transmit, store, and distribute information in a timely manner. Titan operates primarily through subsidiaries that focus on specific markets in defense, communications, software, and emerging technologies.

Evolution and Growth of Company

Titan's President, Dr. Gene Ray, left SAIC in 1981 to start his own company in defense communications. During the 1980's, Titan's core customer was the U.S. Department of Defense, and the company grew rapidly on these contracts. But as the defense budget decreased, Titan lost its major contracts. Titan recognized, however, that communication technology was a growing area, and that the company could refocus some of its resources to develop new products and services in emerging communication areas. Titan's two-fold strategy was (1) to develop new technologies for the government, and (2) to adapt technologies to new commercial markets. Initially, Titan's core defense business provided the capital necessary to adapt selected technologies to commercial markets.

When asked how Titan survived while larger companies such as General Dynamics sank, Dr. Ray said that Titan was fortunate to have had its core business in communications. But Titan's survival also depended on its ability to diversify. The company has diversified its products/processes based on technologies that it had developed under defense contracts. For example, Titan has adapted for medical use, beam technology that the company originally had developed for "Star Wars." Dr. Ray said "we found that the same technology which was used for defense satellites could be used to sterilize medical products."

A major breakthrough for the company came with the acquisition of Linkabit, making Titan a leader in Demand Assigned Multiple Access (DAMA). Titan is now the leading supplier of DAMA to the

U.S. Department of Defense. More recently, Titan has acquired several additional companies. Acquisitions include Eldyne, Unidyne, and DCS, which have given Titan greater control over communication systems. In 1998, Titan also acquired Horizons Technology, Inc., and DBA Systems.

In 1998, Titan was composed of four core businesses: Linkabit Wireless, Titan Software Systems, Titan Technologies and Information Systems, and Titan Sterilization and Pasteurization Systems. It was a leading provider of satellite communications systems, information technology solutions, and sterilization systems and services.

In 1998, Titan generated several major contracts and sales. It sold a system for medical product sterilization, totaling over $4 million. This system uses electronic beam technology to eliminate E-coli and salmonella. It received a DoD contract to develop, deliver, and maintain computer-based and instructor-led courses. The U.S. Department of Navy additionally awarded Titan over $14 million for continued technical support of computer programs, computer-based training, and related services. Titan also received its largest law enforcement order from the FBI's Card Scan Service Program.

Titan has achieved impressive growth. From 1996 to 1997, revenues more than doubled, from $136 million to $276 million, and in 1998, revenues continued to grow. The company attributed the growth to long-term strategic transactions, reorganization of their communications and defense businesses, and streamlining. In 1998, Titan had over 1,400 employees. Table 20 shows the substantial rate of growth in Titan's revenues and net income since 1993.

Table 20
Growth of The Titan Corporation
(1993-98)

Year	Revenue (in $ millions)	Net Income (in $ millions)
1993	149.4	(7.9)
1994	136.2	7.1
1995	131.5	(3.8)
1996	135.5	(3.4)
1997	275.9	5.9
1998	303.4	13.5

Source: The Titan Corporation.

Linkages to Universities and Community Organizations

Titan maintains close ties to UCSD by using professors as consultants and hiring students. Titan also has sponsored R&D projects at the University. Titan has been a member of UCSD's CONNECT program for many years, and Titan officials have served on CONNECT committees. Dr. Ray views CONNECT's ability to foster the growth of small businesses as a valuable asset to Titan and the technology community.

Future

Dr. Ray is optimistic about the continuing growth of Titan, but expressed concern about the shortage of skilled workers, especially electrical engineers. Dr. Ray commented that current U.S. immigration laws placing restrictions on skilled workers coming to the United States has had a negative effect on Titan's business. He said that in 1998 the company had engineering vacancies that it could not fill and was concerned about the long-term impact of these shortages.

A substantial portion of Titan's revenues was dependent upon continued funding by U.S. and foreign government agencies. In 1997, U.S. government contracts represented 72 percent of the company's revenue. However, by the end of 1998, several of the corporation's R&D projects, aimed at new commercial markets, were nearing commercialization. The company plans to continue growing its government services, but hopes to increase its commercial markets by an even greater margin.

APPENDIX

Appendix A

INTERVIEW PARTICIPANTS

Daniel Alspach
President and CEO
ORINCON Corporation

Richard C. Atkinson[1]
President
University of California

Sharon Ballard
Entrepreneurial Training Program
CONNECT
University of California at San Diego

Abigail Barrow
Director, Emerging Technology Programs
CONNECT
University of California at San Diego

Joseph Bear
Director, External Relations
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University of California at San Diego

Linden S. Blue
Vice Chairman
General Atomics

Jane Signaigo-Cox
Vice President
San Diego Economic Development Corp.

Marney Cox
Director, Sourcepoint
San Diego Association of Governments

John J. Donegan
Associate Director
San Diego Supercomputer Center

Carole Ekstrom
Director, Membership
CONNECT
University of California at San Diego

Sanford Ehrlich
Executive Director
Entrepreneurial Management Center
San Diego State University

Mark Fackler
President
Stellcom Technologies

Susan Golding
Mayor
City of San Diego

Barry Janov
Coordinator
Defense Conversion Center
San Diego State University

Charles Nathanson
Director
San Diego Dialogue
University of California at San Diego

Alexander De Noble
Professor of Business Administration
San Diego State University

[1]Former Chancellor, University of California at San Diego.

The late William Otterson[2]
Former Director
CONNECT
University of California at San Diego

Ted Owen
President and Publisher
San Diego Business Journal

D. Elliot Parks
President and CEO
Myelos Neurosciences Inc.
and Chairman of the Board
San Diego Area Governments

Daniel Pegg[3]
Sr. Vice President
Leap Wireless International

Peter Preuss
Regent
University of California and
President
The Preuss Foundation

Joseph Ragusso[4]
Deputy Secretary
Division of Science, Technology
and Innovation
California Trade and Commerce Agency

Ann Ryder Randolph
Former Managing Director
BIOCOM / San Diego

William H. Rastetter
Chairman, President and CEO
IDEC Pharmaceuticals Corporation

Gene Ray
President and CEO
The Titan Corporation

Deanna Rich
Vice President
San Diguido Unified School District

Steven Rockwood
Executive Vice President
Science Applications International
Corporation

Bruce Spivack
Former Executive Director
San Diego Manufacturing Extension
Corporation

Joan Stepsis
Director
Center for Applied Competitive
Technologies
San Diego City College

Kenneth Sulzer
Executive Director
San Diego Association of Governments

Juan Vargas
Council Member
San Diego City Council

Mary Lindenstein Walshok
Associate Vice Chancellor and Dean
Extended Studies and Public Programs
University of California at San Diego

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[2]Director, CONNECT, 1986-99.

[3]Former President, San Diego Regional Economic Development Corporation, and former Sr. Vice President, QUALCOMM, Inc.

[4]Former President & CEO, San Diego Regional Technology Alliance.

Appendix B

San Diego Region's Industry Clusters
Average Annual Employment (1990-1998)

Cluster	1990	1991	90-91 Percent Change	1992	91-92 Percent Change	1993	92-93 Percent Change	1994	93-94 Percent Change	1995	94-95 Percent Change	1996	95-96 Percent Change	1997	96-97 Percent Change	1998	97-98 Percent Change	Average Percent Change	*90-98 Percent Change*
Biotechnology and Pharmaceuticals	11,267	11,909	5.70%	14,720	23.60%	16,123	9.53%	16,335	1.31%	17,228	5.47%	18,617	8.06%	20,328	9.19%	22,999	13.14%	9.50%	104.12%
Software and Computer Services	8,804	8,870	0.75%	9,443	6.46%	10,246	8.50%	11,421	11.47%	12,366	8.27%	13,643	10.33%	15,180	11.27%	17,700	16.60%	9.21%	101.04%
Communications	13,166	11,278	-14.34%	13,194	16.99%	13,913	5.45%	14,704	5.69%	14,787	0.56%	16,400	10.91%	18,094	10.33%	20,619	13.95%	6.19%	56.61%
Business Services	48,159	48,606	0.93%	47,967	-1.31%	50,521	5.32%	51,869	2.67%	55,149	6.32%	65,871	19.44%	71,039	7.85%	78,792	10.91%	6.52%	63.61%

National Industry Clusters
Average Annual Employment (1990-1998)

Cluster	1990	1991	90-91 Percent Change	1992	91-92 Percent Change	1993	92-93 Percent Change	1994	93-94 Percent Change	1995	94-95 Percent Change	1996	95-96 Percent Change	1997	96-97 Percent Change	1998	97-98 Percent Change	Average Percent Change	*90-98 Percent Change*
Biotechnology and Pharmaceuticals	861,398	855,042	-0.74%	873,683	2.18%	885,492	1.35%	861,252	-2.74%	852,043	-1.07%	851,730	-0.04%	859,547	0.92%	880,281	2.41%	0.29%	2.19%
Software and Computer Services	708,116	719,478	1.60%	766,702	6.56%	820,124	6.97%	880,526	7.36%	998,001	13.34%	1,127,357	12.96%	1,289,341	14.37%	1,472,996	14.24%	9.68%	108.02%
Communications	1,267,311	1,234,876	-2.56%	1,200,922	-2.75%	1,199,011	-0.16%	1,213,135	1.18%	1,236,244	1.90%	1,268,430	2.60%	1,339,627	5.61%	1,443,367	7.74%	1.70%	13.89%
Business Services	4,209,466	4,025,966	-4.36%	4,257,157	5.74%	4,638,176	8.95%	5,007,872	7.97%	5,440,527	8.64%	6,265,999	15.17%	6,769,997	8.04%	7,252,227	7.12%	7.16%	72.28%

Source: San Diego - California Employment Development Department, 1990 - 1998; U.S. - Bureau of Labor Statistics "ES202."

Notes: Biotechnology and Pharmaceuticals Cluster represents a compilation of SIC industries 2819, 2833, 2834, 2835, 2836, 2869, 2899, 8731*, 8733, 8734.
Software and Computer Services Cluster represents a compilation of SIC industries 7371, 7372, 7373, 7374, 7379, 8711*, 8731*.
Communications Cluster represents a compilation of SIC industries 3661, 3663, 3669, 4812, 4813, 4899, 8711*, 8731*.
Business Services Cluster represents a compilation of SIC industries 2741, 7311, 7319, 7361, 7363, 7375, 7376, 7377, 7389, 8111, 8712, 8741, 8742, 8748.
*SIC 2752 and SIC 7334 in Business Services Cluster: Due to definitional changes to the cluster, only 1996-1998 figures are included in totals.
* Portions of the employment in SIC industries 8711 and 8731 are included in more than one cluster group.

Appendix C

San Diego Region's Industry Clusters
Average Annual Wage (1990-1998)

Cluster	1990	1991	90-91 Percent Change	1992	91-92 Percent Change	1993	92-93 Percent Change	1994	93-94 Percent Change	1995	94-95 Percent Change	1996	95-96 Percent Change	1997	96-97 Percent Change	1998	97-98 Percent Change	Average Percent Change	*90-98 Percent Change*
Biotechnology and Pharmaceuticals	43,280	44,275	2.30%	46,183	4.31%	46,583	0.87%	47,103	1.12%	48,954	3.93%	52,287	6.81%	56,451	7.96%	55,974	-0.84%	3.31%	29.33%
Software and Computer Services	47,372	50,288	6.16%	50,445	0.31%	51,242	1.58%	51,758	1.01%	54,712	5.71%	54,965	0.46%	58,231	5.94%	63,657	9.32%	3.81%	34.38%
Communications	45,625	47,015	3.05%	48,360	2.86%	50,716	4.87%	47,601	-6.14%	50,314	5.70%	50,425	0.22%	50,671	0.49%	51,352	1.34%	1.55%	12.55%
Business Services	31,651	30,603	-3.31%	32,203	5.23%	31,770	-1.34%	31,205	-1.78%	31,830	2.00%	31,064	-2.41%	31,473	1.32%	30,884	-1.87%	-0.27%	-2.42%

National Industry Clusters
Average Annual Wage (1990-1998)

Cluster	1990	1991	90-91 Percent Change	1992	91-92 Percent Change	1993	92-93 Percent Change	1994	93-94 Percent Change	1995	94-95 Percent Change	1996	95-96 Percent Change	1997	96-97 Percent Change	1998	97-98 Percent Change	Average Percent Change	*90-98 Percent Change*
Biotechnology and Pharmaceuticals	49,969	49,695	-0.55%	52,609	5.86%	50,617	-3.79%	50,732	0.23%	52,044	2.59%	53,411	2.63%	56,191	5.21%	58,133	3.46%	1.95%	16.34%
Software and Computer Services	49,609	49,603	-0.01%	52,291	5.42%	52,033	-0.49%	53,162	2.17%	55,633	4.65%	58,003	4.26%	61,192	5.50%	66,163	8.12%	3.70%	33.37%
Communications	47,235	46,137	-2.32%	48,195	4.46%	48,784	1.22%	49,553	1.58%	50,415	1.74%	50,737	0.64%	52,087	2.66%	54,532	4.69%	1.83%	15.45%
Business Services	32,907	32,214	-2.10%	32,627	1.28%	31,137	-4.57%	30,116	-3.28%	30,179	0.21%	30,579	1.33%	31,217	2.09%	32,384	3.74%	-0.16%	-1.59%

Source: San Diego - California Employment Development Department, 1990 - 1998; U.S. - Bureau of Labor Statistics "ES202."
Note: Adjusted for Inflation. Average annual wage is calculated in 1998 dollars based on Consumer Price Index.

Notes: Biotechnology and Pharmaceuticals Cluster represents a compilation of SIC industries 2819, 2833, 2834, 2835, 2836, 2869, 2899, 8731*, 8733, 8734.
Software and Computer Services Cluster represents a compilation of SIC industries 7371, 7372, 7373, 7374, 7379, 8711*, 8731*.
Communications Cluster represents a compilation of SIC industries 3661, 3663, 3669, 4812, 4813, 4899, 8711*, 8731*.
Business Services Cluster represents a compilation of SIC industries 2741, 7311, 7319, 7361, 7363, 7375, 7376, 7377, 7389, 8111, 8712, 8741, 8742, 8748.
*SIC 2752 and SIC 7334 in Business Services Cluster: Due to definitional changes to the cluster, only 1996-1998 figures are included in totals.
* Portions of the employment in SIC industries 8711 and 8731 are included in more than one cluster group.

Appendix D

CLUSTER DEFINITIONS
(by 1999 SIC Code)

High-Technology Clusters

Biomedical Products
3821
3827
3841-45
3851

Biotechnology and Pharmaceuticals
2819
2833-36
2869
2899
8731 (.60)
8733-34

Business Services[1]
2741
2752
7311
7319
7334
7361
7363
7375-77
7389
8111
8712
8741-42
8748

Communications
3661
3663
3669
4812-13
4899
8711 (.10)
8731 (.25)

Computer and Electronic Manufacturing
3571-72
3577
3629
3651
3671-72
3674-79
3695
3699
3825

Defense Manufacturing
3511
3721
3724
3728
3731-32
3761
3769
3812

[1]Prior to 1996, 2752 and 7334 were not included in the business services cluster definition.

Environmental Technology
3564
3569
3589
3823-24
3826
3829

Financial Services[2]
6035-36
6061-62
6091
6099
6140
6162-63
6282

Recreational Goods Manufacturing
3940

Software and Computer Services
7371-74
7379
8711 (.05)
8731 (.15)

Other Clusters
Entertainment and Amusement 4830
7812
7819
7922
7941
7992
7996
7999
84

Fruit and Vegetables
161
171-72
174-75
179
762
2033
2449

Horticulture
181
182
191
711
781
783

Medical Services
7352
8011
8021
8049
8062-63
8069
8071-72
8092-93
8099

[2]Prior to 1996, 6091 and 6099 were not included in the financial services cluster definition.

Visitor Industry Services 4489
4499
4512
4581
4724-25
5800 (.55)
7011
7021
7032-33
7041
7514