

INNOVATION AND TECHNOLOGY IN HAWAII:
An Economic and Workforce Profile



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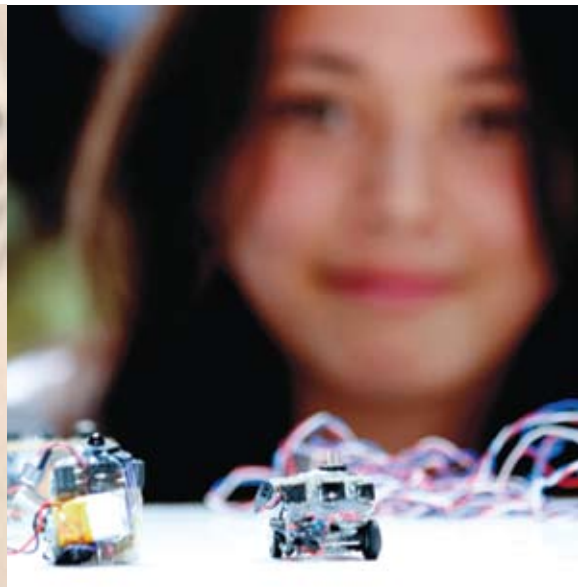
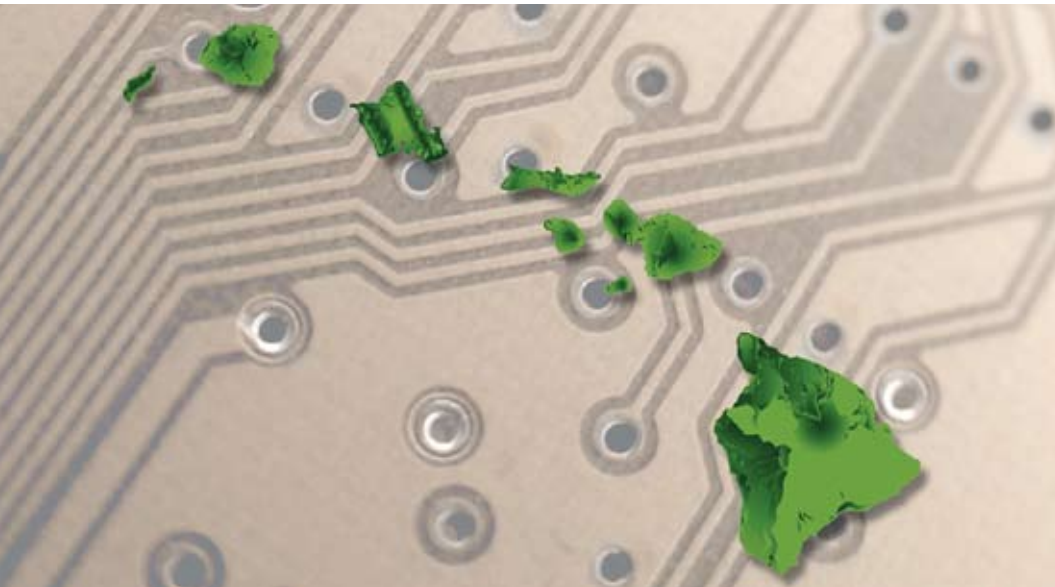
The State of Hawaii Department of Business Economic Development and Tourism (DBEDT) is Hawaii's resource center for economic and statistical data, business development opportunities, energy and conservation information, and foreign trade advantages.

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Available at <http://www.HISciTech.org/Information>

Message from Sen. Daniel K. Inouye

DANIEL K. INOUE
HAWAII

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COMMERCE, SCIENCE AND TRANSPORTATION,
CHAIRMAN
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October 1, 2008

I recently had the great privilege of being surrounded by a group of energetic, hardworking, risk-taking entrepreneurs committed to growing a high technology sector in Hawaii. It was indeed heartwarming to see the many thriving “fruit” of our collective labor.

After all of these years of investment, it was a terrific feeling both emotionally and empirically, with solid data to validate the important role of this sector in our economy. There is always room for economic diversification. It need not be an either or proposition on whether to invest in a new sector which holds much promise for the future. This science and technology sector is succeeding in reducing the “brain-drain” and providing exciting jobs with good salaries to support working families.

We must never limit our sights or sell ourselves short. We are a destination for world-class science and research, for defense and dual-use technology and cutting edge medical biotechnology and telehealth innovations. The data presented in this report demonstrates the progress we have made to date in Hawaii, and provides for a healthy discussion on the way forward in a competitive global marketplace.

Please join me in celebrating this report - it is a call to action and a statement of hope to encourage Hawaii’s talented stars to come home and stay home. The future is bright. Congratulations to the Hawaii Science & Technology Council and Institute.

Aloha,

DANIEL K. INOUE
United States Senator

Message from Gov. Linda Lingle



Message from Governor Linda Lingle

A fact-based, comprehensive understanding of the technology industry in Hawai'i is essential for developing policies to improve its growth. This report provides a foundation for understanding the industry and its activities throughout our islands. It is the first in-depth look at technology in Hawai'i to be a fully collaborative effort between the private and public sectors.

Public-private partnerships provide the foundation upon which we may encourage growth and innovation in our economy. My Administration has worked with our partners in the private sector to pursue economic alternatives aimed at reducing our over-dependence on land development, and bringing better paying jobs to Hawai'i.

This project has not only furthered our knowledge of the technology sector but also served as a model for combining public and private sector resources and expertise towards industry research and development. These arrangements will be essential in attracting and retaining investments, entrepreneurial talent, and innovative companies that can enhance Hawai'i's role in the global technology sector.

We look forward to continued collaborations of this kind to better understand and assist technology and the range of other emerging industries that will help achieve our goal of transforming our economy for the 21st century.

Aloha,


Linda Lingle
Governor, State of Hawai'i

Executive Summary

INTRODUCTION

While there remains no doubt that the sun, the sea, and the land are key economic drivers in Hawaii's future, leaders have come to recognize the increasing importance of developing another critical asset: the knowledge and talent of the state's people. Innovation and technology, in particular, represent the foundation on which Hawaii is achieving productivity growth and competitive advantage. As Hawaii's people want better jobs for themselves and their children, industries must transform or emerge to provide those opportunities.

METHODOLOGY AND SCOPE

This report will offer a baseline analysis of Hawaii's technology sector in order to better understand how innovation contributes to the state's economic present and future. We use the most recently available data from 2007 (unless otherwise specified), with trends from 2002 to 2007, which we will assume for the sake of this report as current. The project team relied on long-standing national and state databases, with significant qualitative input from numerous industry representatives. The definition of technology was adopted from the Bureau of Labor Statistics (BLS), with conservative modifications to improve its relevance for Hawaii.¹ The report defines what constitutes the technology sector, identifies the specific industries that are currently or are likely to contribute most to its growth, examines linkages with other parts of the economy, and assesses the quality of the jobs available to Hawaii

1. Please see Technical Appendix 2: Defining Hawaii's Technology and Innovation Industry Sectors for a full discussion, available at <http://www.HISciTech.org/Information>.



Researcher at the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa (courtesy of DBEDT).

workers through these industries. The study further provides an overview of the companies and people working in the state's emerging technology sector. It also examines how the Neighbor Islands are participating in this growth and development. A key assumption in preparing this study is that Hawaii's technology sector will need to prepare workers to fill emerging new jobs as well as those jobs being vacated as baby-boomers begin retiring or as workers leave their jobs in Hawaii for opportunities elsewhere. Thus, an assessment of the workforce needs is provided as a companion to an analysis of the emerging industries in the state's technology sector.

The report's findings and recommendations are highlighted.

SIZE AND SCOPE OF SCIENCE AND TECHNOLOGY ACTIVITIES IN HAWAII

Hawaii's private technology sector contributed about \$3 billion to the state's economy in 2007—a figure that represented 5 percent of the state's total \$61 billion economy.²

2. Source: U.S. Bureau of Economic Analysis, (BEA). Estimates for Hawaii's science and technology industry sectors are derived using a ratio of total earnings to GDP applied to technology sector earnings to generate an estimate of GDP. This same method is used by BEA in calculating GDP by metro.

Executive Summary

- Private sector tech companies generated an additional \$2 billion through purchases from suppliers and goods and services consumed by tech company employees
- The state’s science and technology sector’s direct impact of \$3 billion dollars combined with the \$2 billion in indirect impacts represented about 8% of the state’s economy in 2007.

Last year, Hawaii’s science and technology companies and government entities generated a total of approximately 31,106 jobs, or 3.6 percent of the state’s employment.

- 23,985 technology-related jobs—77 percent of the total—were found in private tech sector companies.
- 7,121 technology-related jobs were in the public sector, either through the state university, state agencies or nearly 50 different federal agencies and offices.
- The Department of Defense (DoD) and the University of Hawaii employed the most public sector technology workers.
- Technology companies in Hawaii represented a smaller proportion of total employment (3.6 percent), than do technology companies in the overall US economy (4.6 percent)

Between 2002 and 2007, employment within Hawaii’s private sector technology companies grew at an annual average rate of 3.3 percent—and added 3,557 net new private sector jobs.

- Hawaii outpaced the US annual employment growth rate of 1.8 percent for the private sector technology industries between 2002 and 2007.

- Employment in Hawaii’s public technology activities grew at a more modest 1.8 percent per year between 2002 and 2007, representing 601 net new jobs
- Employment projections suggest that the private technology sector is likely to grow at about 2.1 percent annually during the coming decade – 61 percent faster than the rest of Hawaii’s economy.

Workers in technology sectors accounted for 3.6 percent of total employment in 2007, but they generated 5.4 percent of Hawaii’s total worker earnings³ (\$2.1 billion).

3. Data are provided by EMSI based on US BEA data. According to the BEA, earnings represent the combined income earned from wages and salaries as well as fringe benefits and proprietors’ income. For all industries, non-wage earnings tend to be about 25 percent of total personal income, but the proportion can vary significantly by sector.

- Workers in Hawaii’s private technology sector earned an annual average of \$63,623—38 percent more than the average worker in Hawaii. Tech workers earned about \$1,500 more per month in total earnings than the average worker.
- When public sector workers are included, the average earnings were \$68,935 — 50 percent higher than the statewide average.
- However, the state’s technology workers earned less than their counterparts on the mainland. Hawaii’s workers across the whole economy earned about 94 percent the US average for all workers

ES Figure 1: Annual Earnings by Commercial Market Segment, 2007

MARKET SEGMENT	GROWTH RATE (2002-2007 EMP.)	AVERAGE EARNINGS (2007)
Agricultural Biotech	6.4%	\$53,866
Astronomy	3.6%	\$70,951
Biotech/Life Sciences	2.3%	\$54,532
Defense/Aerospace	4.1%	\$76,697
Energy	8.4%	\$58,498
Environmental	4.0%	\$66,971
Film/Digital Media	0.2%	\$73,335
ICT	2.5%	\$75,056
Ocean Sciences	5.2%	\$53,959
Engineering	3.8%	\$80,799
Overall Tech	3.3%	\$63,623
Overall HI Economy	2.5%	\$45,963

Note: Earnings reflect the combined value of wage and salary income as well as other non-wage earnings including retirement pay and fringe benefits.

ES Figure 2: Sector Employment by Island

COUNTY	PRIVATE SECTOR	PUBLIC SECTOR	COMBINED TECH EMPLOYMENT	ALL JOBS	% OF TOTAL EMPLOYMENT
Honolulu	19,160	6,728	25,888	621,569	4.2%
Maui	1,847	39	1,886	100,971	1.9%
Hawaii	1,681	215	1,896	95,831	2.0%
Kauai	933	69	1,002	43,235	2.3%
State of Hawaii	23,985	7,121	31,106	861,608	3.6%

- The disparity was even greater in Hawaii’s private technology sector. These workers earned about 72 percent of the US average for workers in those same private sector industries.

There were 1,964 science and technology companies and organizations (including public and private sector organizations) in the State of Hawaii in 2007. These companies represented approximately 5 percent of all establishments.

- The private sector accounted for 96 percent of these establishments.
- Science and technology companies tended to employ fewer workers. The average tech company had 15.8 workers—about two-thirds the size of the average Hawaii company.

MARKET SEGMENTS DRIVING HAWAII’S TECHNOLOGY AND INNOVATION

Hawaii’s science and technology industries can be categorized into one or more commercial market segments. These segments were determined by interviewing and surveying Hawaii companies, and

categorizing them according to the markets they target for their products and services. These segments employ workers in the public as well as the private sector, but they also include overlapping industries. As a result, they reflect the multi-disciplinary nature of many technologies and the convergence of many market opportunities. This research identified ten commercial market segments. Their characteristics in Hawaii are described below:

- **Agricultural Biotechnologies:** This market segment represents part of the broader life sciences market segment (as defined by the Biotechnology Industry Organization). Agricultural biotechnologies in Hawaii focus on food hybridization and marine sciences research. Due in large part to the seed industry’s rapid growth, this market segment grew 6.4 percent annually over the past five years. Average annual earnings were \$53,866 in 2007.
- **Astronomy:** While astronomy is the smallest of the state’s market segments, it is the most prominent science and technology activity on the Islands of Hawaii and Maui. The state’s mountains offer the finest viewing locations on the planet, and Mauna Kea currently has the largest observatories in the world. The segment grew 3.6 percent annually during the past five years, and workers earned an average of \$70,951 per year in 2007.



Sample 3D digital ahupua’a created at Hyperspective Studios in Honolulu, one of Hawaii’s digital media companies. (courtesy of Hyperspective Studios, Inc.)

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- **Biotechnology/Life Sciences:** The biotechnology/life sciences market segment—a segment distinct from the agricultural biotechnology—is largely driven by significant biomedical and bioinformatics research activities. In addition to research-related activities, this market segment also includes significant data management and analysis activities. The segment grew 2.3 percent annually between 2002 and 2007 and offered average annual earnings of \$54,532.
- **Defense/Aerospace:** This is the second largest commercial market segment. Over the past five years, it grew 4.1 percent annually due mainly to recent increases in U.S. defense spending. DOD agencies in Hawaii have a sizable employment base in science and technology occupations. Within the private sector, defense-related technology activities focus heavily in areas such as computer design, information technology, communications and sensors. Successful dual-use strategies may be critical for continued growth among companies in this commercial market segment. Average earnings were \$76,697 per year in 2007.
- **Renewable Energy:** Employment in the renewable energy industries grew 8.4 percent annually during the past five years and workers earned an average of \$58,498 per year. Historically, government policies drive renewable energy demands in most markets. The state's Renewable Portfolio Standard requires that 20 percent of energy be derived from renewable sources by 2020. Currently, much of the sector's activity is in the consulting and management services

BIGSTOCKPHOTO.COM © M. BRAKE



The ocean sciences market segment is growing at an annual rate of 5.2%, and converges with defense, information technologies, engineering, life sciences, and energy.

industries with some research and testing activities supporting those efforts.

- **Environmental:** Environmental remediation and consulting services, including environmental management and prevention activities, overlaps significantly with the technical and engineering services segment. Many companies operating in the environmental market segment do so as part of a larger set of business activities, including defense-funded projects. This segment grew 4.0 percent annually between 2002 and 2007 and offered average earnings of \$66,971 per year.
 - **Digital Media:** Digital media is the technology-intensive component of the state's much larger film or 'Creative Arts' industry. It is relatively small and exists at the convergence between film/music production and information technology to support commercial production as well as computer entertainment.
- Consequently, it is difficult to specify the exact number of people working in the industry. Based on an estimate of the key involved industries, Digital Media added new employment relatively slowly—about 0.2 percent—annually over the past five years. Last year, Average earnings were \$73,335 per year.
- **Information and Communications Technology (ICT):** ICT is the state's largest technology-related commercial market segment (based on employment) and is closely tied to the defense sector. Growing 2.5 percent annually since 2002, the segment includes activities related to custom computer programming and design services as well as computer facilities management. Last year, average earnings were \$75,056 per year.
 - **Ocean Sciences:** The ocean sciences market segment

converges with defense, information technologies, engineering, life sciences, and energy. Not surprisingly, companies and researchers in this field fall into other categories as well. Research activities being undertaken by the Navy, NOAA, and the University of Hawaii (UH) drive much of this market segment's growth. Between 2002 and 2007, this growth occurred at an annual rate of 5.2 percent. Workers earned an average of \$53,959 annually in 2007.

- **Engineering/Professional Services:** Engineering and Professional Technical Services represent a cross-section of industries largely involved in engineering (excluding civil engineering) and architectural design. The market segment grew 3.8 percent annually between 2002 and 2007 and offered workers average earnings of \$80,799 per year.

ISLAND HIGHLIGHTS

4,784 technology-related jobs were located on the neighbor islands in 2007. This represented 17 percent of total technology sector employment.

- Maui and the Island of Hawaii each had almost 1,900 technology-related jobs, while Kauai had approximately 1,000.

In 2007, Kauai had the smallest science and technology workforce. However, it grew 6.3 percent annually between 2002 and 2007, thereby making it the fastest growing technology sector of any island.

- The Pacific Missile Range Facility (PMRF) generated the majority of Kauai's science and technology

related employment and is the island's 3rd largest employer.

- Kauai remains an important site for several of the state's major seed producers.

Astronomy is prominent on the Island of Hawaii, as the observatories on Mauna Kea represent the world's finest viewing platforms and the largest observatories in the world.

- The Island has 13 astronomical facilities, including two 10-Meter telescopes at the W.M. Keck Observatories. Combined, these facilities represent more than \$1 billion of infrastructure. A proposed new extra large telescope, Thirty Meter Telescope (TMT) is being considered for Mauna Kea that could result in another \$1 billion in new investment and 430 more jobs.
- Companies in astronomy on the Island of Hawaii offer workers the highest average earnings at \$81,748 per year of any technology market

segment on the Island - a figure 58 percent higher than the average earnings for all tech-related jobs on the Island of Hawaii.

- The Island of Hawaii is producing the highest level (estimated at 37 percent) of renewable energy in the State of Hawaii with the added advantage of geothermal sources.

Maui's largest commercial market segments are in defense/aerospace and information and communications technology (ICT). These activities are driven partly by the activities occurring at the Maui High Performance Computing Center (MHPCC) and the Haleakala High Altitude Observatory Site.

- Maui and Molokai also represent important sites for the state's burgeoning seed industry.
- Maui's energy needs are increasingly being met by a variety of alternative energy activities (including wind, solar, and bio-fuels).



On Kauai, the defense/aerospace market segment is driven almost entirely by activity at the Pacific Missile Range Facility (PMRF) also generating \$3 million in tourism activity for each launch. (Courtesy of KEDB)

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The Maui Digital Bus, a mobile laboratory designed to cultivate student interest in becoming scientists and engineers, is operated and equipped by Akimeka, LLC, with digital cameras and microscopes, water-testing equipment, Global Positioning System devices and laptop computers, (courtesy of The Maui Digital Bus-Alaka'ina Foundation).

In 2007, Oahu accounted for 72 percent of the state's total employment, but 83 percent of the state's science and technology employment.

- 94.5 percent of all public sector science and technology workers were located on Oahu.
- Last year, science and technology workers represented 4.2 percent of Oahu's total employment.

Last year, a majority of Oahu's science and technology employment were found within the defense/aerospace and the ICT commercial market segments.

- The large federal and military presence drives much of the science and technology employment on Oahu.

- The University of Hawaii in Manoa contributes to the high concentration of research in areas such as life sciences and ocean sciences on Oahu.
- Major seed producers also have a significant presence on Oahu.

HAWAII'S SCIENCE AND TECHNOLOGY WORKFORCE

Workers in a variety of industries fill science, technology, engineering and mathematics (STEM) occupations, but they are particularly critical to the state's technology industries.

- STEM occupations accounted for about 58,442 jobs in Hawaii in 2007; a large share was employed by tech companies, but many were employed in Hawaii's traditional industries.

- STEM occupations are expected to demand about 1,650 new workers per year (to fill vacant positions as well as newly created jobs).
- About 77 percent of those jobs will require postsecondary education and about 17 percent more will require at least one year of on-the-job training and work experience.

Hawaii's community colleges and universities offer a wide array of the STEM programs needed to grow the state's science and technology industries. However, business and management programs are also important for growing small and entrepreneurial science and technology businesses.

UH graduated a combined 88 new engineers (from its baccalaureate and advanced degree programs) in 2006.

- All of the state's companies and government entities (including those outside the technology sector) annually need about 100 electrical engineers to fill projected existing and newly created jobs.
- Companies will also need a wide range of mechanical, industrial, and related engineers, totaling about 35 to 50 more annually to fill their new and existing job vacancies each year.
- If no graduates leave Hawaii, Hawaii companies will have to import about 60 to 70 new engineers annually to meet their overall engineering workforce needs.
- An available, globally competitive talent pool with appropriate science technology, engineering and math skills, and
- An appreciation for the state's heritage and the need to balance the role of technology within the state's unique culture

With these factors in mind and taking into consideration the input from all partners and stakeholders, the consultants offered the following policy recommendations:

1. In collaboration with private and public sector stakeholders, develop and implement a strategic plan, and then monitor progress in achieving greater development of technology and innovation in the state.
2. Diversify the state's technology base by encouraging private investment in non-defense activities and by increasing local commercialization of technology developed with Defense Department funding.
3. Support existing professional and trade group efforts to develop cluster networks that support the key technology market segments.
4. Assist the formation of risk capital for all stages of research and commercialization and continued private sector investment in technology and innovation.
5. Design a comprehensive technology workforce retention strategy to reduce turnover and keep talent in Hawaii.
6. Monitor the contribution of the state's technology sector to the overall economy, and especially the state's growth opportunities in global technology value chains.
7. Assess how well the state's entire business incentive portfolio has fostered private sector investment in technology, innovation, and related value chains.
8. Enhance the workforce programs designed to both increase internships with technology companies and provide information about STEM careers.
9. Systematically examine how two-year and four-year degree programs at UH and the private universities can better meet industry needs, either through the expansion of existing programs or the development of new programs.
10. Develop a community consensus building process that establishes greater understanding between technology advocates and the state's traditional business leadership.

RECOMMENDATIONS

These findings reveal several key factors for success:

A vision and plan for promoting private and public investment in Hawaii's innovation and technology sectors

- Information about the factors that influence growth, as well as the most efficient ways to encourage technology-based economic development (TBED)
- A deeper and more diverse technology base to take advantage of emerging opportunities
- Increased networking across industry sectors
- The availability of risk capital for all stages of research and commercialization

Introduction

Hawaii's leaders recognize the importance of diversifying the state's economic base in order to create new and better jobs for the state's residents. Traditional sources of growth include government and military activities, as well as Mainland and foreign companies moving to or investing in the state. However, sustained high-quality job creation requires a flourishing entrepreneurial sector as well. The state's economic success also requires Hawaii's existing companies to continuously reshape and enhance their international competitive positions.

Innovation increasingly drives business competitiveness and creates new market opportunities in advanced industrialized nations where the cost of doing business is relatively high and companies have access to comparatively advanced infrastructure and workers with high levels of education. Innovation is at the heart of productivity growth that, in turn, can help to increase wages and free resources for investment in new product areas or industries. This new investment can, in turn, generate new growth in new industries capable of offsetting declines in traditional ones. Innovation-based economies are more likely to sustain themselves and become more prosperous by regenerating into higher value activities.

This report begins by identifying technology-oriented industries and businesses. These are the businesses that are most likely to be either engaging in innovation in the Islands or tapping innovations developed elsewhere. These businesses are described as comprising Hawaii's

technology sector. It then analyzes the interrelated technology-oriented markets that are served by the state's existing mix of technology companies.

Hawaii's leaders understand the importance of innovation as a mechanism for creating a more productive and prosperous economy.

Private-sector innovation thrives in places where knowledge creation, entrepreneurship, and risk-taking are valued, and where a creative and talented workforce is available.

Indeed, Senator Daniel K. Inouye and the congressional delegation, Governor Linda Lingle, the Hawaii state Legislature, and many other key leaders in Hawaii have identified innovation as essential to the state's economic future. Many in Hawaii also believe that innovation is a critical element in addressing priority social issues challenging the state. These issues include the relative lack of sufficient affordable housing, the rapidly rising cost of living in general, the increasing socioeconomic disparity (the widening gap between the "haves" and "have nots"), the availability and affordability of healthcare, the need to develop renewable energy sources, challenges in the provision of quality education, and demands for more efficient and responsive government.

Private-sector innovation thrives in places where knowledge creation, entrepreneurship, and risk-taking are valued, and where a creative and talented workforce is available. However, the public-sector also plays an important role in nurturing an environment that encourages innovation and takes advantage

of opportunities emerging from businesses, colleges and universities, and public and private research laboratories. This can and should be done through the public-sector's central role in education and workforce development, infrastructure provision, taxation and regulation, land management and planning, and economic development. However, crafting effective and broad-based economic development strategies requires an in-depth understanding of the role of innovation in Hawaii's economy. Identifying and documenting that role is the purpose of this report.

INNOVATION AND HAWAII'S TECHNOLOGY SECTOR

Businesses innovate in three basic ways: through the creation of new products or services (most often through the use of existing and emerging knowledge and technologies that meet new market demands); through the deployment of new techniques and technologies to produce goods or services in uniquely efficient ways; and through the more effective organization of work. Innovation can occur in any economic sector, from the state's most traditional industries to its high-technology businesses and most state-of-the-art research facilities. Spillovers between innovating sectors are also critical to the process. Thus, innovation is not simply relevant to technology-oriented businesses or to technology workers. Innovation creates more and better jobs not only for scientists, engineers, and high-level managers, but also for workers in a wide variety of support and linked roles, as well as workers in

Introduction

the region's traditional industries.⁴ Due to the high degree of interdependence in the economy, innovation touches all kinds of industries, from the "low tech" to the "high tech." This report attempts to provide a baseline measure of the size and scope of the state's technology sector.

HAWAII'S TECHNOLOGY SECTOR TALENT POOL

The growth of the state's technology sector is contingent on an available talent pool. If existing residents are not prepared for emerging employment opportunities, the jobs will go to workers attracted from the Mainland or abroad or, barring a sufficient rate of in-migration, the growth of the industries will be constrained by labor shortages. Ensuring that technology-oriented growth produces widely shared prosperity, and not a worsening in the distribution of incomes in the state, requires an appropriate and proactive workforce development strategy in conjunction with a technology-oriented economic development strategy. This report also seeks to provide a foundation for identifying education and training needs as well as key educational assets that will help to prepare a new generation of Hawaii residents for the relatively high-paying jobs in Hawaii's technology sector.

The research in this report relies heavily on quantitative statistics derived primarily from published data sources. To supplement that data, the research

4. Atkinson, R. and Wial. "Boosting Productivity, Innovation, and Growth Through a National Innovation Foundation," Brookings Metropolitan Policy Program, April 2008, p. 4.



Kauai Economic Development Board Aloha Ike program an example of outreach education for math and science (courtesy of Pioneer Hi-Bred).

team also interviewed numerous representatives from technology companies, institutions, and workers located on the islands of Kauai, Hawaii, Maui, and Oahu. From these interviews

As the state's costs continue to rise, new jobs that offer higher-than-average wages will be increasingly important to sustain and enhance economic prosperity.

and focus groups, the research team derived input on important business challenges and issues, efforts to build networks and partnerships, and insights on the growth potential of the technology sector in Hawaii.

The research makes clear that Hawaii will always remain unique. Hawaii's distinctive assets and location will undoubtedly remain important drivers

for its economic future. Moreover, the state's location has long made it an important strategic military post for the U.S. However, as military technology, strategies, and priorities change, and Hawaii's residents demand better opportunities for themselves and their children, it will be increasingly important for the state to find new economic opportunities to supplement its traditional advantages in tourism and defense. As the state's costs continue to rise, new jobs that offer higher-than-average wages will be increasingly important to sustain and enhance economic prosperity. In the following pages, this report examines the nature and scope of the state's technology sector, and its capacity to create economic opportunities for the residents of Hawaii.

Overview of Hawaii's "Technology Sector"

In the context of the state's overall economy, the technology sector (which is comprised of a number of individual industry sectors) is certainly important, but, taken as a whole, the technology sector is not nearly as big as the state's current largest employing industries. For generations, tourism, the military, and agriculture dominated Hawaii's economic landscape. It is important to describe their relative impact as a way to establish the technology sector's relative importance. Agriculture has waned as a major economic driver, but tourism and the military remain vital parts of the economy.

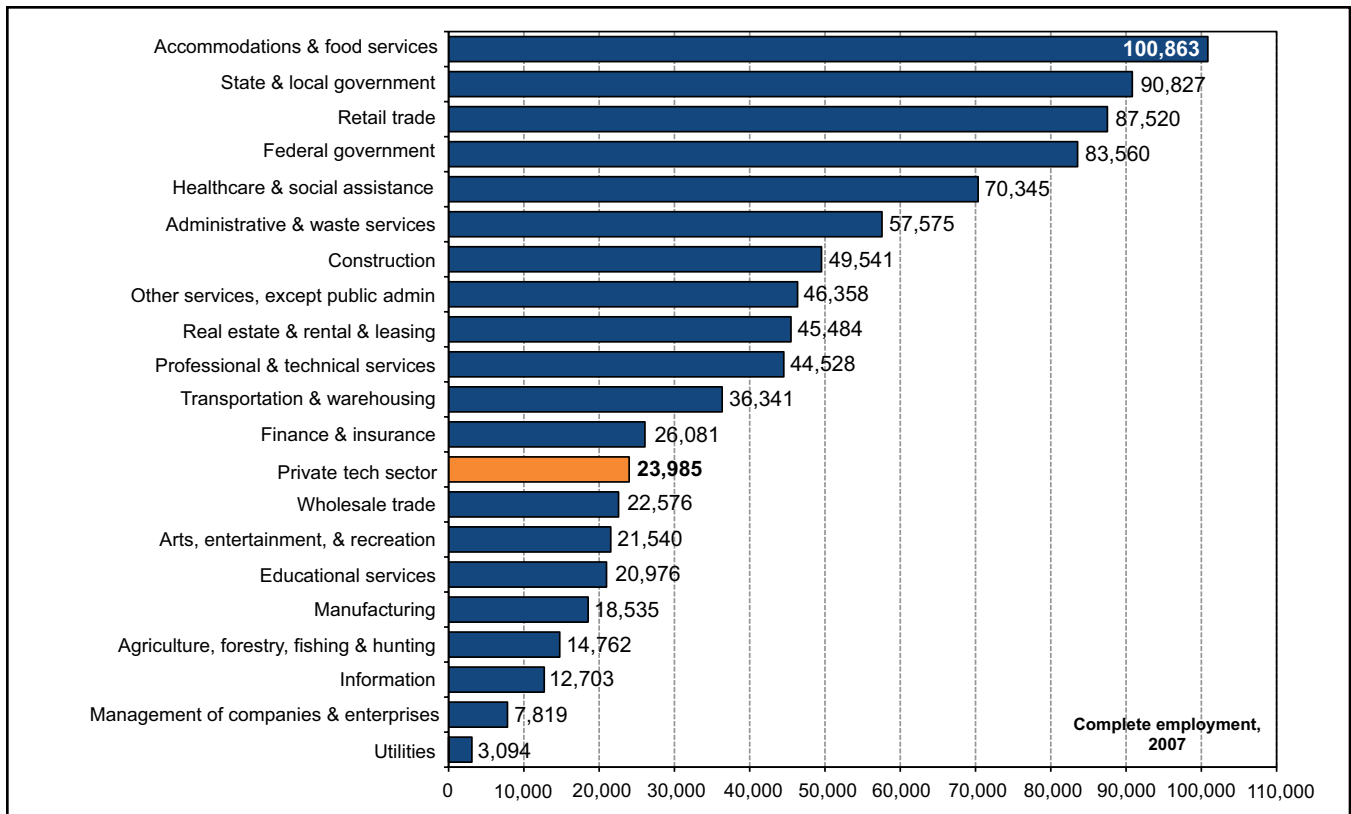
In 2007, the U.S. Bureau of Economic Analysis reported that economic output related to tourism-reliant services, the federal defense sector, and agriculture

represented more than 17 percent of the state's \$61.5 billion economy. The accommodations industry represented the single largest segment of the state's tourism industry, alone accounting for about 5.6 percent of state gross domestic product (GDP).⁵ Federal civilian and military expenditures accounted for another 11.5 percent of the state's GDP. Nationally, these two economic sectors combined to comprise only 5.4 percent of the U.S. gross domestic product (GDP), so they were over three times more concentrated in terms of relative economic output in Hawaii as they were in the U.S. as a whole.

5. All percentages of GDP in this report are estimated using U.S. Bureau of Economic Analysis (BEA) methodology, with the ratio of tech-sector earnings to GDP.

Between 2002 and 2007, the state benefited from growth in both tourism and defense. Hawaii's accommodations industry increased at a rate of about 4.2 percent annually (as compared with 3.9 percent for the nation) and its military expenditures grew 2.7 percent annually while spending nationally grew at 1.4 percent annually. These trends represented a turnaround for Hawaii, as prior to 2002 growth in both sectors lagged behind the rest of the nation. However, increased fuel prices, rising airline ticket prices, and reduced airline carrying capacity suggest that the state's tourism economy will face significant challenges in the months and years ahead. Likewise, changes in defense policy priorities and continued strains on the U.S. budget point to a

Figure 1: Industry Employment in the Hawaii Economy, 2007



Overview of Hawaii's "Technology Sector"

future in which military spending in Hawaii could either stagnate or even decline.

Not surprisingly, the tourism-related and federal civilian/military sectors were also among the state's largest employing sectors in 2007. The state's accommodations and food services industry provided more than 100,000 jobs, representing 11.7 percent of the state's nearly 870,000 jobs (See Figure 1).⁶ About 84,000, or 10 percent of the state's workers, were employed in federal military or civilian agency jobs. Average income for the two sectors was significantly different, however. Average income earned for federal workers was \$85,081 while the average income for accommodations industry workers was \$43,978.⁷ Figure 1 also compares total employment in private technology-related industries (to be defined below). Last year, the private-sector component of Hawaii's technology sector was nearly the size of Hawaii's financial sector.

6. Data are provided by EMSI based on U.S. BEA data. According to the BEA, earnings represent the combined income earned from wages and salaries as well as fringe benefits and proprietors' income. For all industries, non-wage earnings tend to be about 25 percent of total personal income, but the proportion can vary significantly by sector. For instance, average wages in federal agencies are about 62 percent of average earnings for federal workers in Hawaii due to the current benefits offered to federal employees, including cost of living allowance, healthcare and retirement contributions, as well as pensions paid (including the amount paid to retirees no longer in the workforce).

7. Data are provided by EMSI based on U.S. BEA data. According to the BEA, earnings represent the combined income earned from wages and salaries as well as fringe benefits and proprietors' income. For all industries, non-wage earnings tend to be about 25 percent of total personal income, but the proportion can vary significantly by sector. For instance, average wages in federal agencies are about 62 percent of average earnings for federal workers in Hawaii due to the current benefits offered to federal employees, including cost of living allowance, healthcare and retirement contributions, as well as pensions paid (including the amount paid to retirees no longer in the workforce).

While the state's economy remains relatively healthy, the significant difference between the earnings of federal personnel as compared with food and accommodations workers illustrates the tremendous divide among Hawaii residents in their ability to afford a high quality of life in their home state. As Hawaii seeks to diversify its economic base, the state's technology sector could represent an important "third leg" in supporting the Hawaii economy and providing quality jobs for middle-class Hawaii residents.

DEFINING TECHNOLOGY INDUSTRIES

Defining the industries that comprise a singular "technology sector" has always posed a challenge for the economic development community. Numerous organizations have developed their own approach and no single standard exists. The real objective is not the precise definition of the sector, but how Hawaii can better position itself to develop and benefit from products and services emerging from scientific research and development. From this perspective, the best overall definition identifies and measures activities throughout the entire spectrum of the technology process—from basic scientific research all the way to the technology-related end products and services produced. Due to their importance, this definition should also incorporate the key activities that

Last year, the private-sector component of Hawaii's technology sector was nearly the size of Hawaii's financial sector.

support science and technology, (e.g., testing labs, data processing capacity, education, etc.). With this broader identification of the technology sector, pockets or clusters of opportunity and potential can more easily be identified for special attention.

Using nationally recognized definitions adapted to Hawaii's unique economy, the team identified a set of economic sectors (or components of those sectors) to be included in the definition of Hawaii's technology sector used for this report.⁸ Overall, Hawaii's public and private technology sectors employed 31,106 people in a total of 1,964 establishments in 2007.

The great majority of Hawaii's technology workers are employed largely in the private-sector. In 2007 there were 23,985 technology workers employed by private-sector establishments, and an estimated 7,121 workers by public-sector entities. As Figure 2 illustrates, overall technology-sector employment grew at an annual rate of 2.9 percent from 2002 to 2007,

8. The specific industries included in the definition, and their rationale for inclusion, can be found in Technical Appendix 2: Defining Hawaii's Technology and Innovation Industry Sectors at <http://www.HISciTech.org/Information>.

Figure 2: Hawaii's Technology Employment in the Private- and Public-Sector

TECHNOLOGY EMPLOYMENT	2002 JOBS	2007 JOBS	CHANGE	ANNUAL % CHANGE	EARNINGS PER WORKER, HAWAII
Private-sector	20,428	23,985	3,557	3.3%	\$63,623
Public-sector	6,520	7,121	601	1.8%	\$86,937
All Hawaii Tech Employment	26,948	31,106	4,158	2.9%	\$68,935

Overview of Hawaii's "Technology Sector"

faster than the 2.5 percent for the rest of the economy (despite the slow increase in the number of public-sector technology workers). In Hawaii, the private tech sector grew at 3.3 percent annually between 2002 and 2007—a pace faster than the state's public-tech sector, which grew at 1.8 percent annually during the same period. Growth in the state's public- and private-tech sectors is projected to slow to a pace of 1.9 percent annually over the next decade. However, at a projected 2.1 percent annual growth rate, the state's technology sector is expected to grow 61 percent faster than the overall Hawaii economy. On average, public- and private-sector technology workers earned \$68,935 in 2007. That was more than 50 percent greater than the average earnings for jobholders in Hawaii.

PRIVATE-SECTOR TECHNOLOGY INDUSTRIES

Last year, Hawaii's 23,985 workers employed by private-sector tech companies represented 5.0 percent of the state's 1,895 private-sector establishments and 2.8 percent of the state's total employment. Nationally,

Hawaii's private technology sector employment grew 3.3 % annually between 2002 and 2007, outpacing the state's overall 2.5% economic growth for the same period.

private-sector industries accounted for 4.5 percent of all U.S. jobs.⁹ Combined, Hawaii's private-sector companies contributed an estimated \$2.4 billion to Hawaii's economy, representing about 3.9 percent of the state's GDP.¹⁰

9. Estimates of the number of US establishment data for 2007 is not readily available so comparisons were not made to the share of US establishments in technology industries or in the average US establishment size.

10. This estimate was developed by applying a ratio of 2007 earnings to gross domestic product

Figure 3: Hawaii Private-Sector Science & Technology Impacts

EMPLOYMENT (PVT SECTOR)	MULTIPLIER	INDIRECT JOBS
23,985	0.84	20,147

The *direct* economic benefits to Hawaii from private-sector technology-related jobs are also "multiplied" into other parts of the economy. Our analysis of the impact of such multiplier effects suggests that last year the state's private technology sector was associated with another 20,147 jobs in "indirect" and "induced" jobs outside the technology and innovation sector itself.¹¹ *Indirect impacts* occur when companies outside the technology sector benefit from the money spent by science and technology companies in the state.

These impacts represent linkages between industries in which technology companies are buying from and selling to other companies.¹² This local spending may include purchases of office supplies, hotel room nights for business visitors, as well as legal and accounting services that help technology businesses monitor

by industry to each industry defined as part of the "technology sector."

11. This ripple effect from direct science and technology employment was determined based on a model constructed from data generated through business surveys conducted every five years by the Census Bureau and then analyzed by economists at the U.S. Bureau of Economic Analysis. These economists as well as economists at private companies (including the model used in this analysis constructed by Economic Modeling Specialists Inc.—www.economicmodeling.com) have developed estimates that suggest how much each industry within each state spends and how that is likely to affect the local economy. These estimates were used in determining the multiplier effect of technology industries within Hawaii.

12. For a more detailed discussion of how value chain analysis—particularly as it related to R&D services and custom computing industries—can be used to identify supplier and market opportunities for companies both in and out of the state, please see Technical Appendix 3: Value Chains available at <http://www.HISciTech.org/Information>.

their financial performance. Induced impacts are the result of employees of science and technology companies also spending their money in the state—to buy groceries, housing, utilities, and a number of other consumer services. Combined, these indirect and induced effects are referred to as "multipliers"—the money earned by the science and technology companies that is in turn re-spent in the economy.

Looking at just the next five years, (as compared with the next decade above), the annual employment growth rate is projected to slow to 1.6 percent for all industries in Hawaii, but these private-sector technology industries are expected to continue growing at a relatively healthy 2.5 percent annual rate.¹³

PUBLIC-SECTOR TECHNOLOGY EMPLOYMENT

Employment in public-sector agencies will not likely match the growth in the private-sector. Yet, many federal, state, and university centers conduct extensive research and development at their facilities throughout Hawaii. These public-sector enterprises account for 23 percent of the state's technology-related activity and employment. By comparison, federal, state, and local government comprise 20 percent of total employment in Hawaii.

In 2007, 48 federal agencies employed 3,304 workers in occupations related to science, technology, engineering, and mathematics (STEM) disciplines,¹⁴ including 2,817 in 39 U.S. Department

13. Unless otherwise noted, industry and occupation projections for private-sector agencies are provided by Economic Modeling Specialists Inc. (EMSI), based on data available as of April 2008.

14. For the purposes of this analysis, federal agencies' STEM occupations defined by the U.S. Bureau of Labor Statistics include only those occupations categorized as scientists, technologists or technicians, engineers, and mathematicians or statisticians.

Overview of Hawaii's "Technology Sector"

Examples of public-sector technology employers include the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish & Wildlife Service, the state Department of Land and Natural Resources division of Aquatic Resources, and the University of Hawaii system.

of Defense agencies and 487 at the National Oceanic and Atmospheric Administration (NOAA) and the National Institute of Science and Technology at the Department of Commerce; the Agricultural Research Service, Forest Service, Natural Resources Conservation Service, National Agricultural Statistics Service, and the Office of the Chief Information Officer at the USDA; and the Geological Survey and the U.S. Fish & Wildlife Service at the U.S. Department of Interior.¹⁵

At the state level, the Department of Land and Natural Resources divisions of Fisheries and Recreational Enhancement, Forestry, Aquatic Resources, Natural and Water Resources, Natural Area Reserves, and Natural and Physical Environment employed 210 technology workers in 2008, primarily in environmental management and ocean sciences-related activities.¹⁶

The University of Hawaii has a number of faculty members teaching and conducting research in science and technology-related fields. The research and teaching centers employ a total of 2,700 employees. According to 2008

15. Projections for employment in Federal and state agencies as well as the University of Hawaii were not readily available. Estimates for future employment changes were developed based on changes in past employment between 2002 and 2007 for individual agencies, and then projecting that data forward to 2017.

16. Source: Employment estimates based on the full-time equivalent personnel authorized for the agency in the Hawaii FY 2008 budget.

UH data, an estimated 2,332 workers in this group participate directly in research programs in the physical sciences, engineering, or life sciences. Key programs at the Manoa campus include the College of Natural Sciences, the College of Tropical Agriculture and Human Resources, the College of Engineering, the School of Medicine, the School of Ocean and Earth Science & Technology, and the Cancer Research Center. The UH Hilo campus also makes significant contributions to the state's research base with faculty serving in the Natural Sciences Division of the College of Arts & Sciences as well as the College of Agriculture and the College of Pharmacy.

The Research Corporation of the University of Hawaii (RCUH) separately employs researchers and support personnel under sponsored grants and related program activities. In addition to personnel working alongside regular UH employees in the college of Natural Sciences, the College of Engineering, the School of Ocean and Earth Science and Technology, as well as the School of Medicine and the Cancer Research Center, RCUH also employs workers for a variety of research centers such as the Institute for Marine Biology, Geophysics and Planetology in Manoa, the Natural Energy Institute, the Joint Institute for Marine and Atmospheric Research, the Institute for Astronomy, the Pacific Biomedical Research Center, and the Water Research for Hawaii and the Pacific. These RCUH employees—counted separately from regular UH faculty—total 1,377 researchers and support personnel involved in research in these program areas. Adjusted for 2007, the combined university and RCUH employment in these programs is estimated at 3,607.¹⁷

17. The data provided by the university was for 2008 and by RCUH was for 2005 and 2008. The authors estimated 2007 data based on an

In total, federal, state, and university activities in Hawaii accounted for an estimated 7,121 technology workers in 2007. Based on historical data available for certain years, the research team estimated that employment in these agencies and organizations grew at a rate of about 1.8 percent annually during the past five years. This represents an increase of 601 workers since 2002, nearly half of which were employed by DOD agencies (especially the U.S. Navy). Future projections suggest that this growth rate will likely slow to 0.3 percent annual growth due to tightening federal and state budgets as well as changing policy priorities.¹⁸

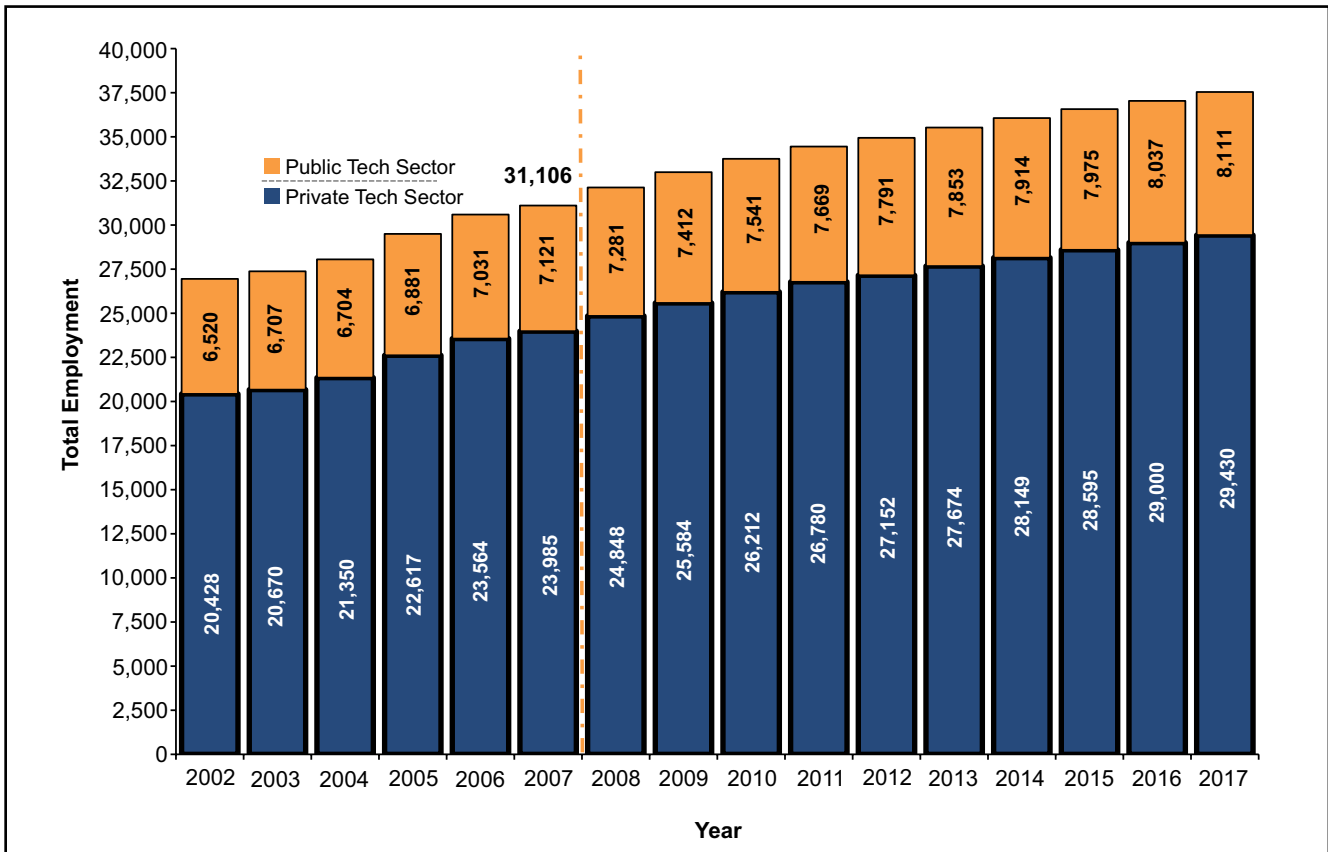
Public-sector technology agencies pay relatively well when compared with all other jobs, and even with private-sector technology-related jobs. The average earnings for public-sector employees in STEM occupations were \$92,519 in 2007 (including salary, all fringe benefits, and retirement pay). From among this group of public-sector technology workers, average earnings for federal employees were \$114,494.

It should be noted that the average earnings data reported for federal workers may overstate the immediate benefits to workers in Hawaii because generous benefits and pension contributions and payments increase the per-person average earnings. The impact of pension annuities on total wage bills, and the proportion of workers who are full-time employees, makes it challenging to compare public-sector earnings and employment with the private-sector. For instance, federal earnings appear to be relatively high compared with the private-sector, but

interpolation based on data made available for this report.

18. Source: EMSI

Figure 4: Employment Trends in the Hawaii Technology Sector



this may be due to retirement pay going to federal retirees living in Hawaii.

A closer inspection of wages and salaries, as reported by the U.S. Office of Personnel Management (OPM), revealed that the average federal worker living in Hawaii and working in a technology occupation was paid \$70,249 in wage and salary income in 2007. Presumably, the remaining \$44,245 per worker in earnings is attributable to fringe benefits provided to current and past federal employees living in Hawaii.

Furthermore, an analysis of Hawaii Department of Land and Natural Resources budget data suggest that the average wages paid to all state workers in the agency's technology-related divisions was estimated at \$65,510. Unlike the federal employment numbers report, this group includes administrative support personnel as well as technology occupations. While comparable data for UH were not readily available, RCUH reports that the average annual wage paid to grant-sponsored researchers and

support personnel was \$48,417 in 2007. It is notable that the RCUH data also includes graduate or undergraduate assistants and other part-time personnel supported by grants to the university. It is likely, due to the nature of the funding for these personnel, that RCUH employs many more temporary workers and research assistants than the rest of the university and certainly more than the technology-oriented federal and state agencies.



Markets Driving Hawaii's Technology Sector

In order to understand Hawaii's technology markets, the research team built upon data accessed from long-standing national and state databases. The methodology is outlined here to help clarify our understanding of Hawaii's tech sector markets.

To start the process, the Hawaii Science & Technology Institute developed a comprehensive database of technology companies and research organizations in Hawaii. This Industry Directory (available at www.HISciTech.org/Directory) offers an online "catalog" of Hawaii's products and services in science and technology. To date, more than 900 organizations are listed, with more added on a continuing basis. From on-going interaction with economic development professionals and technology firms in the state, the Institute identified 10 "commercial markets" that reflect how Hawaii science and technology companies tend to define themselves.



For this study, the definition of technology was adopted from the Bureau of Labor Statistics (BLS), with conservative modifications to improve its relevance for Hawaii.¹⁹ During the process of determining which industries (i.e., groups of companies) to include in this study's definition of the state's technology sector, the research team also conducted extensive analysis designed to assign these industries to commercial market segments. The state's technology companies registered with the Hawaii Science & Technology Industry Directory also provided sources

19. Please see Technical Appendix 2: Defining Hawaii's Technology and Innovation Industry Sectors available at <http://www.HISciTech.org/Information> for a full discussion.

of industry market information for this study. To supplement that information, economic development experts familiar with the state's technology companies reviewed a list of the largest technology firms that do not appear in the database and helped to complete the information about the commercial markets. As can be seen from the Industry Directory, it is quite common for companies to serve a variety of commercial markets.

That information was then used to estimate the total employment in 2006 for the coded companies in each commercial market segment. That resulted in data by market segment for several of the largest NAICS²⁰ industries identified as part of the technology sector. This process made it possible to estimate the number of workers in each commercial market segment for the key technology industries including research and development, custom computer programming, engineering, architectural services, environmental consulting, medical labs, and several others. To recognize the overlapping nature of the commercial market segments, industries that had at least 10 percent of their employment serving a commercial market segment were said to be integral to that segment. Consequently, the research team assigned the total employment of that industry to each commercial market segment in which it was found to be a substantial part. In this manner, many industries were assigned to more than one market segment.²¹ Thus the

20. NAICS stands for the North American Industry Classification System.

21. Once an industry was assigned to a commercial market through this research, the researchers further assumed that the industry and the market segment were linked in examining historical trends as well as projected market-segment opportunities.



The largest of the state's science and technology market segments is information and communications technology (ICT), followed closely by defense/aerospace.

employment figures in each market segment double count employees from other market segments, due to the overlap. Figure 5 shows the industries that comprise each of these commercial market segments.²²

These commercial market segments are discussed in greater detail below. Information was gathered about these market segments during the course of interviews with representative companies as well as a review of relevant research reports. As noted earlier, companies are frequently involved in a variety of commercial activities so it is quite common for executives to classify their company in multiple commercial market segments. Because of the convergence between the market segments, the total number of employees will be counted for each segment in which the company does business. As a result the employment for certain industries may be counted

22. More detailed wage and employment data for the industries that comprise these commercial market segments can be found in Technical Appendix 4: Industry Composition of Commercial Market Segments at <http://www.HISciTech.org/Information>.

Figure 5: Technology Sector Industries by Commercial Market Segment

HAWAII SCIENCE AND TECHNOLOGY INDUSTRIES

NAICS CODE	DESCRIPTION	COMMERCIAL MARKET SEGMENTS									
		01 AG BIOTECH	02 ASTRONOMY	03 BIOTECH/LIFE	04 ENVIRON.	05 FILM & DIG. MEDIA	06 DEF/ AERO	07 OCEAN SCI	08 ENERGY	09 ICT	10 ENG./PROF. SVCS
325211	PLASTICS MATERIAL AND RESIN MFG .	X		X							
325320	PESTICIDE AND OTHER AG. CHEMICAL MFG.	X		X							
325411	MEDICINAL AND BOTANICAL MFG .	X		X				X			
325412	PHARMACEUTICAL PREPARATION MFG .			X							
325414	OTHER BIOLOGICAL PRODUCT MFG .	X		X				X			
333314	OPTICAL INSTRUMENT AND LENS MFG.										
334510	ELECTRO-MED/THERAPEUTIC APPARATUS MFG .			X							
334516	ANALYTICAL LABORATORY INSTRUMENT MFG.			X							
339113	SURGICAL APPLIANCE AND SUPPLIES MFG .			X							
339115	OPHTHALMIC GOODS MFG .			X							
339116	DENTAL LABORATORIES			X							
423420	OFFICE EQUIPMENT MERCHANT WHOLESALERS									X	
423430	COMPUTER AND SOFTWARE MERCHANT WHOLESALERS			X						X	
423450	MEDICAL EQUIPMENT MERCHANT WHOLESALERS				X						
511210	SOFTWARE PUBLISHERS					X	X			X	
516110	INTERNET PUBLISHING AND BROADCASTING					X				X	
517510	CABLE AND OTHER PROGRAM DISTRIBUTION										
517910	OTHER TELECOMMUNICATIONS									X	
518111	INTERNET SERVICE PROVIDERS									X	
518112	WEB SEARCH PORTALS									X	
518210	DATA PROCESSING AND RELATED SERVICES			X			X			X	
541310	ARCHITECTURAL SERVICES				X					X	X
541320	LANDSCAPE ARCHITECTURAL SERVICES				X					X	
541332	ENGINEERING SERVICES (EXCEPT CIVIL ENGINEERING)				X		X				X
541360	GEOPHYSICAL SURVEYING AND MAPPING SERVICES			X				X	X		
541380	TESTING LABORATORIES			X	X						
541511	CUSTOM COMPUTER PROGRAMMING SERVICES					X	X			X	
541512	COMPUTER SYSTEMS DESIGN SERVICES						X			X	
541513	COMPUTER FACILITIES MANAGEMENT SERVICES			X						X	
541519	OTHER COMPUTER-RELATED SERVICES									X	
541611	ADMINISTRATIVE MGT CONSULTING SERVICES	X			X		X	X	X	X	X
541614	PROCESS AND LOGISTICS CONSULTING SERVICES					X	X			X	
541620	ENVIRONMENTAL CONSULTING SERVICES				X		X	X			X
541690	OTHER TECHNICAL CONSULTING SERVICES	X		X				X	X		
541711	R&D (BIOTECH, EXCEPT AG. BIOTECH)			X							
541711	R&D (AG. BIOTECH INC. CORN FARMING)	X		X							
541712	R&D-PHYSICAL, ENGINEERING — ASTRONOMY			X							
541712	R&D-PHYSICAL, ENGINEERING — OTHER						X		X	X	X
541720	SOCIAL SCIENCE AND HUMANITIES RESEARCH	X					X	X			
61131x	COLLEGES, UNIVERSITIES (UH)-AG. BIOTECH	X									
61131x	COLLEGES, UNIVERSITIES (UH/RCUH)-ENERGY								X		
61131x	COLLEGES, UNIVERSITIES (UH/RCUH)-LIFE SCI			X							
61131x	COLLEGES, UNIVERSITIES (RCUH)-OCEAN SCI	X			X			X			
61131x	COLLEGES, UNIVERSITIES (UH)-OCEAN SCI							X			
61131x	COLLEGES, UNIVERSITIES (UH/RCUH)-ASTRONOMY		X								
61131x	COLLEGES, UNIVERSITIES (RCUH)-OTHER TECH						X			X	X
61131x	COLLEGES, UNIVERSITIES (UH)—OTHER TECH									X	X
61131x	COLLEGES, UNIVERSITIES (UH)—ENGINEERING										X
61131x	COLLEGES, UNIVERSITIES (UH)—ENVIRONMENTAL				X						
621511	MEDICAL LABORATORIES			X							
621512	DIAGNOSTIC IMAGING CENTERS			X							
911001	FEDERAL USDA (STEM OCCUPATIONS ONLY)	X									X
911002	FEDERAL DOC (STEM OCCUPATIONS ONLY)				X			X		X	X
911003	FEDERAL DOI (STEM OCCUPATIONS ONLY)				X			X			X
911004	FEDERAL U.S. DOD (STEM OCCUPATIONS ONLY)						X			X	X
920211	STATE CONSERVATION (FISH AND AQUATIC)			X	X			X			
920212	STATE CONSERVATION (NATURAL RESOURCES)	X			X						

Markets Driving Hawaii's Technology Sector

more than once. Another way of counting the number of workers would have been to allocate the employees across the segments, prorating the numbers, but we opted to illustrate the ability of the companies to adapt across the market segments. Therefore the market segments are not summed up, because of the double counting.



INFORMATION AND COMMUNICATIONS TECHNOLOGY

In 2007, the largest of the state's science and technology market segments was information and communications technology (ICT) with 17,355 workers (about 13,900 of which were in the private-sector). ICT includes activities under the NAICS-defined "information" sector as well as related manufacturing, wholesaling, and programming activities. The Information sector comprises only establishments engaged in (a) producing and distributing information and cultural products, (b) providing the means to transmit or distribute these products as well as data or communications, and (c) processing data.

Federal, state, and university tech activities in Hawaii accounted for an estimated 7,121 technology workers in 2007.

The ICT market segment incorporated more than one-half of the state's total technology employment because its industries significantly overlap with other market segments, thereby providing an important infrastructure to every industry. ICT is particularly dependent on the state's defense/aerospace activities, but it also provides services to a broad array of other professional and business

services. For instance, the Maui High Performance Computing Center represents an example of how defense/aerospace and astronomy needs are tied to information technology solutions provided by enterprises located in Hawaii.

Looking to the future, the industries serving this high-wage commercial market segment are expected to add most of their jobs in activities related to custom computing and computer design as well as architectural design and environmental systems. While there are a few large companies in the state, in 2007 the average size for the state's ICT firms was 12.9 employees. By comparison, the average size of other Hawaii companies was 22.8 workers.



DEFENSE/AEROSPACE

Another large market segment is defense/aerospace, which had 15,516 workers (with about 12,329 in the private-sector) in 2007. This market segment also included more than one-half of the state's total technology employment as a result of its significant overlap with ICT. Certainly the size and nature of the state's defense/aerospace

industry depends on the large military and Department of Defense presence on all of the islands. It is also the result of Hawaii's success in attracting key federal investments—most prominently through the aid of Senator Daniel K. Inouye. Many high-profile defense contractors have a relatively small presence in the state, but maintain the ability to reach back to their extensive networks on the Mainland to provide unique expertise and capacity. Driven by recent increases in U.S.

Defense/aerospace job creation in the future will likely come from industries that form a nexus with ICT and other market segments—custom computing and computer design, architectural design, and environmental systems.

Department of Defense spending, this growth is expected to continue through the next several years, but at a slightly less rapid pace. In the future, job creation for this segment will likely come from industries that form a nexus with the ICT market segment—custom computing, computer design, architectural design, and environmental systems. While there are a few large companies in the state, the average size of the state's defense/aerospace firms was 12.4 employees in 2007.

Figure 6: Information and Communications Technologies Market Segment

Information and Communications Technology (ICT) Market Segment	Hawaii	US
Emp 2007 (all ICT jobs)	17,355	n/a
Emp 2007 (private-sector ICT jobs)	13,901	4,432,865
% of all private-sector emp	2.0%	2.5%
Annual private-sector emp growth rate ('02-'07)	2.7%	2.4%
Avg earnings 2007	\$75,056	n/a
Avg earnings 2007—private-sector only	\$66,485	\$85,726
Establishments 2007	1343	n/a

Markets Driving Hawaii's Technology Sector

Numerous large, mainland-based companies are located in Hawaii. Frequently, they seek locally-owned firms to partner with as they compete for federal contracts (especially from DOD) to be performed in Hawaii. However, the limited availability of skilled talent to meet the industry's needs poses a common challenge. Some smaller locally-owned companies express reluctance to grow substantially. This reluctance is often driven by a desire to keep the firm small and manageable, as it takes a very different corporate infrastructure to support a company of 100 than it does a company of 12 people—the average size for these firms. Companies in the defense/aerospace market segment face further challenges, including the cost of living, and the limited infrastructure capacity with regards to areas such as electricity, port facilities, and telecom (with one company owning most of the network).

Hawaii-based companies attracted more than \$2 billion in defense contracting in 2007.

That said, a number of local Hawaii-based companies have successfully established themselves. Overall the state attracted more than \$2 billion in defense contracting, and over 1,100 companies each generated more than \$50,000 in business from the Defense Department in 2007. Of those, 42 had contracts totaling more than \$10 million and another 217 had contracts totaling between \$1 million and \$10 million. Many of these companies have come to realize that they may be too dependent on one single customer.

With likely changes in public policy priorities as well as ever tightening budgets, the Federal marketplace may

Figure 7: Defense/Aerospace Market Segment

Defense/Aerospace Market Segment	Hawaii	US
Emp 2007 (all def/aero jobs)	15,516	n/a
Emp 2007 (private-sector def/aero jobs)	12,329	4,205,396
% of all private-sector emp	1.8%	2.4%
Annual private-sector emp growth rate ('02-'07)	4.7%	3.3%
Avg earnings 2007	\$76,697	n/a
Avg earnings 2007—private-sector only	\$68,069	\$84,894
Establishments 2007	1,254	n/a

In the months and years ahead, developing successful dual-use strategies may be critical to continued growth among companies in the defense/aerospace commercial-market segment.

become much more competitive with fewer dollars available for defense-related contracts. Companies seeking to diversify their markets are examining “dual uses”—or finding commercial applications and markets for defense products. Particular opportunities may exist for defense companies in the energy²³ and homeland security areas.

The dual use strategy has worked for many companies and industries, especially those that offer products or services that are uniquely designed for the military. Successful dual use efforts more often focus as much on re-deploying talent and developing similar, but new, products for commercial markets as they do on finding new markets for existing products previously purchased by DOD. Additionally,

23. LMI Government Consulting, “Transforming the Way DOD Looks at Energy: An Approach to Establishing an Energy Strategy,” Report FT602T1, April 2007.

energy considerations, in terms of efficiency and alternative energy technologies, are expected to play an important role as DOD considers future acquisitions. In the months and years ahead, developing successful dual use strategies may be critical to continued growth among companies in the defense/aerospace commercial market segment.



ENGINEERING/PROFESSIONAL SERVICES

Engineering and professional services represent the next largest commercial-market segment. Last year, engineering and professional services employed about 12,019 workers (nearly 8,500 of whom work in the private-sector).²⁴ This commercial segment is also closely related to environmental consulting. About 7,700 workers were employed in private-sector environmental

24. Civil engineering is tied predominantly to the construction industry and is therefore not included in these figures.

Figure 8: Engineering and Professional Services Market Segment

Engineering/Professional Services Market Segment	Hawaii	US
Emp 2007 (all eng/prof svcs jobs)	12,019	n/a
Emp 2007 (private-sector eng/prof svcs jobs)	8,080	1,879,094
% of all private-sector emp	1.2%	1.1%
Annual private-sector emp growth rate ('02-'07)	4.9%	5.7%
Avg earnings 2007	\$80,799	n/a
Avg earnings 2007—private-sector only	\$68,424	\$76,920
Establishments 2007	755	n/a

consulting, specialized engineering, and architectural design companies that frequently classify themselves in both engineering and environmental services-related industries. The state's average size for professional technical and engineering companies was 15.9 workers in 2007.

Generally speaking, there are two kinds of engineering firms in Hawaii. One kind includes the large engineering firms like Earth Tech Inc. or CH2M Hill or Weston Solutions,²⁵ which serve global markets and have the ability to "reach back" for additional expertise through their Mainland and international offices. The other group of firms represents smaller, boutique firms that are almost always locally based and focused on local markets. While many professional technical and engineering services are involved in environmental areas, these firms are also found in a miscellaneous array of management, applied research, and consulting areas.

25. Examples of companies which do a variety of engineering work (aside from civil engineering) are included as an important part of the tech industry.

Significant opportunities exist for these firms to partner on projects. Smaller firms often need larger firms to access larger contract opportunities that would otherwise be unfeasible, as well as higher risk overseas contracts. Larger firms will look to partner with smaller boutique firms because they seek unique skills or knowledge. They may also need to partner with smaller firms for competitive reasons. For instance, Department of Defense contracts often require the participation of small-business enterprises. Also, the smaller firms may have a lower cost structure that can help make a fee proposal more viable.

Figure 9: Environmental Technologies Market Segment

Environmental Market Segment	Hawaii	US
Emp 2007 (all environmental jobs)	8,593	n/a
Emp 2007 (private-sector environmental jobs)	7,685	2,156,438
% of all private-sector emp	1.1%	1.2%
Annual private-sector emp growth rate ('02-'07)	4.0%	3.5%
Avg earnings 2007	\$66,971	n/a
Avg earnings 2007—private-sector only	\$65,314	\$76,534
Establishments 2007	739	n/a



ENVIRONMENTAL TECHNOLOGIES

Firms in the environmental technologies commercial market employ about 8,600 workers (of which more than 7,700 were employed in the private-sector).²⁶ Most workers are employed in industries related to environmental consulting, specialized engineering, and architectural design—industries in which the companies tend to consider themselves related directly to environmental engineering. In 2007, the state's average size for environmental companies was 11.6 employees, about half the size of a "typical" Hawaii company.

Many tech market segments address specific Hawaii problems; however, opportunities exist to market Hawaii's expertise globally.

26. Much like the engineering and professional services commercial market segment, civil engineering is tied predominantly to the construction industry and is therefore not included in these figures.

Markets Driving Hawaii's Technology Sector

Market factors, including increased consumer demand for green technologies and products, as well as increased redevelopment activities, will generate additional demand in this market. However more stringently regulated development will remain a challenge for both the engineering and environmental services fields. Management consulting, environmental consulting, and related engineering services are the industries that are expected to have the most growth.

Environmental remediation needs, combined with the ongoing demand for sustainable, "greener" development and building techniques (e.g., LEED certification—Leadership in Energy and Environmental Design), energy conservation, and renewable energy development, represent key drivers in these commercial markets. Environmental experts often partner with civil engineering and architectural firms to offer more environmentally sensitive methods. Honolulu is a hub for environmental work in Asia, including Japan and Korea. There is a positive connection to tourism as well, as sound environmental practices support the natural environment that makes Hawaii an attractive destination.

Environmental services firms not involved in engineering tend to focus on testing and environmental landscaping services, as well as applied research related to ocean sciences to solve environmental challenges. Many of these initiatives are aimed at addressing specific problems for Hawaii, but nonetheless offer opportunities for product or process technologies that might be licensed for use in other parts of the world. For instance, through their relationship with the Department of Defense, some firms have gained contracts elsewhere in the Pacific, in places such as the island of Guam.



LIFE SCIENCES, EXCLUDING AGRICULTURAL BIOTECH

The next largest commercial market segment is in the life sciences. Last year, about 7,970 workers were involved in the "non-ag" life sciences, including about 1,020 workers conducting research and related consulting assignments that were classified in both the life sciences and the agricultural biotech segments because their work contributed to both.

When describing the life sciences and biotechnology activities in Hawaii that are not focused on agricultural activities, the discussion tends to focus on the discovery of pharmaceuticals as well as the exploration of medical applications of tropical plants and marine organisms. Two research facilities contributing to this industry are the Cancer Research Center and the John A. Burns School of Medicine in Kakaako. The new UH Hilo College of Pharmacy will create another state asset that could support research in this sector.

The diversity of the state's population makes it particularly valuable to researchers seeking to examine how

people of different ethnic backgrounds might respond to similar medical treatments during clinical trials. For instance, researchers report that Hawaii's large Japanese population allows them to test treatments for the Japanese population without having to go through the bureaucracy of the Japanese Food and Drug Administration. This diversity and proximity to the Pacific Basin can be an asset for both U.S.- and Japan-based firms. There is an opportunity to form a center of excellence for tropical medicine along with pandemic disease research and control in Hawaii. An example of this is Hawaii Biotech, a leader in vaccine development for tropical diseases including dengue fever and West Nile virus.



AGRICULTURAL BIOTECH

In 2007, agricultural biotechnology employed 4,833 workers, of which about 1,020 were involved in conducting research and related consulting assignments that cannot be easily classified as agricultural or other life sciences. Recent growth is largely the result of two factors—increases in

Figure 10: Biotech/Life Sciences Market Segment

Biotechnology/Life Sciences Market Segment	Hawaii	US
Emp 2007 (all bio/life jobs)	7,970	n/a
Emp 2007 (private-sector bio/life jobs)	6,441	2,357,208
% of all private-sector emp	0.9%	1.3%
Annual pvt sector emp growth rate ('02-'07)	2.3%	1.4%
Avg earnings 2007	\$54,532	n/a
Avg earnings 2007—private-sector only	\$52,468	\$91,933

Markets Driving Hawaii's Technology Sector

Figure 11: Agricultural Biotechnology Market Segment

Agricultural Biotechnology Market Segment	Hawaii	US
Emp 2007 (all ag. biotech jobs)	4,833	n/a
Emp 2007 (private-sector ag. biotech jobs)	4,138	1,228,922
% of all private-sector emp	0.6%	0.7%
Annual private-sector emp growth rate ('02-'07)	7.3%	5.7%
Avg earnings 2007	\$53,866	n/a
Avg earnings 2007—private-sector only	\$51,293	\$80,375
Establishments 2007	274	n/a

management and technical consulting, and the growth of the state's seed-corn farming activities. Like medical research, the state has unique competitive advantages for doing research related to agricultural biotech. These unique advantages are mainly derived from Hawaii's climate and relative isolation from other agricultural and aquacultural regions. The state has established significant expertise in seed research and development. These activities involve developing a variety of hybrid plants for the purpose of utilizing those seeds elsewhere for seed production on a commercial scale. The state's corn research industry has developed into a significant exporter of seeds to the Mainland and Asia. Unlike traditional farming operations, workers in these operations are more likely to be Ph.D. and master's level research scientists rather than unskilled laborers.

Similarly, aquaculture operations benefit from the tropical climate and isolation beneficial to build pathogen-free broodstock. Hawaii research organizations such as the Oceanic Institute are global leaders in developing new technologies. These advancements include rearing shrimp and saltwater fish (as well as related feedstocks such as algae) for

use as food, to help replenish wild populations, for aquarium hobbyists, and potentially for renewable energy.

Challenges in the agricultural biotech sector include attracting and retaining sufficiently skilled employees, especially at the middle technical and lower skill levels. Availability and cost of land is another key obstacle, along with access to water, and significant regulatory

Unlike traditional farming operations, workers in seed research operations are more likely to be Ph.D. and master's level research scientists.

hurdles. Challenges in aquaculture include recruiting and especially retaining employees, as well as the lack of transparency in the permitting process. To insure continued sustainable activities in this sector, land, workforce, and permitting issues need to be addressed.

Hawaii is uniquely positioned to capture these activities due to its favorable climate. The seed industry is not only one of the state's fastest growing biotechnology industries, but one of its fastest growing technology industries overall. Five global companies with operations in Hawaii—

BASF, Dow AgroSciences, Monsanto, Pioneer Hi-Bred International, and Syngenta Seeds—employ more than 1,000 people in Hawaii. Their activities are primarily focused on seed corn. Hawaii's climate gives a unique advantage in that agricultural scientists in Hawaii can plant three times a year rather than just once as in similar Mainland facilities. Significant growth is anticipated by many of these companies in coming years.



OCEAN SCIENCES

The ocean sciences market segment converges with many other market segments, including defense, information technologies, engineering, environment, life sciences/biotechnology, and energy. One company—Oceanic Imaging Consultants—is a spin-off of the Office of Naval Research at the University of Hawaii. Oceanic Imaging Consultants designs seafloor mapping software, as well as provides consulting and analytical services. The company provides services for federal agencies, including the Navy and the National Oceanic and Atmospheric Administration, and also has customers in Europe and Asia.

Other ocean sciences companies have sought to find ways to use the cold temperatures at deep-ocean depths for use in applications such as energy generation and refrigeration. For instance, Makai Ocean Engineering conducts research applied to real life projects in the areas of sea water air conditioning (SWAC) and ocean thermal energy conversion (OTEC).

Markets Driving Hawaii's Technology Sector

Figure 12: Ocean Sciences Market Segment

Ocean Sciences Market Segment	Hawaii	US
Emp 2007 (all ocean science jobs)	5,288	n/a
Emp 2007 (private-sector ocean science jobs)	4,115	1,217,942
% of all private-sector emp	0.6%	0.7%
Annual private-sector emp growth rate ('02-'07)	6.4%	6.2%
Avg earnings 2007	\$53,959	n/a
Avg earnings 2007—private-sector only	\$47,439	\$72,870
Establishments 2007	309	n/a

The company has also become a world leader in deep-water pipeline design and deployment. In addition, significant marine research is underway at the UH Joint Institute for Marine and Atmospheric Research and the UH Institute for Marine Biology.

Core research and development activities accounted for about 22 percent of the nearly 5,300 total in 2007. Much of the remaining employment is found in environmental and technical services companies, especially marine sciences consulting. Employment growth can be attributed primarily to these consulting activities as employment in research has been relatively stable since 2002. Future employment in these R&D activities is expected to decline slightly while the consulting activities continue growing.

requirements to increase the use of renewable energy sources, state legislation requires electric power suppliers to provide at least 20 percent of their energy generation from renewable sources by 2020. As of 2003, 8.2 percent of net electricity sales were

Renewable Energy is the fastest growing tech market segment in Hawaii, with an annual employment growth rate of 8.7 percent in the private-sector, compared with 5.8 percent nationally.

derived from renewable sources. The goal is to achieve 10 percent by 2010 and 15 percent by 2015. Given the need to generate more energy—and more energy locally—there is considerable

opportunity for the state's energy sector to develop a wide array of methods for increasing renewable energy generation.

Hawaii is unique in that it has potential for generating energy from almost every renewable resource (e.g., solar, wind, geothermal, wave, biofuel, etc.), while other states must rely on one or two primary sources to meet their demand for alternative energy sources. While this potential exists for the state, it also faces some very unique challenges. For instance, each island currently must produce its own energy, as the power grid is not interconnected across the Islands. This means that the raw material (e.g., fossil fuels and renewable sources) required to generate electric power must be generated on the island where it will be used. It is often simply too costly to ship the material from one island to another.

This commercial market segment is focused on conducting research and testing new applications for numerous renewable resources, rather than scaling up for mass production. Renewable resources under current use and development include biofuels, wind energy, solar collection and

Figure 13: Renewable Energy Market Segment

Renewable Energy Market Segment	Hawaii	US
Emp 2007 (all energy jobs)	3,587	n/a
Emp 2007 (private-sector energy jobs)	3,509	1,028,543
% of all private-sector emp	0.5%	0.6%
Annual pvt sector emp growth rate ('02-'07)	8.7%	5.8%
Avg earnings 2007	\$58,498	n/a
Avg earnings 2007—private-sector only	\$58,370	\$82,968
Establishments 2007	295	n/a



RENEWABLE ENERGY

Another commercial market segment identified as significant among the state's technology and innovation firms is that involved in developing and producing energy alternatives to fossil fuels. Driven by regulatory

Markets Driving Hawaii's Technology Sector

storage, geothermal, ocean wave, and the deployment of photovoltaic technologies for off-grid and on-grid power generation.

Puna Geothermal Ventures on Hawaii Island provides one example of a successful enterprise. Puna Geothermal harnesses geothermal energy to help meet Hawaii's renewable energy portfolio standards. Many energy experts in Hawaii suggest geothermal as a promising opportunity to meet the needs of the island of Hawaii, and also provide a surplus of energy. As with any energy source, the challenge lies in storage and transmission. Other promising areas of energy development in Hawaii include biodiesel, ethanol, and cellulosic biomass from crops such as sugar cane and algae. Hawaii has a long history of sugar-cane production and technological development, as well as research and development in a wide variety of tropical and subtropical crop improvement and cultivation. Algae, for instance, can be cultivated rapidly in Hawaii to produce biodiesel, ethanol, and bio-jet fuel. Additionally, the byproducts can be used for animal feed and carbon sequestration (the removal of carbon dioxide from coal or other fossil fuel plant exhaust gases). Several companies in Hawaii are showing promise in energy development, including HR Biopetroleum, which recently received two years of funding from Shell Dutch Oil.

Solar energy offers another promising area of energy development in Hawaii. Sopogy Inc. has developed and commercialized technology that

directly harnesses solar energy in Hawaii. The company specializes in the development, design, manufacturing, and distribution of concentrated solar power (CSP) products to the distributed generation market. This proprietary design uses mirrors and optics to focus and intensify the power of the sun to create steam for use in electricity generation and air conditioning. Another Hawaii company—Hoku Scientific—develops clean energy technologies used in fuel cells and photovoltaic (PV) products.



DIGITAL MEDIA

The digital media industry represents an important technology-intensive portion of the state's larger film and digital media industry. It is relatively small, but growth is occurring from the convergence of the information technology and film/music/entertainment industries. Unfortunately, digital media is particularly difficult to detect because it is masked within other, larger industry segments. Furthermore, digital media

companies involved in this commercial market segment appear to be emphasizing game design and the technical support of films, particularly short films. While major motion pictures and television programs (such as the television series, *Lost*) may be higher profile, they are also important because they bring in much-needed investments in facilities and equipment. Yet, short-film commercials are probably a more significant and stable part of the economic activity in this market segment, because the large projects involve greater risks for investors and sustaining business operations during nonproduction periods can be costly. Hawaii's high cost structure adds to the challenge, when compared to lower-cost global options.

Film industry representatives liken the industry to construction in that companies require continuous work in order to build scale and capacity. As a result, it is expected that short commercials will remain quite important to the industry's long-term development. These companies have tremendous export potential and can meet the demand to develop the technological capacity needed to succeed in digital media.

Figure 14: Digital Media Market Segment

Digital Media Market Segment	Hawaii	US
Emp 2007 (all dig. media jobs)	2,270	n/a
Emp 2007 (private-sector dig. media jobs)	2,270	1,293,874
% of all private-sector emp	0.3%	0.7%
Annual private-sector emp growth rate ('02-'07)	0.2%	2.3%
Avg earnings 2007	\$73,335	n/a
Avg earnings 2007—private-sector only	\$73,335	\$93,207
Establishments 2007	359	n/a

Markets Driving Hawaii's Technology Sector



ASTRONOMY

The astronomy commercial market segment is dominated by a concentration of telescopes located at observatories on Mauna Kea, Mauna Loa, and Haleakala, as well as research activities at the University of Hawaii campuses at Manoa and Hilo, and the Maui High Performance Computing Center. The smallest of the market segments, in 2007 it employed about 885 people in companies related to astronomy, of which about 342 were in the private-sector and 543 were in the public-sector. The astronomy market segment tends to be concentrated in a very small number of firms and relies on contracts with an international network of governments doing basic research on space, as well as conducting atmospheric and defense-related research.

Most private-sector firms involved in astronomy are located on Hawaii Island. For instance, W.M. Keck Observatory and Canada France are in Waimea. Most of their employees are not astronomers, but engineers and technicians who



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The state's mountains offer the finest viewing locations on the planet, and Mauna Kea currently has the largest observatories in the world.

monitor the equipment used in the observatories. Other major astronomy enterprises include Subaru, AURA-Gemini, the Institute for Astronomy in Hilo, and UH Manoa.

The islands of Hawaii and Maui were able to attract the observatories because of the relative height of their mountaintops, the relative location on the planet, and the islands' relative isolation from large population centers. Activity on Hawaii Island is almost exclusively related to basic research sponsored by a number

of governments and government consortia worldwide. Maui-based observatory activities tend to be more related to market applications, including defense and satellite observation activities. Maui also offers one of the world's premier locations for solar astronomy. Plans for larger telescopes at locations around the world could place pressure on Hawaii's observatories to make significant investments to increase the size of their equipment.

Figure 15: Astronomy Market Segment

Astronomy Market Segment	Hawaii	US
Emp 2007 (all astronomy jobs)	885	n/a
Emp 2007 (private-sector astronomy jobs)	342	222,685
% of all private-sector emp	0.0%	1%
Annual private-sector emp growth rate ('02-'07)	7.3%	1.2%
Avg earnings 2007	\$70,951	n/a
Avg earnings 2007—private-sector only	\$83,654	\$106,567
Establishments 2007	28	n/a

OVERALL TRENDS IN THE COMMERCIAL MARKET SEGMENTS

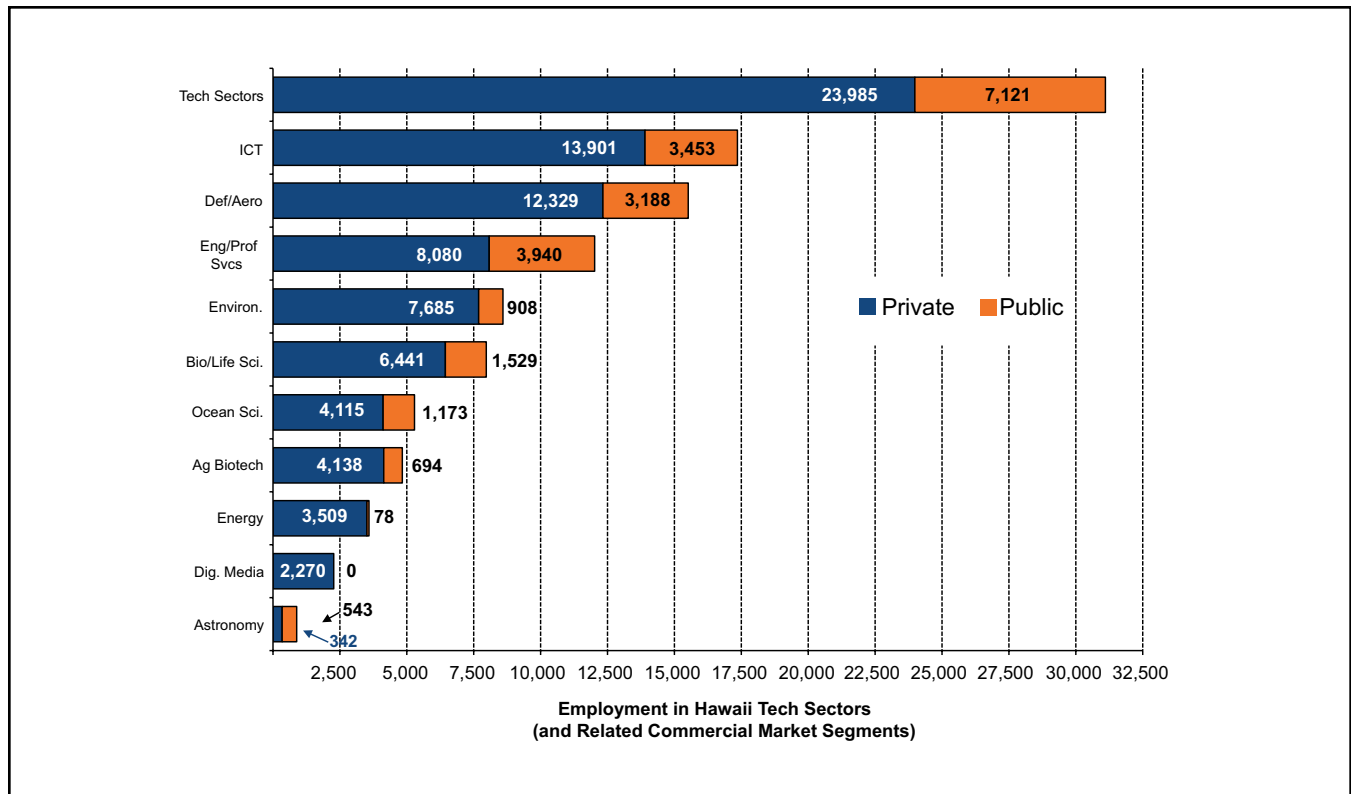
Last year, in all of the commercial market segments, 31,106 people were employed, of which nearly 24,000 worked in the private-sector and about 7,100 worked for government

Overall, growth in Hawaii's technology sector is more rapid than in the rest of the economy.

agencies (including the University of Hawaii). Figure 16 shows the private- and public-sector employment in each of the commercial market segments.

Markets Driving Hawaii's Technology Sector

Figure 16: Hawaii Tech Employment by Commercial Market Segment, Estimated, 2007



Since certain industries are included in multiple sectors, the employment totals in each segment do not add up to the total overall technology sector employment.

Overall, growth in Hawaii's technology economy is more rapid than in the rest of the economy—and it is expected to continue to grow faster in the future. This growth is due in no small part to the prevalence of small companies in the technology sector. Large numbers of small companies can indicate strength. According to a longitudinal study of small businesses in the U.S.

The technology sector pay differential translates into roughly \$1,500 per month in added benefits and wages above the earnings of the average Hawaii worker.

from 1992 to 2004, smaller businesses were likely to grow at a faster rate than larger ones and almost all of the net new-job creation occurred among companies with 250 employees or less.²⁷

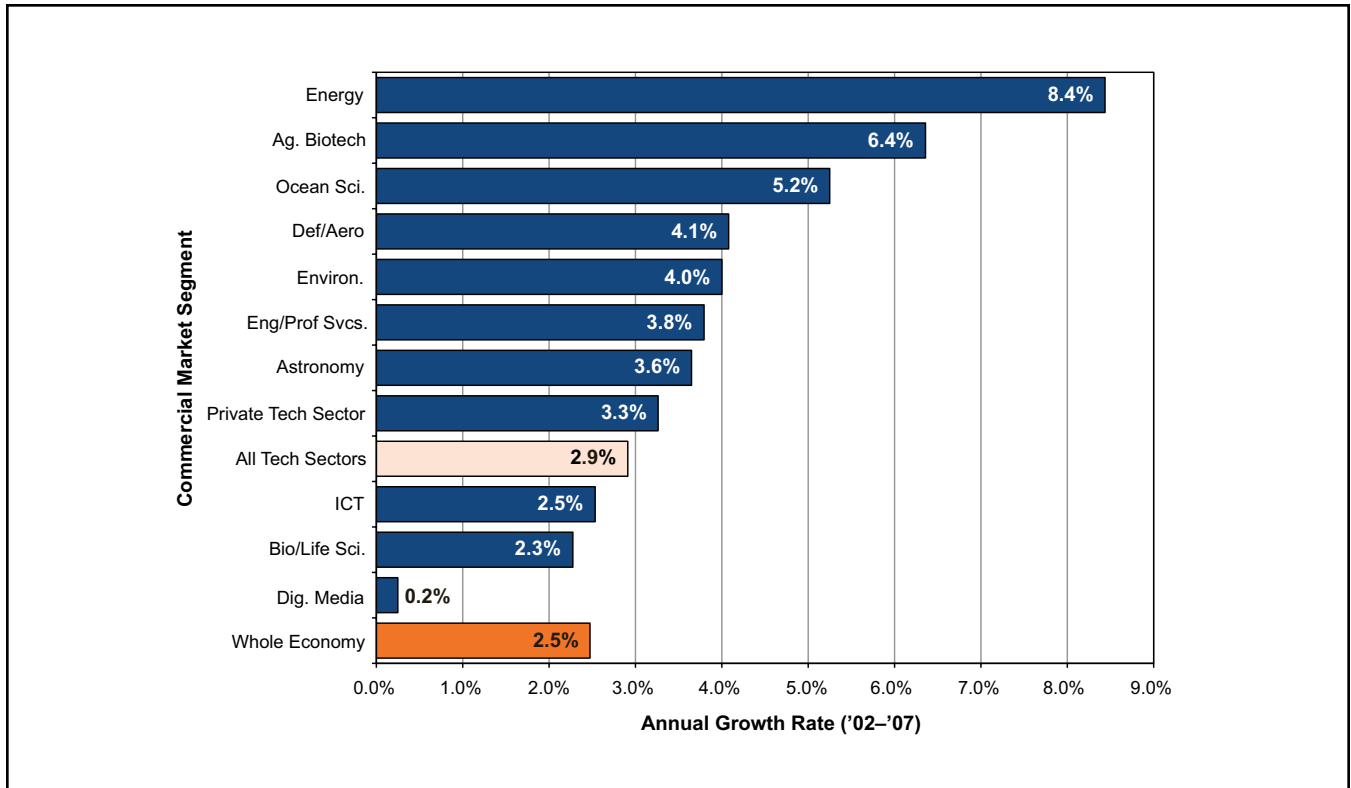
Between 2002 and 2007, the growth rate for the entire Hawaii economy

27. Neumark, D., Wall, B. and Zhang J. "Do Small Businesses Create More Jobs? New Evidence from the National Establishment Time Series," NBER Working Paper No. 13818, Cambridge, Massachusetts, 2008.

was 2.5 percent annually while the tech industries grew at 2.9 percent annually, during the past five years. This means the tech sector added jobs at a rate of 16 percent faster than the rest of the state, but private-sector tech companies' employment grew at a rate 32 percent faster than the rest of the state. Figure 17 shows that employment in most of the technology commercial market segments (combined public and private tech sectors) grew at an annual rate that was faster than the economy overall. The fastest growth occurred in several segments—such as energy,

Markets Driving Hawaii’s Technology Sector

Figure 17: Annual Growth Rates for Employment by Commercial Market Segment (2002–2007)



agricultural biotechnology and ocean sciences—that are small relative to other market segments. Nevertheless, defense/aerospace is one of the largest segments and was also one of the fastest growing.

Figure 18 shows the projected employment growth in each of the commercial market segments over the next decade. While the annual growth rates are projected to slow somewhat, most commercial market segments are nevertheless projected to grow faster than the economy overall. Projections for 2007–2017 suggest that the entire

economy will grow at a quite modest 1.3 percent annually, while the tech industries are expected to grow at about 1.9 percent annually. The private-sector portion of the tech industries are expected to grow 2.1 percent annually. During the next decade, the tech sector is expected to grow at a rate that is 46 percent faster than the rest of the economy, and private-sector companies in tech industries are expected to grow at a rate that is 61 percent faster. Figure 18 also shows that wages in the technology sector are higher than the state average for

every commercial market segment. Professional technical and engineering services offers the highest earnings, followed closely by defense/aerospace and information and communications technologies industries.

During the next decade, the tech sector is expected to grow at a rate that is 46 percent faster than the rest of the economy, and private-sector companies in tech industries are expected to grow at a rate that is 61 percent faster.

Markets Driving Hawaii's Technology Sector

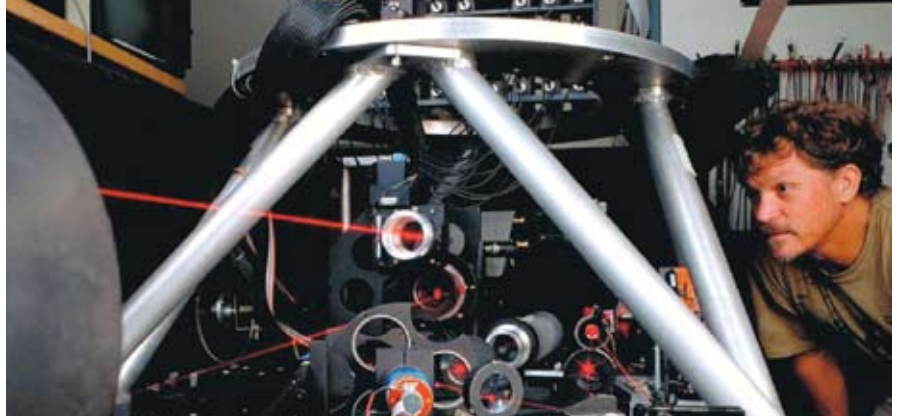
Figure 18: Annual Earnings for Economic Industries Compared with Technology Commercial Market Segment, 2007

Description	2007 Earnings Per Worker, Hawaii	Projected Annual Growth Rates, 2007-17
Utilities	\$105,974	1.0%
Management of companies and enterprises	\$82,424	1.4%
Engineering/professional services	\$80,799	1.5%
Defense/aerospace*	\$76,697	2.3%
Information and communications tech*	\$75,056	1.9%
Digital media*	\$73,335	2.2%
Astronomy*	\$70,951	1.3%
Government	\$69,652	-0.8%
ALL TECHNOLOGY INDUSTRIES	\$68,935	1.9%
Environmental*	\$66,971	1.7%
Construction	\$64,704	1.7%
Mining	\$59,763	2.4%
Information	\$59,033	1.2%
Renewable energy*	\$58,498	2.8%
Manufacturing	\$54,891	0.3%
Bio/life sciences, except ag. biotech*	\$54,532	0.9%
Finance and insurance	\$54,029	1.5%
Professional and technical services	\$54,023	0.7%
Ocean sciences*	\$53,959	2.6%
Ag. biotech*	\$53,866	3.2%
Wholesale trade	\$53,566	1.0%
Transportation and warehousing	\$49,042	3.6%
ALL INDUSTRIES	\$45,963	1.3%
Healthcare and social assistance	\$45,846	1.8%
Real estate and rental and leasing	\$37,346	3.0%
Educational services	\$31,499	1.7%
Accommodations and food services	\$29,680	1.0%
Administrative and waste services	\$29,134	2.4%
Retail trade	\$28,983	1.1%
Other services, except public administration	\$23,969	0.9%
Agriculture, forestry, fishing, and hunting	\$21,331	-0.6%
Arts, entertainment, and recreation	\$20,968	1.9%

Note: Earnings reflect the combined value of wage and salary income as well as other non-wage earnings including retirement pay and fringe benefits.

*Commercial Market Segments of Hawaii's Science & Tech Industries

Source: Economic Modeling Specialists Inc.



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Island Highlights—Strengths and Opportunities

Just as Oahu accounts for the majority of the state’s population and employment, so, too, does it contribute the bulk of the state’s technology business, research, and employment. Nevertheless, each of the islands makes contributions—often quite unique—to the state’s technology sector. Figure

Nearly 25,888 tech sector jobs were located on Oahu in 2007, and another 4,784 of those jobs were on the neighbor islands.

19 shows the number of private- and public-sector technology-related jobs found on each of the islands.²⁸ Nearly 25,888 tech-sector jobs were located on Oahu in 2007, and another 4,784 were on the Neighbor Islands. Last year, Maui and the island of Hawaii each had almost 1,900 tech sector jobs, while Kauai had about 1,000. This section describes the size and scope of technology activities on each island, as well as their unique assets and strengths.



KAUAI COUNTY

In absolute numbers, Kauai has the state’s smallest technology sector. In 2007 it had 1,002 jobs, of which 933 were in the private-sector. These jobs accounted for 2.3 percent of Kauai’s total employment. Although it is the

28. To generate data on the commercial market segments for each county, the team generated employment estimates at the industry level by county for each six-digit NAICS code and then allocated individual industries to each commercial market segment in a similar fashion to what was done for the state as a whole.

Figure 19: Private-sector Employment by Island

COUNTY	PRIVATE SECTOR	PUBLIC SECTOR	COMBINED TECH EMPLOYMENT	ALL JOBS	% OF TOTAL EMPLOYMENT
Honolulu	19,160	6,728	25,888	621,569	4.2%
Maui	1,847	39	1,886	100,971	1.9%
Hawaii	1,681	215	1,896	95,831	2.0%
Kauai	933	69	1,002	43,235	2.3%
State of Hawaii	23,985	7,121	31,106	861,608	3.6%

island with the smallest tech sector, Kauai enjoys the fastest growing technology sector. Between 2002 and 2007, Kauai’s tech sector grew at an annual rate of 6.0 percent. By comparison, overall employment on Kauai grew 3.2 percent annually during the same period.

Although Kauai is the island with the smallest tech sector, it enjoys the fastest growth, at 6.0 percent annually.

Private-sector technology companies on Kauai generated approximately \$52.8 million in earnings, which represented almost 3.3 percent of the island’s total earnings.²⁹ The average technology worker on Kauai earned \$52,723 annually, about 42 percent more than the average worker on the island. In addition to the earnings generated, the tech sector also indirectly supported another 842 jobs in sectors providing goods and services to technology enterprises or workers.

In 2007, approximately 52 companies comprised Kauai’s private tech sector. This represented 2 percent of all Kauai establishments. Unlike the other islands, tech companies on Kauai are relatively larger than other companies on the

29. Source: U.S. Bureau of Economic Analysis, (BEA). Estimates are derived using a ratio of total earnings to GDP applied to technology-sector earnings to generate an estimate of the GDP.

island. Last year, the average Kauai tech company employed 19 workers, while the average Kauai firm employed 18. By comparison, the average Hawaii tech company provided work for 16 employees and the average Hawaii firm employed nearly 23.

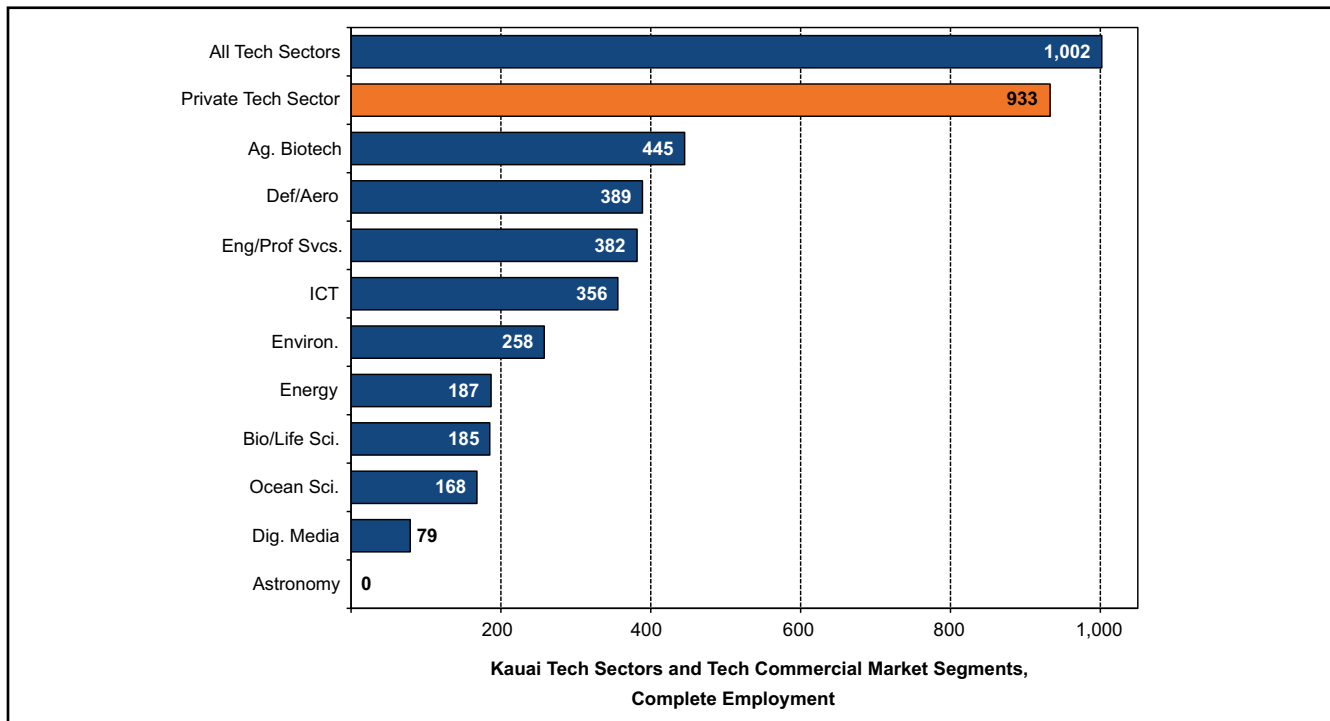
The commercial market segments that employ the largest number of workers are defense/aerospace and agricultural biotech. The defense/aerospace market segment is driven almost entirely by activity at the Pacific Missile Range Facility. The PMRF is a premier location for testing air, space, surface, and subsurface missiles. PMRF is the island’s third-largest employer (behind the county and Wilcox Memorial Hospital). It employs approximately 1,000 people, with 600 to 700 of those being private-sector workers. It should be noted however, that not all of these 1,000 people are considered technology workers.

Many of the civilian workers at PMRF are actually private-sector workers—employed by military contractors such as General Dynamics, Raytheon, or Northrop Grumman. These employees do sophisticated work that requires a high level of skill. For instance, Trex Advanced Materials³⁰ develops and manufactures advanced ceramic

30. Trex Advanced Materials is the Kauai affiliate of the San Diego-based Trex Enterprises. Trex Enterprises reports that it employs 65 people on Maui, Kauai, and Oahu.

Island Highlights—Strengths and Opportunities

Figure 20: Kauai Tech Employment by Commercial Market Segment, Estimated 2007



materials for semiconductors, ballistics, and optics. While most of Trex Advanced Materials' activities have military applications, perhaps 5 percent to 10 percent of their contracts are non-DOD related.

In addition to defense contractors, PMRF also attracts researchers from universities like MIT, Georgia Tech, and Johns Hopkins University, who are involved in the research and testing activities that occur at the facility. It should also be noted that PMRF attracts 300 to 400 "technology tourists" to the facility for each missile launch. These people work as contractors, researchers, and DOD civilian or military personnel. These technology tourists are an important source of revenue for Kauai, and generate an estimated \$3 million per launch in additional dollars to the local economy.

Kauai has also seen considerable growth in its agricultural biotech market. This growth is primarily the product of statewide growth in the seed corn industry. For instance, Pioneer Hi-bred International, Monsanto, and Syngenta are located on Kauai. Pioneer employs approximately 120 people on the island, including many at a research center in Waimea. That facility employs eight Ph.D.-degree holders and 10 master's-degree holders. While these agricultural activities are related to seed genomics, there are other Kauai-based agricultural activities related to the development of biofuels. For instance, an ethanol plant to use sugar cane as a source for fuel is being built on the Gay and Robinson Sugar Plantation.



HAWAII COUNTY

Hawaii Island's technology and innovation sector in 2007 consisted of roughly 1,681 jobs in the private-sector and another 215 in the public-sector, the latter largely driven by federal and university employment. These jobs comprised 2 percent of all jobs on Hawaii Island. Private-sector technology-related jobs on Hawaii grew at a pace of 3.2 percent annually between 2002 and 2007. As a result, the tech sector on the island of Hawaii kept pace with the overall employment growth rate on

Island Highlights—Strengths and Opportunities

the island during the same period (3.2 percent). It also exceeded the overall annual employment growth rate of the state (2.5 percent).

Hawaii Island’s private technology sector directly contributed an estimated \$97.8 million in earnings to the economy, or almost 2.7 percent of the island’s total earnings. Last year, the average tech worker in the private-sector on the island of Hawaii made \$51,585 annually—almost 34 percent more than the average worker. Combined, public- and private-sector technology-related jobs were also responsible for creating another 1,593 jobs in a variety of non-technology-related sectors that provide supplies and services to the companies and workers employed in the technology sector.

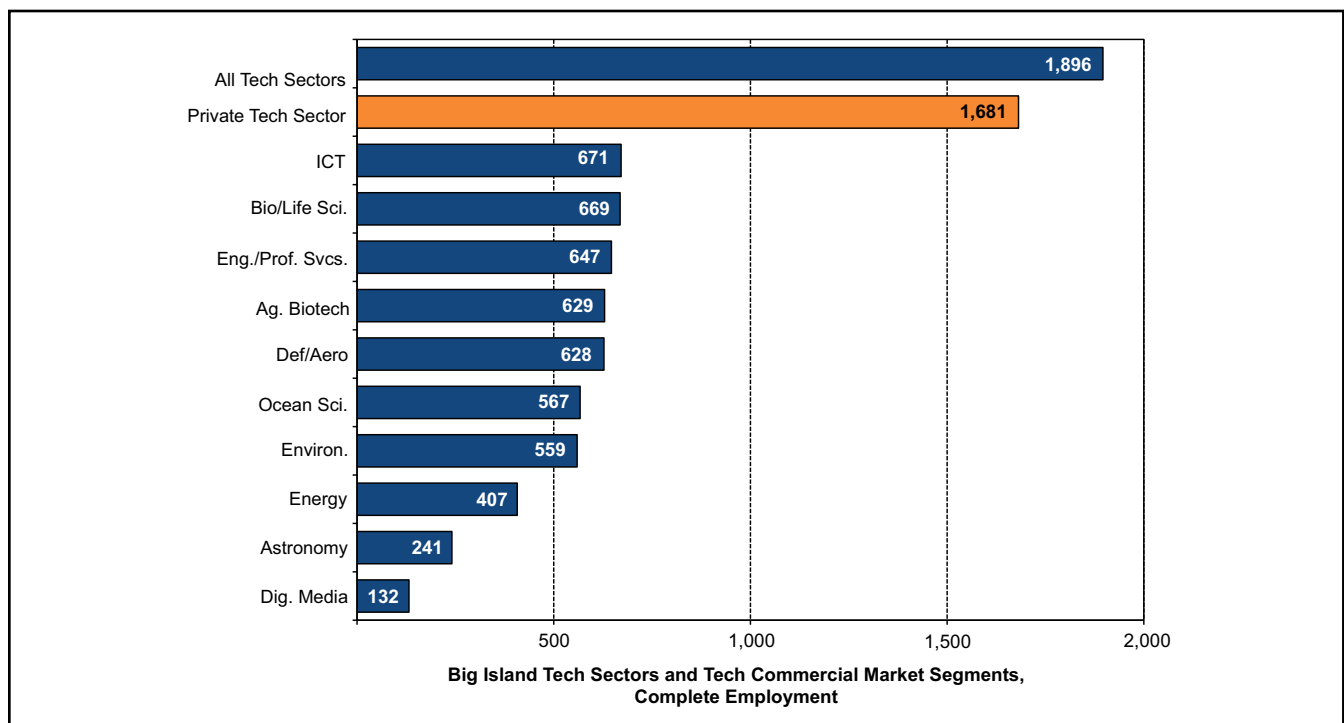
In 2007, companies in astronomy offered workers the highest average earnings, \$81,748/year, of any commercial market segment on the island of Hawaii.

There were approximately 162 tech-related establishments on Hawaii Island in 2007, and they accounted for 3.1 percent of the island’s total number of establishments. These tech companies on Hawaii Island are smaller than the state as a whole, as the average firm employed 12 workers as opposed to 16 for the state. Much like the other Neighbor Islands, defense/aerospace and ICT have the greatest number of establishments, although many of the island’s unique strengths are in astronomy, energy, and life sciences.

Astronomy is one of Hawaii Island’s most prominent technology

activities. Mauna Kea represents the best viewing location in the world, and has 13 distinct astronomical facilities, representing more than \$1 billion in infrastructure. A number of prominent companies own and operate the telescopes, including Canada France and the W.M. Keck Observatory, both located in Waimea. The W.M. Keck Observatory is one of the largest and alone employs almost 140 people. Other prominent astronomy organizations are located in Hilo, including Subaru, Gemini, and the University of Hawaii’s Institute for Astronomy at UH-Hilo. Unlike the telescopes on Maui’s Haleakala, the work occurring atop Mauna Kea predominantly involves basic scientific research. The telescopes are much larger and more powerful as well. Furthermore, TMT Observatory

Figure 21: Island of Hawaii Tech Employment by Commercial Market Segment, Estimated 2007



Island Highlights—Strengths and Opportunities

Corporation has selected Mauna Kea as one of two potential sites (the other being Cerro Armazones in Chile) for a proposed new extra-large, 30-meter telescope. At an estimated cost of \$1 billion, TMT would employ an average of 300 people during the eight- to nine-year construction phase, and the telescope would create approximately 130 new permanent operations jobs, increasing the size of the island's astronomy sector substantially. The advent of the Thirty-Meter Telescope (TMT) presents a significant opportunity for collaboration between cultural, environmental, and astronomical resources.³¹

Much like Tucson, Arizona, where optics is an important economic driver, Hawaii Island's astronomy advocates see this market segment as a potential economic engine that makes the island truly unique in the global marketplace. The industry not only brings in numerous visitors and researchers to the island, but also creates a substantial number of high-paying, highly skilled jobs. In 2007, companies in astronomy offered workers the highest average earnings, at \$81,748/year, of any commercial market segment on the island of Hawaii. This was 58 percent higher than the average earnings for all tech-related jobs on the island.

In addition to astronomy, the island of Hawaii also has perhaps the greatest potential for alternative energy generation. The island has significant capacity for wind power, and efforts are underway to find sites for more wind farms. The island also has Hawaii's greatest capacity for geothermal

energy. For instance, Puna Geothermal Ventures produces 30 megawatts and alone can provide 20 percent of the energy needs on the island. It has contracted with Hawaii Electric Light Company (HELCO) to expand its output another 8 MW, and has the capacity to expand up to 200 MW, the island's total electricity needs.

While wind, photovoltaic, hydro, and geothermal activities are in place, there are also a number of energy-related activities that are more exploratory in nature. For instance a number of other alternative energy activities underway at National Energy Laboratory of Hawaii Authority (NELHA). At NELHA, some research activities focus on using deep-ocean water for cooling, and finding ways to make Ocean Thermal Energy Conversion (OTEC—a process that uses the temperature differences between deep and shallow water to power heat engines) more viable.

Life sciences are another notable technology-related activity with potential for Hawaii Island. For instance, there are several companies involved in developing pharmaceuticals and nutraceuticals. Two NELHA tenants—Cyanotech and Enzamin USA—are involved in this market area. Cyanotech is NELHA's anchor tenant and is creating microalgae-based products for use in human nutrition as well as in the aquaculture industry. The new Pacific Basin Agricultural Research Center (PBARC) is to be the largest facility concentrating on tissue culture and transgenic research and to house the largest seed repository in the Pacific Basin. The PBARC, coupled with the new UH-Hilo College of Pharmacy, is set to take advantage of these Island assets.



MAUI COUNTY

Among the Neighbor Islands, Maui County (including Maui, Lanai, and Molokai Islands) has the most private-sector technology-related jobs. Overall, the tech sector represented 1.8 percent of Maui's total employment in 2007. Between 2002 and 2007, Maui's technology sector employment grew 3.7 percent annually, about the same rate as the rest of the state's tech economy but faster than the statewide annual average of 2.5 percent.

Among the Neighbor Islands, Maui has the most private-sector technology-related jobs.

Last year, the private tech sector contributed an estimated \$106.4 million to the Maui economy—about 2.7 percent of Maui's total earnings. On average, a private-sector tech worker's annual earnings were \$56,443 in 2007, a figure 47 percent greater than the average Maui worker's earnings. These technology activities also helped to support another 1,584 jobs in supplier companies or service providers operating in non-technology sectors.

Maui had an estimated 163 technology companies in 2007. These companies represented about 3 percent of Maui's total establishments. Most of the companies were in ICT and defense/aerospace. An average-sized Maui tech company had 12 workers, which was the same average size as tech companies statewide, but they are still

31. For more information on TMT, please see Additional Economic Development Information: Preliminary TMT Impact at <http://www.HISciTech.org/Information>.

Island Highlights—Strengths and Opportunities

smaller than the state average for all companies, which was 16 workers. This was also smaller than the average Maui-based companies across all industries, which had an average of 19 workers.

Among private-sector technology workers in 2007, the largest concentration was in the ICT and defense/aerospace markets, which employ 993 and 864 people, respectively. Many of these activities are overlapping and interrelated. For instance, Akimeka is a Maui-based IT company whose business is focused on the federal market, serving the Defense Department in particular. Partnered with other large defense contractors like ITT and Raytheon, Akimeka now employs 130 people nationwide, with 60 workers on Maui—42 of whom were hired during the past year.

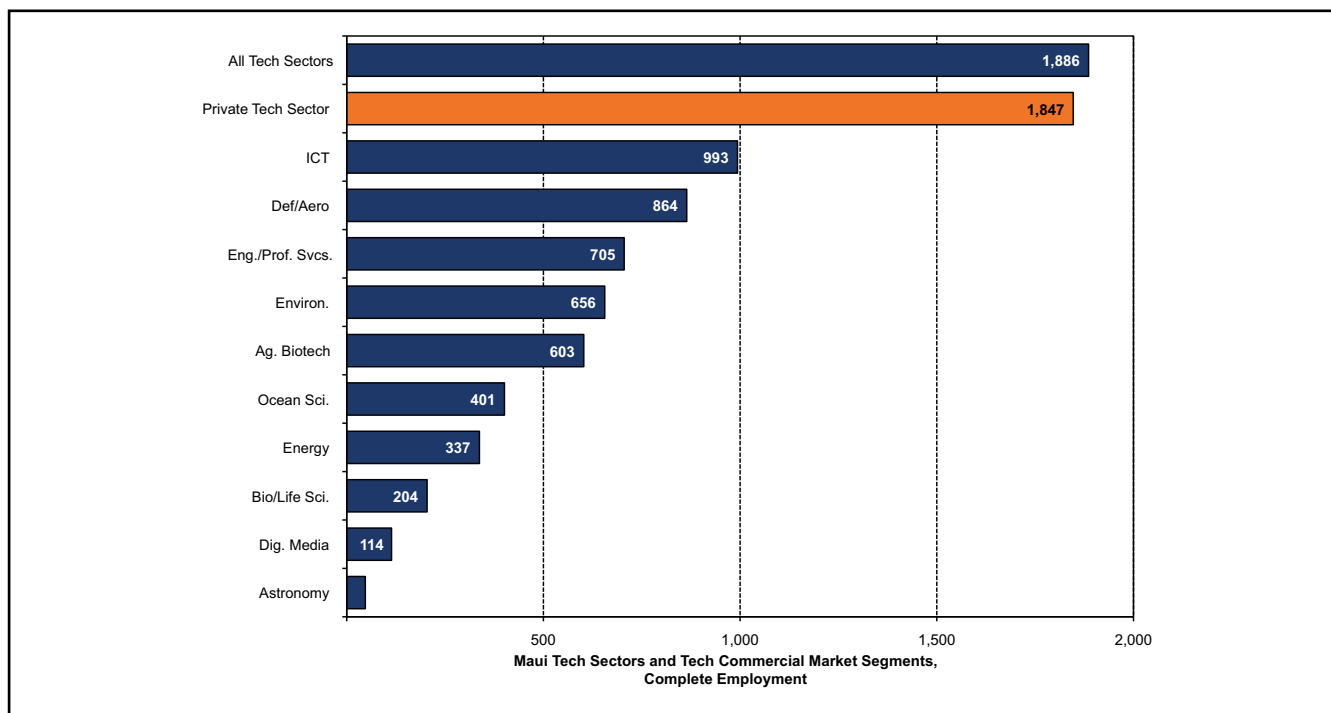
The MHPCC has a highly skilled workforce, 15 percent with advanced degrees (master's or Ph.D.), 30 percent to 40 percent with bachelor's degrees, and the rest with associate degrees.

Perhaps the highest profile defense and IT activity on Maui is taking place at the Maui High Performance Computing Center (MHPCC). The MHPCC is an Air Force Research Center managed by the University of Hawaii. It provides a facility to do complex computing, which is used predominantly by the Defense Department and other government users. For instance, the MHPCC helps to meet some of the computation needs of the Pacific Missile Range Facility on Kauai. MHPCC also serves the needs of the Haleakala High Altitude Observatory

Site facility, directly connecting it to the island's astronomy market segment as well. The center has a highly skilled workforce, 15 percent with advanced degrees (master's or Ph.D.), 30 percent to 40 percent with bachelor's degrees, and the rest with associate degrees.

On Haleakala, the astronomy sector is also highly visible. The Air Force owns, and Boeing manages, a telescope that is used for space situational awareness. Boeing employs about 125 people, many on the island. Most of the Haleakala operations and maintenance workforce are non-degreed workers, but their engineering staff includes seven with Ph.D.s and 14 with master's degrees while the rest have baccalaureate degrees. Another telescope on Haleakala is operated by the UH Institute for Astronomy. The

Figure 22: Maui Tech Employment by Commercial Market Segment, Estimated 2007



Island Highlights—Strengths and Opportunities

Haleakala telescopes also represent one of the world's best sites for solar astronomy. Unlike the telescopes on Hawaii Island's Mauna Kea, the research on Maui tends to be more applied in nature. Astronomy and ICT also represent the best paying of the island's commercial market segments.

Other notable market areas with growth potential include agricultural biotech and renewable energy. Maui and Molokai have become important sites for Hawaii's burgeoning seed industry as companies continue to add jobs. It is also an area with a growing number of alternative energy activities. For instance, Maui's wind farm on the spine of the West Maui Mountains is now contributing 10 percent to Maui Electric's power generation and more windmills have been approved for installation on the Haleakala slopes. Proposed wind farms on Lanai may further add to Maui County's wind energy generation. Maui also has the state's second best potential for geothermal energy, after the island of Hawaii. Maui's sugar-cane crops are now being used as a biofuel, thereby further contributing to the state's power-generation needs. Solar is a smaller segment of Maui's energy market; however, one company—Hnu Photonics—has created three patents for solar-related technology. Hnu Photonics illustrates that emerging technology companies often operate in multiple commercial markets—as the company is also involved in medical instrumentation, optical sensors, spectrometer design, laser beam control and projection, and microscope design and construction. The company is an entrepreneurial spin-off, as the founder once worked at the Haleakala High Altitude Observatory site before establishing the business.



BIGSTOCKPHOTO.COM © R. IRUSTA

The island of Hawaii is producing the highest level of renewable energy in the state, with wind, photovoltaic, hydro, and geothermal.



ISLAND OF OAHU/CITY AND COUNTY OF HONOLULU

The most highly concentrated tech sector is located on Oahu. Whereas Oahu accounted for 72 percent of the state's employment in 2007, it contributed 83 percent of the state's tech-sector employment. Oahu's technology workers accounted for roughly 4.2 percent of its total employment. These activities generated an additional 21,746 jobs on Oahu in non-technology-related sectors. Employment growth in tech-related activities has also been occurring at a faster rate than employment growth overall. Between 2002 and 2007, the combined private and public tech sector grew 2.6 percent annually. By comparison, overall employment on Oahu grew 2.2 percent annually.

In 2007, Oahu's private tech sector directly contributed an estimated \$1.7

billion to Oahu's economy. This figure represented 5.7 percent of Oahu's total earnings. The jobs being created by the private-sector are relatively high paying. The average worker in Oahu's

Oahu has the most highly concentrated tech sector, contributing 83 percent of the state's tech-sector employment, compared with 72 percent of the state's overall employment in 2007.

private tech sector had annual earnings of \$66,185, or almost 35 percent more than the average worker on Oahu. The three highest paying tech-related commercial market segments on Oahu were digital media, professional, engineering/professional services, and defense/aerospace. Last year, there were roughly 1,490 tech-related establishments on Oahu, or 76 percent of all tech companies in Hawaii. These firms represented 6 percent of all Oahu establishments. Tech companies on Oahu were larger on average than tech companies in the rest of the state. Oahu companies had an average of 17.4 employees, just above the state average of 15.8.

Island Highlights—Strengths and Opportunities

The commercial market segments with the largest number of both establishments and employees are the defense/aerospace and ICT market segments. This is not surprising given Oahu's considerable military presence, and specifically the large naval presence. While there are numerous major defense contractors located on Oahu to meet the needs of the military, there are also a large number of smaller firms who support the military, either directly or indirectly as subcontractors to the major defense contractors.

Other technology activities are also growing. Much of the seed research taking place in Hawaii occurs on Oahu. The presence of the University of Hawaii at Manoa also means that a great deal of research-intensive activities occurs on the island. Most of the employment in the digital media market segment also occurs on Oahu.

Areas of concern for all islands relate to the sustainability of development, and the effect that technological achievements have on the spirit and place that is Hawaii. As developments generate new potential for growth, these changes will need to acknowledge and integrate into the unique cultural perspective of Hawaii.

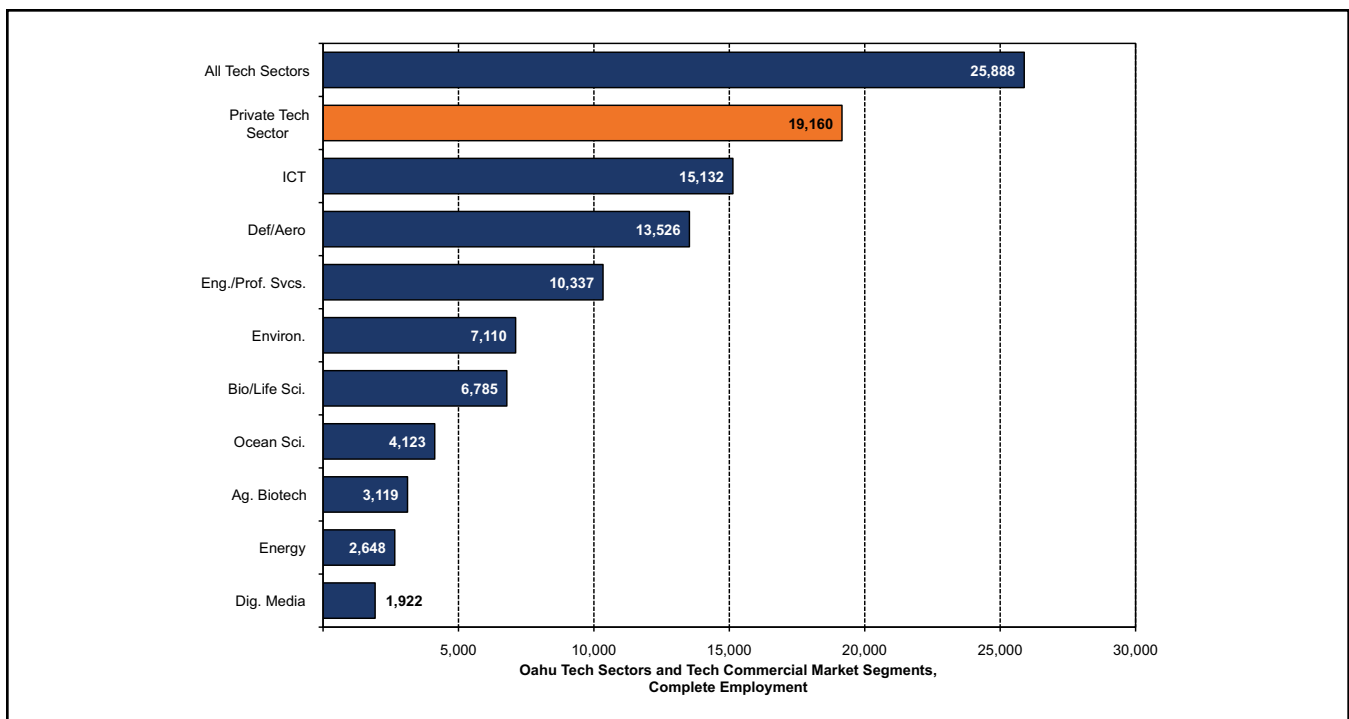
ISLAND OPPORTUNITIES

Oahu remains the primary driver of the state's technology sector, but niche opportunities exist for the Neighbor Islands. The unique climate and geology of the Neighbor Islands make them particularly important for certain research and development activities. Public investments—in the form of major DOD installations at PMRF, MHPCC, and the observatories—have served as the nucleus for much of the Neighbor Islands' research

and development. Further state investments in UH Hilo and NELHA, and state regulatory policy (especially regarding the environment and renewable energy) have also been critical to the success of technology development on the Neighbor Islands. The private-sector across the state has long taken advantage of DOD contracting opportunities, and recently more entrepreneurial spin-off activities have emerged. The development of newly incubated companies is becoming increasingly important as a source of private-sector employers.

The next section examines the needs of these growing sectors and the efforts underway to address those needs.

Figure 23: Honolulu County (Oahu) Tech Employment by Commercial Market Segment, Estimated 2007



Labor Market Trends in Technology Clusters

Many policy makers involved in innovation-driven economic development are particularly concerned about the availability of talented workers. Skilled talent represents the most important asset for most technology companies, so there is great emphasis on having direct access to both the technical expertise and the entrepreneurial talent to help companies innovate. These workers are needed, not only for the new jobs being rapidly created in the technology sector, but also to replace those workers who are leaving the state's workforce due to retirement, emigration to the Mainland, or other factors that spur workers to change careers. In the report we refer to these as "new" and "vacant" jobs.

Anecdotally, company executives and education experts all agree that there is a significant shortage of talented workers available in Hawaii to meet demand. Whether those jobs are in highly skilled occupations related to science technology engineering and math (STEM)³² or in vital support jobs, many of these careers require post-secondary education. A recent national study of the technology industry (as defined by the U.S. Bureau of Labor Statistics) found that 56 percent of the industry's current job mix requires at least two years of college education. Furthermore, 77 percent of the new jobs that the technology industry will create during the next 10 years will also require at least two years of college.³³

32. STEM includes about 130 occupations identified by the U.S. Bureau of Labor Statistics as requiring science, technology, engineering, or math skills. Those occupations are identified at <http://online.onetcenter.org>.

33. Kenneth E. Poole, "Preparing Working Poor Families for the Jobs of Tomorrow: A Policy Brief," prepared for the Working Poor Families Project, forthcoming 2008. Data is based on employment by occupation as developed from Economic Modeling Specialists Inc. (EMSI).

A recent national study of the technology industry found that 56 percent of the technology industry's current job mix requires at least two years of college education expected to increase to 77 percent during the next decade.

At the foundation of success in technology are the knowledge, skills, and abilities that individuals with adequate educational background have in the STEM disciplines. Rightly so, much attention has been targeted on the careers that are related to the STEM disciplines, but an assessment of the workforce needs of technology industries cannot be limited just to STEM knowledge, skills, and abilities. This assessment must also explore the many other occupations that are also vital to the success of technology companies. The technology sector offers many well-paying jobs in both STEM and non-STEM-related occupations, many of which do not require a four-year degree. Figure 24 demonstrates how technology industry jobs include a wide variety of occupations, including many that are not necessarily STEM-related. It also illustrates how many STEM occupations can be found in companies that are not defined as being part of the tech sector for the purposes of this report.

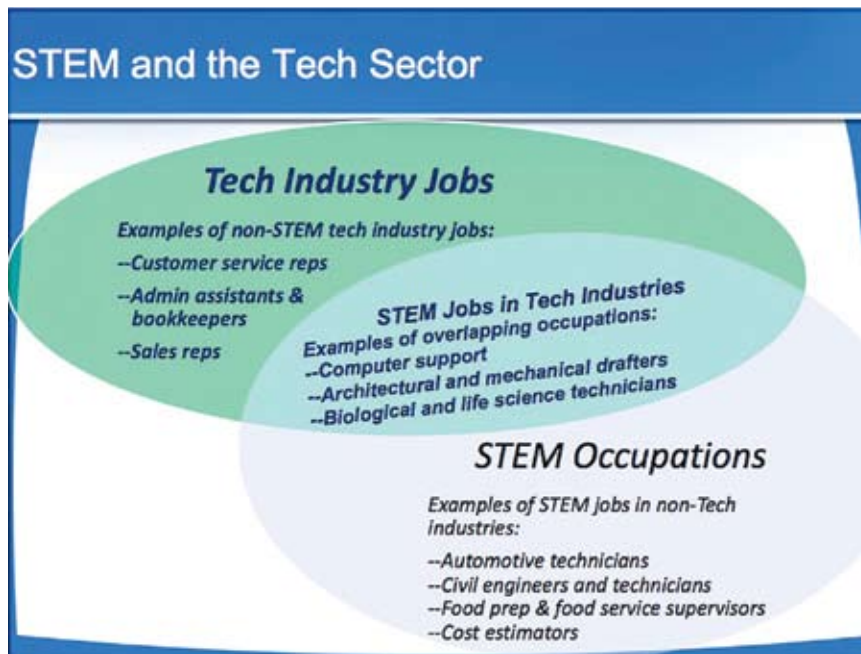
This section first examines the full array of occupations that are critically important to the state's STEM workforce, including those that may not be employed in technology industries. It is not always easy to tell whether a worker employed in a STEM occupation will actually work for a technology company. For instance, it may be quite possible for a network administrator to work for an information technology company—a technology industry—but it may be just as likely

that this same person could work for a bank or a distributor—not included as technology companies. After the discussion of STEM industries, the report turns to an assessment of occupational needs of companies in the technology sector, describing employment growth patterns, wage trends, and key educational requirements of the largest occupations demanded by technology industries. Wherever the data are available, the analysis also provides an estimate of the proportion of workers in individual occupations that are employed by technology companies. As noted earlier, 31,106 workers were employed in the state's technology industries in 2007. By comparison, an estimated 37,106 workers were employed in all STEM occupations in the same year, many of which are not included in the technology sector. It would require an additional research study of all 700 occupational categories to determine precisely the number of STEM workers employed by technology industry companies, but companies in the technology industries employ about 41 percent of the workers in the largest STEM-related occupations analyzed later in this section.

STEM Occupation Trends

Before examining the largest technology occupations, it is first important to explore those occupations related to the science, technology, engineering, and math disciplines. Certainly, STEM-related occupations are not exclusive to the technology sector, but tech companies rely on having access to an adequate supply of workers with skills in the STEM disciplines. Consequently, it is vital that STEM-related occupations (including those jobs that are filled by companies both within and outside the technology sector) have adequate support from

Figure 24: The Intersection of Technology Industries and STEM Occupations



Hawaii’s postsecondary education system. This support must come in the form of established degree programs, an adequate supply of enrolled students, and, most importantly, a sufficient number of quality graduates from those programs. Furthermore, as will be noted later, it is also important to technology companies that non-

STEM academic disciplines expose their students to relevant principles so that they can be effective employees in a workplace—no matter the industry—that increasingly assumes a basic understanding of science and technology.

The U.S. Bureau of Labor Statistics has identified a specific set of occupations closely tied to STEM disciplines. These occupations are tied to science (in the form of scientists and technicians), technology (primarily in the form of computing-related occupations), engineering (engineering and drafting occupations of all kinds), and mathematical sciences (including statisticians and accountants). The U.S. Department of Labor’s Employment and Training Administration-sponsored O*Net data system reveals nearly 100 specific occupations related to seven STEM disciplines— computer science, engineering, environmental science, geosciences, life sciences, mathematics, and physics/astronomy.

The U.S. Bureau of Labor Statistics has identified a specific set of occupations closely tied to STEM disciplines:

- **Science (in the form of scientists and technicians);**
- **Technology (primarily in the form of computing-related occupations);**
- **Engineering (engineering and drafting occupations of all kinds); and**
- **Mathematics (including statisticians and accountants)**

These occupations are each assigned to at least one of the STEM disciplines. In many cases, occupations are assigned to multiple disciplines, reflecting the overlap and convergence of many STEM-related activities.

According to data from EMSI, the U.S. economy had about 15 million STEM-related jobs in 2006, representing nearly 8.6 percent of all employment. By 2017, that number is expected to grow to 18 million, or 8.8 percent of total employment. That represents a projected 1.7 percent annual growth rate.

In all Hawaii industries, about 58,442 jobs in 2006 were STEM related.³⁴ By 2017, the state is expected to have 63,666 jobs in these disciplines (see Figure 25), which represents a 0.8 percent annual growth rate. Average annual earnings for these jobs were about \$48,000 per year. Based on current projections for the next decade, Hawaii companies (in all industries)

Based on current projections for the next decade, Hawaii companies (in all industries) must find 16,500 more workers that have knowledge, skills, and abilities in science, technology, engineering, and math.

must find 16,500 more workers, representing about 1,650 workers annually, that have knowledge, skills, and abilities in science, technology, engineering, and math disciplines. To be successful in obtaining jobs in these growing occupations, about 77 percent of these workers will need some kind of post-secondary education and another 17 percent will require at least a year of experience and on-the-job training. As a result, understanding the supply of new workers coming from the state’s educational system becomes critical.

34. Source: EMSI Occupational Estimates for all STEM disciplines.

Labor Market Trends in Technology Clusters

Figure 25: 20 Largest STEM Occupations in Hawaii

OCCUPATION	STEM DISCIPLINES	2006 JOBS	2017 JOBS	NEW JOBS	ANNUAL GROWTH RATE	REPLACE- MENT JOBS	AVG ANNUAL TOTAL JOBS AVAILABLE (INCLUDING NEW & VACANT JOBS)	AN- NUAL JOBS	MEDIAN ANNUAL EARNINGS
Accountants and auditors	Computer Science	7,957	8,297	340	0.4%	1,652	1,992	181	\$42,015
First-line supervisors/managers of food preparation and serving workers	Life Sciences	5,055	5,526	471	0.8%	1,323	1,794	163	\$30,552
Automotive service technicians and mechanics	Engineering	3,867	4,223	356	0.8%	1,132	1,488	135	\$32,926
Farmers and ranchers	Life Sciences	2,518	2,444	(74)	-0.3%	565	491	45	\$16,828
Computer systems analysts	Computer Science	2,419	2,939	520	1.8%	301	821	75	\$66,578
Civil engineers	Engineering	2,335	2,431	96	0.4%	409	505	46	\$62,281
Construction managers	Engineering	2,224	2,374	150	0.6%	443	593	54	\$71,473
Computer support specialists	Computer Science	2,110	2,441	331	1.3%	286	617	56	\$34,993
Computer programmers	Computer Science	1,690	1,615	(75)	-0.4%	439	364	33	\$49,839
Cooks, institution and cafeteria	Life Sciences	1,609	1,693	84	0.5%	548	632	57	\$28,215
Computer security specialists	Computer Science	1,289	1,678	389	2.4%	157	546	50	\$54,979
Computer and information systems managers	Computer Science	1,232	1,459	227	1.6%	246	473	43	\$80,170
Network systems and data communica- tions analysts	Computer Science	1,191	1,668	477	3.1%	154	631	57	\$51,059
Environmental compliance inspectors	Life Sciences	1,118	1,168	50	0.4%	289	339	31	\$46,298
Architects, except landscape and naval	Engineering	1,114	1,072	(42)	-0.3%	140	98	9	\$51,379
Cost estimators	Engineering	1,078	1,176	98	0.8%	266	364	33	\$53,869
Computer software engineers, systems software	Computer Science, Engineering	1,004	1,279	275	2.2%	109	384	35	\$72,791
Farm, ranch, and other agricultural managers	Life Sciences	910	933	23	0.2%	172	195	18	\$34,343
Computer software engineers, applica- tions	Computer Science, Engineering	842	1,133	291	2.7%	91	382	35	\$60,654
Engineering managers	Chemistry, Computer Science, Engineering, Geosciences, Life Sciences, Physics/Astronomy	826	876	50	0.5%	181	231	21	\$98,022
All other STEM occupations		16,053	17,241	1,190	0.7%	4,042	5,232	476	\$52,565
	Total	58,442	63,666	5,227	0.8%	12,946	18,173	1,652	\$47,996

Source: Economic Modeling Specialists Inc. • 4/07

THE LARGEST TECHNOLOGY INDUSTRY OCCUPATIONS

Not all of the largest technology industry occupations, however, are STEM-related. By and large, technology companies require workers with relatively higher-than-average educational attainment and skills. In fact, most technology industry workers are employed in occupations that require at least some postsecondary education and often four or more years of college. Even so, a few occupations offer opportunities for those who have attained a high school degree. Combined, 40 percent (or nearly

12,400 workers) of technology sector workers are employed in the largest occupations (see Figure 26).³⁵ The state's tech companies and organizations are expected to add another 1,800 jobs in the largest occupations during the next five years, a rate of 2.8 percent (nearly twice the anticipated growth rate for all state employment during that same period). The average earnings that workers can expect from these jobs are about \$56,060 per year, ranging from

35. Source for occupation and earnings data: EMSI. Occupation estimates were developed based on industry-by-industry national staffing patterns as reported in the Current Employment Survey and then estimated for Hawaii.

\$23,442 per year for office clerk jobs to \$85,800 per year for computer and information managers.

In the following section, we will examine several key occupational groups that represent the top occupations in the technology sector. Many of those jobs—like management analysts, general business and office personnel, and technology sales and service representatives—are not defined as STEM-related occupations, while many others—including a number of computer-related occupations, engineers, and architects, as well as financial management

Labor Market Trends in Technology Clusters

Figure 26: Largest Occupations for Tech Industries

SOC CODE	DESCRIPTION	2007 JOBS	PROJECTED 2012 JOBS	CHANGE	ANNUAL % CHANGE
13-1111	Management analysts	1,692	1,944	252	2.8%
25-1099	Postsecondary teachers	1,327	1,487	160	2.3%
15-1021	Computer programmers	872	937	65	1.4%
43-9061	Office clerks, general	648	740	92	2.7%
17-1011	Architects, except landscape and naval	599	606	7	0.2%
15-1041	Computer support specialists	529	603	4	2.7%
11-1021	General and operations managers	508	560	52	2.0%
15-1051	Computer systems analysts	541	653	112	3.8%
43-4051	Customer service representatives	561	731	170	5.4%
11-9199	Managers, all other	462	511	49	2.0%
15-1032	Computer software engineers, systems software	424	509	85	3.7%
15-1099	Computer specialists, all other	397	456	59	2.8%
15-1081	Network systems and data communications analysts	389	481	92	4.3%
15-1031	Computer software engineers, applications	386	477	91	4.3%
11-1011	Chief executives	369	406	37	1.9%
43-3031	Bookkeeping, accounting, and auditing clerks	356	408	52	2.8%
43-6011	Executive secretaries and admin assistants	352	400	48	2.6%
43-6014	Secretaries, except legal, medical, and executive	322	346	24	1.4%
43-1011	First-line supervisors/mgrs of office and admin	328	365	37	2.2%
41-3099	Sales representatives, services, all other	350	438	88	4.6%
17-2071	Electrical engineers	319	346	27	1.6%
11-3021	Computer and information systems managers	319	372	53	3.1%
15-1071	Network and computer systems administrators	311	383	72	4.3%

Source: EMSI Complete Employment - March 2008

workers—are included in the definition for STEM occupations. The purpose of the following discussion is to provide a more detailed analysis about the opportunities and challenges related to the technology industry's efforts to attract and keep talent in its largest occupations.

Management Analysts

For companies in the technology-related industries, the single largest occupation is management analyst. It is important to place this into context. Even though it is the largest occupation, management analysts still account for just 7 percent of all jobs in the state's technology sector.

Technology companies employed nearly 1,700 management analysts in 2007, representing 45 percent of all management analysts employed in the entire state. So, the tech sector is particularly important as a source of employment for this particular occupation. In their jobs, management analysts are asked to evaluate how work is done and how to improve it. They are responsible for documenting and communicating operations and procedures in a company and also assist in managing operations efficiently.

The state's technology companies

created about 430 new management analyst positions during the past five years. Over the next decade, the state's technology companies are expected to create another 46 (of the projected 118 positions statewide) new management analyst positions annually. Workers seeking management analyst positions typically must have a postsecondary degree in business and related fields as well as work experience. In addition, knowledge of specific science and technology disciplines is becoming increasingly necessary for these management roles, particularly for the available jobs in the tech sector. Starting pay averages about \$26,560 per year and median annual earnings are \$45,340.

Computer-Related Occupations

Ten of the largest occupations in the technology sector are related to programming, managing, and supporting computer software and hardware. Last year, nearly 5,000 Hawaii workers were employed by the technology industry in computer-related occupations such as programming, support specialists, systems analysts, software systems and applications engineers, network analysts, systems managers and administrators, and repairers.

The field offers jobs that have a wide range of degree and skill requirements. Figure 27 provides employment and wage data for the 10 largest of these computer-related occupations, as well as the minimum educational requirements for each occupation. The figure also illustrates that most jobs in these occupations are actually found outside the technology sector. Only in a few occupations (e.g., computer systems and applications engineers), are the majority of workers employed in technology industries. Meanwhile, other computer-related jobs such as

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Figure 27: Ten Largest Computer-Related Occupations within Hawaii's Technology Industries

DESCRIPTION	2002 JOBS	2007 JOBS	2012 JOBS	% OF THE OCCUPATION'S JOBS IN THE TECH SECTOR, 2007	PROJECTED ANNUAL NEW TECH JOBS	AVG ANNUAL TOTAL JOBS AVAIL-ABLE (INCLUDING NEW AND VACANT JOBS)	ENTRY LEVEL ANNUAL EARNINGS	MEDIAN ANNUAL EARNINGS	MINIMUM EDUCATION LEVEL
Computer programmers	779	872	937	51%	5	39	\$29,973	\$57,200	Bachelor's degree
Computer support specialists	448	553	536	30%	8	80	\$24,835	\$39,686	Associate's degree
Computer systems analysts	436	529	603	36%	21	72	\$40,518	\$63,315	Bachelor's degree
Computer software engineers, systems software	341	419	442	63%	15	25	\$47,445	\$75,982	Bachelor's degree
Computer specialists, all other	335	397	456	32%	9	48	\$48,464	\$73,757	Associate's degree
Network systems and data communications analysts	311	389	481	37%	17	57	\$36,171	\$56,846	Bachelor's degree
Computer software engineers, applications	302	386	477	61%	16	30	\$44,366	\$69,888	Bachelor's degree
Computer and information systems managers	266	319	346	32%	8	34	\$55,619	\$85,800	Degree plus work experience
Network and computer systems administrators	243	311	383	29%	13	54	\$37,482	\$57,096	Bachelor's degree
Computer, automated teller, and office machine repairers	210	255	287	29%	1	6	\$20,114	\$33,114	Postsecondary vocational award
Total Top 10 computer-related occupations	3,671	4,430	4,948	38%	113	445	\$37,505	\$54,385	

Source: Economic Modeling Specialists, Inc. • 4/07

those related to network administration, employ the majority of their workers in industries that are not defined as technology-related.

In just the handful of computer-related occupations identified in Figure 27, the state's technology sector employed 4,430 of the state's 11,561 workers in 2007. During the coming decade, the tech sector is expected to create 1,130 new computer-related jobs in these occupations, representing about 113 per year. Furthermore, Hawaii tech companies are expected to need about 445 computer-related professionals per year during the coming decade to fill new and existing job vacancies. Average annual earnings for the Top 10 computer-related occupations were \$54,385 in 2007.

Several specific computer-related occupations merit mention. For

example, the largest of these occupations is computer programmers. Technology-sector businesses employ nearly 900 programmers, representing more than half of all programmers employed in the state. These companies are adding about five jobs per year, but constant turnover in all industries is driving the demand to fill about 39 computer programming vacancies annually across the state.

The second-largest computer-related occupation—computer support specialist—typically requires an associate's degree as a minimum educational requirement. About 550

Hawaii tech companies are expected to need about 4,450 computer-related professionals during the coming decade to fill new and existing job vacancies.

computer support specialists worked in the tech sector last year. Throughout the economy in Hawaii, 105 new jobs were created in this occupation during the past five years, with about 30 percent of all such positions in the tech sector. During the coming decade, tech companies are expected to create eight new support specialist jobs annually, but 80 job vacancies are likely to come up each year during the next decade in all industries. Assuming that this is only 30 percent of the state's total demand (from the tech sector), then companies in the state will create a total of 27 new jobs each year and need approximately 267 specialists to fill both new and vacant computer support jobs each year.

About 530 computer systems analyst positions also existed within the technology sector in 2007. These workers analyze user requirements and business problems to determine the

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computer needs of workers. In some cases, they even supervise computer programmers, so they require project management and quality control skills. About 93 new analyst jobs were created in the technology sector between 2002 and 2007. About 36 percent of the state's computer systems analysts work in the tech sector. Looking to the future, technology companies can expect to create about 21 new positions annually, but all companies will likely hire about 72 computer systems analysts each year to fill new and existing job vacancies in just this one occupation. Overall, that means the state will need 56 new computer systems analysts, and a total of 200 to fill both new and vacant jobs combined.

Engineers and Architects

The state's technology and innovation businesses employ approximately 3,635 engineers (excluding civil engineers).³⁶ During the next five years, total demand for new engineering-related jobs (not counting civil engineers) is expected to be about 72 per year. The demand for new and replacement engineers, jobs and vacancies combined, is expected to be nearly 120 per year.

Employment and wage data for only the state's largest engineering and

36. Civil engineers were excluded from the definition of Hawaii's technology sector for the purposes of this report. As noted earlier, civil engineers were considered to be more closely related to the state's construction industry than to its technology sector.

architectural occupations are included in Figure 28. Of the engineering occupations, electrical engineering is the largest by far, with 319 electrical engineers employed by tech-sector businesses in 2007. Tech companies employ about 43 percent of the state's electrical engineers, and the tech sector has added 52 new electrical engineer jobs since 2002. Hawaii tech companies expect to add about five new electrical engineers (requiring a bachelor's degree) annually during the next decade. Hawaii companies will seek to fill about 30 vacancies each year resulting from the combination of new jobs being created and the need to replace existing personnel who are

During the next decade the tech sector is expected to need nearly 1,200 engineers (not including software or civil engineers).

likely to leave the field or move from Hawaii. Overall, this means that the state as a whole will add 12 net new electrical engineering jobs each year, and all companies in the state will need 70 electrical engineers in total to fill new jobs and vacancies combined. Other engineering professions will require new employees as well, but their requirements are more modest than for electrical engineers. In total, tech companies are expected to demand many of the 43 new jobs related to marine, mechanical,

electronics, health and safety, and environmental engineers per year during the coming decade. In addition, tech companies are also expected to need many of the 16 new jobs created for engineering technicians annually.

Other technology-related jobs include architects and their support personnel. Architects lead the creative process in planning and designing a wide array of structures. Architect jobs frequently require knowledge in engineering and technology as well as an understanding of design and the construction process. Nearly 600 architects worked in the technology industry in 2007, representing about 70 percent of all architects in the state. These technology-intensive industries added about 75 new jobs between 2002 and 2007, a result of a building boom in the state. But future job growth is expected to slow dramatically. Based on current projections, only about 23 architect jobs per year are likely to become available in tech-industry companies, including those vacancies created by persons leaving their existing jobs.

Technology Sales and Service Representatives

Sales personnel represent one area of the technology-intensive industries that is often overlooked, but remains vital to the lifeblood of tech companies. Technical or scientific knowledge (of disciplines such as biology, engineering, chemistry, and electronics) is often

Figure 28: Selected Large Engineer and Architect Occupations within Hawaii's Technology Industries

DESCRIPTION	2002 JOBS	2007 JOBS	2012 JOBS	% OF THE OCCUPATION'S JOBS IN THE TECH SECTOR, 2007	PROJECTED ANNUAL NEW TECH JOBS	AVG ANNUAL TOTAL JOBS AVAILABLE (INCLUDING NEW AND VACANT JOBS)	ENTRY-LEVEL ANNUAL EARNINGS	MEDIAN ANNUAL EARNINGS	MINIMUM EDUCATION LEVEL
Engineers and Architects									
Architects, except landscape and naval	524	599	606	70%	2	23	\$32,614	\$59,051	Bachelor's degree
Electrical engineers	567	319	372	43%	5	30	\$22,755	\$76,752	Bachelor's degree

Source: Economic Modeling Specialists, Inc. • 4/07

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required to effectively sell a firm's goods or services. While federal statistics suggest these jobs require about six to 12 months of training, in reality, companies indicate that they prefer candidates that have at least two years of postsecondary education, and frequently may require a bachelor's degree when interviewing job candidates. Figure 29 highlights these occupations employment and wage trends and the minimum educational requirements.

General Business and Office Personnel

Like many other growing industry sectors, the technology sector also has a significant demand for managers, supervisors, administrative personnel, and bookkeepers. A key component for developing Hawaii's technology sector will be the emergence of a deeper pool of professionals who have extensive knowledge of both the business and science of their industry. As a result, these non-STEM occupations cannot be overlooked. Figure 30 provides data on the employment, wage and educational requirements for the key occupations related to business management, administrative support, and financial management.

BUSINESS MANAGEMENT OCCUPATIONS

Business management personnel in greatest demand include chief executives, operations managers, first-line supervisors, as well as other types

of managers. Combined, these four occupations employed nearly 1,900 workers last year in the technology sector, representing just 5 percent of all workers in these occupations across the state's economy. In general, chief executives and general operations managers must have a bachelor's

A key component for developing Hawaii's technology sector will be the emergence of a deeper pool of professionals who have extensive knowledge of both the business and science of their industry.

degree with some experience. First-line supervisors of office personnel and other managers tend to gain their positions through work experience and may not always need a four-year degree to succeed.

Between 2002 and 2007, technology companies created about 182 new jobs for business managers. During the next decade, the Hawaii economy is expected to create about 340 new jobs annually for business managers. Of that total, about 22 new jobs are expected to be created in the technology sector. Including new and vacant jobs, the number of opportunities for business managers is likely to total 9,300 annually for the entire Hawaii economy during the next decade. Of those jobs, about 596 new and vacant positions are expected to be available in the technology sector.

ADMINISTRATIVE SUPPORT OCCUPATIONS

Last year, nearly 2,000 workers were employed in administrative support positions in the technology sector, comprising 5 percent of all workers in these occupations across the state. These jobs include general office clerks, administrative assistants, secretaries, and data entry keyers. While firms in the technology sector added 347 jobs during the past five years, growth is expected to slow to about 31 new jobs annually. The slowdown can be attributed primarily to an expected decline in the required number of data entry keyers as technology continues to transform administrative occupations. For many of these occupations, the jobs are available to high school graduates with about one month to a year of training. Minimum training requirements for general office clerk

Across Hawaii, an estimated 9,300 business management positions will need to be filled annually during the coming decade, of which 596 will be open in the technology sector.

jobs can often be one month or less. Technology companies are competing for administrative personnel workers in a much larger, statewide job market that is expected to create about 670 jobs per year during the next decade.

FINANCIAL MANAGEMENT OCCUPATIONS

Financial management personnel

Figure 29: Key Technology Sales and Service Occupations within Hawaii's Technology Industries

DESCRIPTION	2002 JOBS	2007 JOBS	2012 JOBS	% OF THE OCCUPATION'S JOBS IN THE TECH SECTOR, 2007	PROJECTED ANNUAL NEW TECH JOBS	AVG ANNUAL TOTAL JOBS AVAILABLE (INCL. NEW AND VACANT JOBS)	ENTRY-LEVEL ANNUAL EARNINGS	MEDIAN ANNUAL EARNINGS	MINIMUM EDUCATION LEVEL
Technology Sales and Services Representatives									
Customer service representatives	426	508	560	7%	37	413	\$20,467	\$32,573	Moderate-term OJT
Sales representatives, services, all others	272	322	346	12%	191	33	\$20,030	\$43,742	Moderate-term OJT

Source: Economic Modeling Specialists, Inc. • 4/07

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include accountants and bookkeepers. Representing about 3 percent of total employment, the technology sector employed 619 accountants and bookkeepers in 2007, adding about 109 new positions since 2002. Combined, tech companies expect to create 18 new accountant and bookkeeper positions annually during the next decade. But, each year, these companies will need to fill an estimated 306 bookkeeper vacancies and 211 accountant vacancies (in total, new and replacement positions). Accountants, of course, require a bachelor's degree while bookkeepers require moderate-term, on-the-job training in the financial management field.

EDUCATION PROGRAMS MOST RELEVANT TO HAWAII'S TECH INDUSTRY

Much work is already underway to prepare the next generation of workers for the needs of key technology industries. The state's community colleges and universities have a wide

assortment of programs designed to provide educational opportunities for those interested in pursuing the careers identified in information and computer technologies, engineering, earth and ocean sciences, life sciences, and many other high demand fields. This section taps data on degree program enrollment and completions to assess how well existing educational infrastructure is positioned to deliver required postsecondary degree programs in the most relevant academic disciplines.³⁷

Based on the specific needs identified in the technology sector, this section examines the degree programs and completions from programs such as business management, information and communications technology, architecture and engineering,

37. Data was obtained from the National Center on Education Statistics, Integrated Postsecondary Education Data System as reported by universities and community colleges. This data is not exhaustive, but is thought to provide a representative sample.

agricultural and natural resources, life sciences, and physical sciences. These degree programs are particularly important to ensuring that technology companies have the skilled employees they need, especially the key business management and technical personnel required to lead technology companies.

Business and Office Management

While not strictly tied to technology and innovation, the business administration and management disciplines are particularly important to a cluster of technology industries that are by definition relatively small and entrepreneurial. Certainly, the success of much of Hawaii's technology economy relies directly on the business process—the effective management of product development, the efficient implementation of process improvements, and the critical management decisions associated with organizing work and identifying commercial opportunities. Also, there

Figure 30: Key General Business and Office Occupations within Hawaii's Technology Industries

DESCRIPTION	2002 JOBS	2007 JOBS	2012 JOBS	% OF THE OCCUPATION'S JOB IN THE TECH SECTOR, 2007	PROJECTED ANNUAL NEW TECH JOBS	AVG ANNUAL TOTAL JOBS AVAILABLE (INCL. NEW AND VACANT JOBS)	ENTRY-LEVEL ANNUAL EARNINGS	MEDIAN ANNUAL EARNINGS	MINIMUM EDUCATION LEVEL
General Business & Office Personnel									
Management (Subtotal)	1,098	1,334	1,568	6%	22	596	\$35,052	\$73,656	
General & operations managers	439	541	653	6%	4	278	\$42,349	\$82,805	Degree plus work experience
Managers, all other	362	424	509	6%	12	74	\$30,035	\$67,579	Work experience in a related field
Chief executives	297	369	406	8%	6	144	\$30,118	\$67,226	Degree plus work experience
Administrative support	1,623	1,960	2,319	5%	31	1,142	\$20,810	\$31,772	
Office clerks, general	548	648	740	4%	15	527	\$15,392	\$23,442	Short-term OJT
Executive secretaries & administrative assistants	291	352	400	6%	8	176	\$27,310	\$40,539	Moderate-term OJT
Secretaries, except legal, medical, and executive	284	350	438	4%	0	160	\$20,800	\$32,989	Moderate-term OJT
First-line supervisors/managers of office and administrative support workers	280	328	365	4%	6	244	\$26,686	\$42,411	Work experience in a related field

Source: Economic Modeling Specialists, Inc. • 4/07

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is a growing need for business leaders to have a sound understanding of key technologies and the innovation process, especially among the executives and managers of tech companies. Since many of the most significant career opportunities in technology and innovation relate directly to business management roles, it is appropriate to incorporate a review of those educational programs in this analysis.

As illustrated in Figure 31, Hawaii's higher education institutions had 399 new graduates from business administration, commerce, and related baccalaureate degree programs in 2006. These students graduated from several relevant programs. Among the largest degree-granting baccalaureate-level business degree programs were those at the University of Hawaii Manoa, West Oahu, and Hilo campuses (with a combined total of 188 graduates in 2006).³⁸ Added to that total were 86

38. Source: Data are from the National Center on Education Statistics as reported by EMSI. EMSI has created a matrix of occupations related to each Classification of Instructional Program (CIP) code. This matrix was created using data reported to O*Net—an online database of occupations and curriculum programs data.

There is a growing need for business leaders to have a sound understanding of key technologies and the innovation process, especially among the executives and managers of tech companies.

graduates from Hawaii Pacific University (HPU) and 68 from the University of Phoenix. At the master's level, another 375 degrees were awarded in 2006.

Among the largest advanced degree business-related programs, UH Manoa's program in business administration graduated 158 students and the Hawaii Pacific University program in business/commerce graduated 178 in 2006. In addition, UH Manoa also graduated 52 candidates from its Management Information Systems program in 2006, reflecting the close ties between information technology and business management in today's economy. These are the target business school programs that policy makers might wish to influence to ensure that business leaders are ready to succeed in technology-intensive industries.

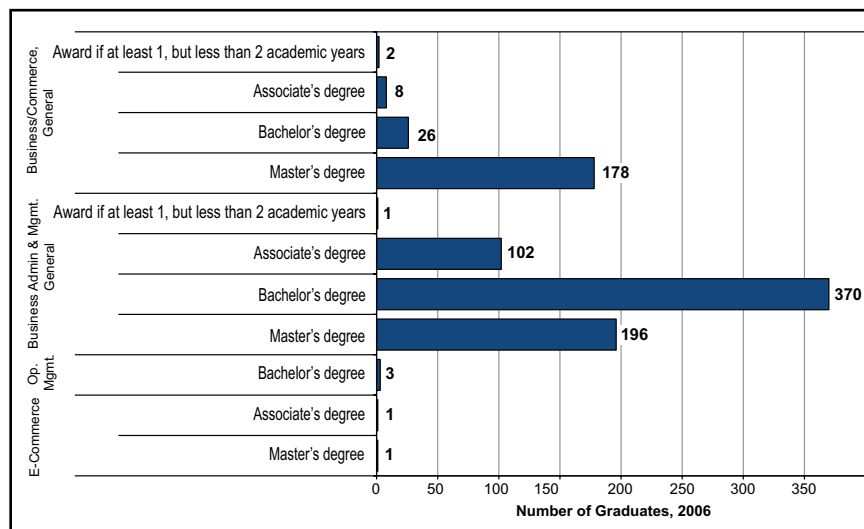
Computing and Information Technologies

The defense/aerospace and the information and communication technology commercial markets rely heavily on the technical competencies of thousands of information technology workers. Hawaii's higher education institutions have implemented a number of computer sciences, information technology, and information management degree programs in response to this and a broader need for these workers.

Degree programs are available at all levels, but many of the largest programs are designed to provide four-year baccalaureate degrees. Hawaii's higher education institutions offer eight different but related bachelor's degree programs in information sciences and related disciplines. All total, in 2006, these programs graduated 286 students with baccalaureate degrees in computer and information sciences, management information sciences, and information technology. Brigham Young University-Hawaii conferred the most degrees in any one program—44 bachelor's degrees in information sciences in 2006 followed by UH Manoa and HPU, which both graduated 40 students. In addition, three more baccalaureate degree programs graduated students in management information systems. UH Manoa graduated 52 students from that program while HPU graduated 38 in 2006.

At the master's or higher degree level, the state's higher education institutions conferred 60 degrees to graduates from three different computer and information or management information science programs in 2006. The largest, at HPU, graduated 39 information sciences master's students

Figure 31: Business and Office Management



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in 2006. The University of Phoenix graduated 10 MIS students in 2006.

Also in 2006, Hawaii institutions conferred 194 associate-level degrees in 12 different programs in computer and information technologies. These programs ranged from computer and information science to Web management. Heald College in Honolulu graduated 80 students in its computer and information sciences-related programs. Honolulu Community College had 27 graduates from its computer electronics and network technologies program. Remington College and HPU had more than 20 graduates each in their computer sciences programs. Kapiolani Community College also graduated 18 students from its information technology program. All of these programs—from associate's to master's degree levels—will be critical in meeting the state's rapidly growing need for information technology workers.

Architecture and Engineering

Engineers are critical requirements for tech companies. While the number of new engineering jobs created is relatively small, this pattern does not fully recognize that most successful engineers move from their first careers into project and business management tracks, leaving their former engineering jobs vacant to be filled by the next generation of trained engineers. Furthermore, newly minted engineers typically operate as technicians at the entry level, frequently developing the expertise required to succeed through on-the-job experience. The key issue may be that, increasingly, engineers require multidisciplinary engineering backgrounds that link electronics, computing, and systems integration. Furthermore, many of these individuals

are employed in industries outside Hawaii's technology industries. In 2006, UH conferred 62 baccalaureate and 16 master's degrees to electrical and electronics engineering candidates.

While occupational demand suggests that the state may require only a few new architects in the coming decade, the number of programs available in the state are quite small. Nine doctoral students in architecture graduated from UH in 2006 and none at the baccalaureate or masters' level. Honolulu Community College graduated 12 students from its architectural computer-aided design (CAD) program and three others earned certificates in CAD.

Life Sciences

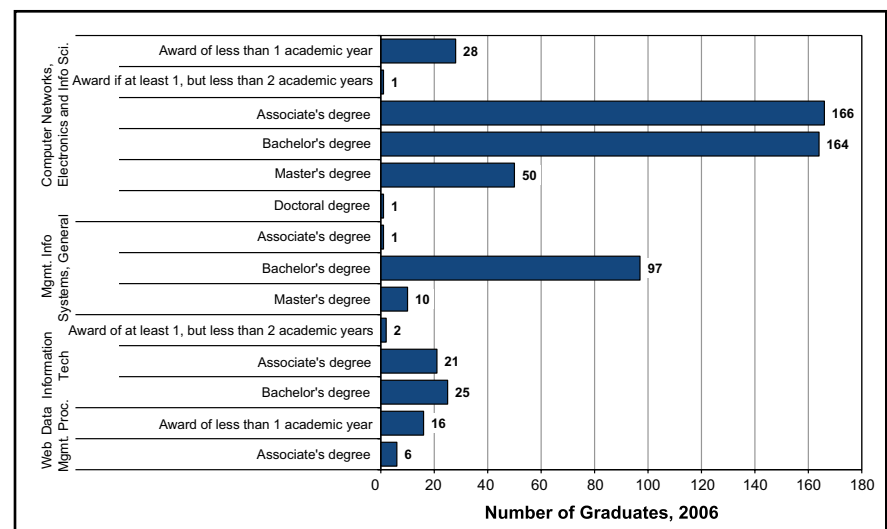
Hawaii's life sciences industries will rely on graduates from a number of degree programs related to biology and biomedicine. Besides a small biochemistry major at Brigham Young University-Hawaii, all of the graduates of related programs earned their degrees from UH. None of the programs are

particularly large, but most degrees granted are baccalaureates and master's in zoology and microbiology. In 2006, the university granted six doctoral degrees in zoology, one in entomology, and one in human genetics. Meanwhile, riding the popularity of several television series and movies, the forensic sciences have grown rapidly in many states. Not surprisingly then, the UH graduated almost as many forensic sciences students as zoology despite the fact that only a few new jobs are created in the field each year.

Physical Sciences

Hawaii's unique geography and geology have driven interest in earth, ocean, and space sciences research. Certainly, the proximity to international observatories and volcanic activity has helped to increase interest in many physical sciences, especially on Hawaii island. All total, in 2006, Hawaii universities graduated 75 baccalaureate degrees in the physical sciences—astronomy, meteorology, geology, earth sciences, oceanography, chemistry, and physics. The state's higher education institutions

Figure 32: Information and Communications Technology Programs



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conferred 31 master's degrees and 15 doctoral degrees in these fields.

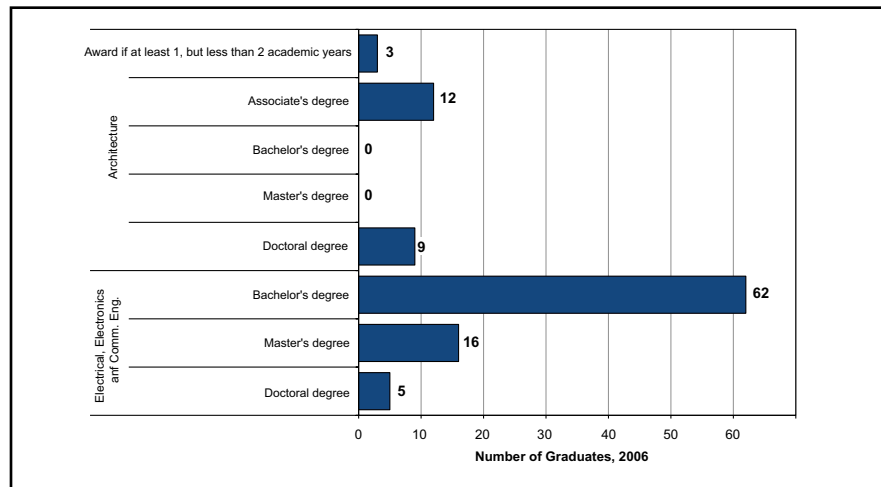
Astronomy and geology are particularly popular majors for baccalaureate degrees conferred by the University of Hawaii in Hilo. In addition, Hawaii Pacific University offers a baccalaureate degree in oceanography that eight majors completed in 2006. That same year, UH also conferred 10 new master's degrees in oceanography. These programs, combined with UH doctoral research in astronomy, geology, and oceanography will be particularly important sources of talent for emerging technology and innovation sectors in Hawaii.

GAPS AND OPPORTUNITIES

This analysis focuses on key gaps and opportunities among the largest occupations. About half of the state's technology workforce was employed among its 23 largest occupations in 2007. Those include management analysts, postsecondary researchers and teachers, a number of computer-related occupations, engineers and architects, technology sales and service representatives, general business and office personnel, as well as financial management workers. Many of these occupations require four-year degrees, but quite a few, including careers in computing and business-related fields, can be accomplished with an associate's or postsecondary career certification. Almost all of these jobs, however, do require at least a high school degree.

As an example of the gaps developing in certain of these occupations, the fastest growing technology industry occupations will need about 751 new persons each year to fill jobs as management analysts, operations managers, chief executives, and accountants during the next decade. (This number reflects only those required for the technology industry,

Figure 33: Architecture and Engineering

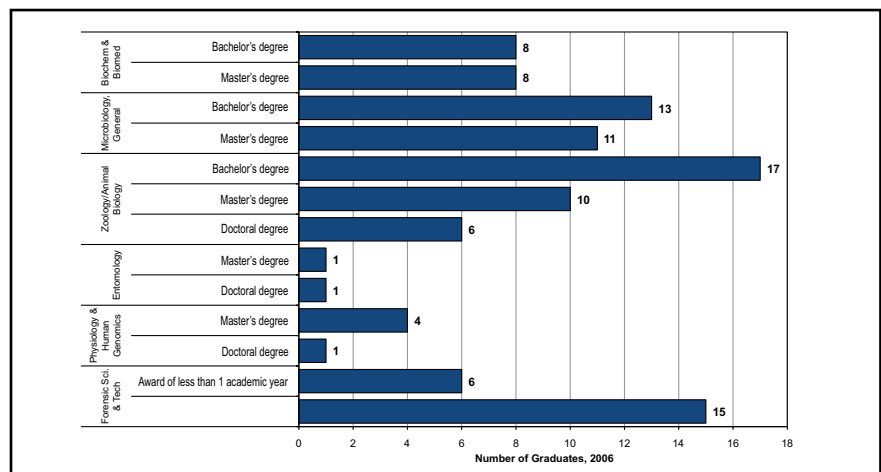


not those required in all other parts of the economy.) The great majority of these jobs require baccalaureate degrees or higher, but the state's institutions graduated only 566 persons in 2006 in related business management and finance fields. This suggests a potentially severe shortage of workers, especially among those with four-year degrees and combined business and science backgrounds.

Technology industry companies are expected to require 301 new and replacement workers in a variety of

computer-related occupations that require a baccalaureate degree or higher in a related discipline. Those jobs include programming, systems analysis, software engineering, as well as network administration and analysis. In 2006, 286 graduates earned degrees in computing, management information systems, and information technology, leaving a shortage of at least 15 graduates to fill the needs of tech companies—let alone the needs of the rest of the economy. Meanwhile, tech companies will need about 128 new and replacement computer support and related specialists

Figure 34: Biological and Biomedical



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each year during the next decade. This represents only about 30 percent of the state's total need, yet about 193 people graduated from these programs in 2006. This suggests that many more associate-level candidates (perhaps as many as 230 annually) are needed as well to meet industry needs.

In examining the gaps in engineering occupations, UH graduated a combined 88 new engineers (from its baccalaureate and advanced degree programs) in 2006. At the same time, all of the state's companies and government entities (including those outside the technology sector) annually need about 70 new engineers (and another 23 civil engineers) to fill just the projected new jobs. Combined with existing jobs, Hawaii may need as many as 150 new engineers to fill available job vacancies. Even assuming none of the current graduates leave the state to find jobs (an unlikely possibility), Hawaii companies will have a gap of 60 new engineers that they must find from the Mainland each year to meet their workforce needs.

Almost all of the science and technology programs are being

offered through the state university and community college systems.³⁹ In fact, the state's private universities appear to provide very few programs in the life or physical sciences, resulting in no graduates reported with specializations in these disciplines. Certainly, the private universities (such as Hawaii Pacific University and Chaminade University) are making important contributions to helping the state meet its needs for workers by offering a wide array of business management and finance programs, but few appear to specialize in integrating STEM knowledge as part of their business programs. It is unlikely that business graduates with limited exposure to the STEM disciplines would fill the rapidly growing demand for workers in science and technology companies.

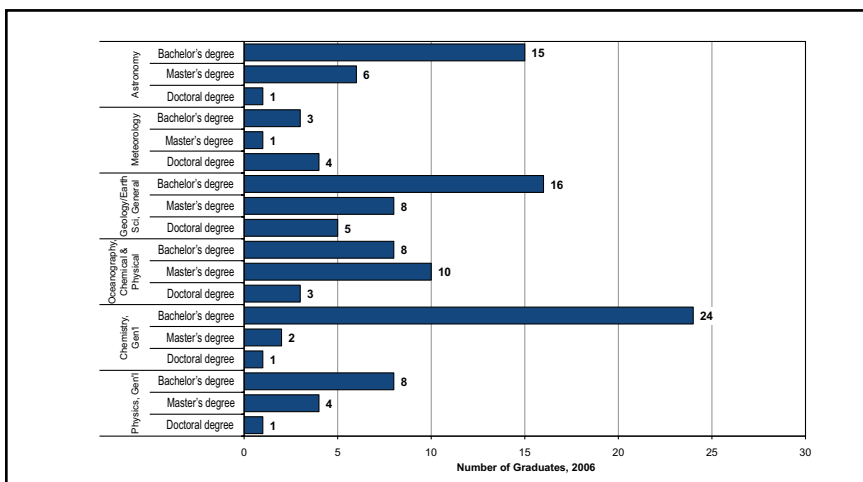
The demand for these and other STEM workers in Hawaii is expected to continue rising. A more detailed analysis of the state's workforce (beyond the scope of this report) would reveal

the total gap, but even without this data, it is clear that there are growing gaps in several key areas—business management, computer-related occupations, and engineering, to name a few.

To address these shortages, it will be necessary to expand specific degree programs in areas related to business management, computing, and engineering, but this alone may not be sufficient to address the challenges ahead, because many colleges and universities maintain that they cannot find students who are interested in and adequately prepared for the technology industry or related STEM careers. One way to overcome this challenge is to better integrate STEM education with other academic disciplines, even those that did not traditionally require such a technical education, including business and management degrees. Because the state's private higher education institutions are so important in helping to meet the state's need for more business and management talent, these institutions must also be included in any statewide strategic effort to prepare the state's next generation of science and technology workers.

39. Data was obtained from the National Center on Education Statistics, Integrated Postsecondary Education Data System, as reported by universities and community colleges. This data is not exhaustive, but is thought to provide a representative sample.

Figure 35: Physical Sciences



Implications for Policy

KEY FINDINGS

In 2007, the Hawaii technology sectors contributed about \$3 billion to the state's economy or roughly 5 percent of the state's \$61 billion economy. Overall, Hawaii's science and technology companies and government entities generated a total of approximately 31,106 jobs, or 3.6 percent of the state's employment. Private-sector technology-intensive businesses generated about 23,985 jobs—a figure representing almost 77 percent of the state's technology activity. Another 7,121 workers worked in the public-sector reflecting the large impact from the federal government and the UH system.

In 2007, these jobs had average annual earnings of \$63,623—a figure about 38 percent higher than the state average. That pay differential translated into roughly \$1,500 per month in added benefits and wages above the earnings of the average Hawaii worker. Furthermore, those private-sector companies generated an additional \$2 billion of indirect economic activity in the form of purchases from suppliers and the goods and services consumed by technology company employees. These workers created sufficient economic activity to support more than 20,000 workers in other parts of the economy. This suggests that the technology sector has linkages well beyond the core activities—impacting almost every other part of the economy. Furthermore, these industries are growing much more rapidly than the rest of the state's economy and much of that growth is being driven by the entrepreneurial efforts of the state's small, emerging private technology companies.

WHAT IS UNIQUE ABOUT TECH SECTORS IN HAWAII?

Hawaii's 1,900 private-sector technology firms pose a particularly difficult challenge for this kind of analysis, because so many firms operate in many different industries and participate in a variety of value chains. There are several reasons for this diversity of interest among Hawaii tech companies. First, small technology companies are often still in the midst of identifying their niche, so they tend to operate in multiple markets, searching for the most effective way to sell their goods or services.

Many of the emerging technology companies in Hawaii are quite small and the breadth of these firms' activities can be broad, since only a few companies may operate in any particular market space. At this stage of the technology economy's development, many of these companies have not yet matured (in an economic sense) sufficiently to specialize in a particular product or service line. This is due in no small part to the limited size of Hawaii as a technology marketplace. Companies serving only the market in Hawaii must be "jacks of all trades" to succeed. Even the largest Hawaii technology companies tend to operate in multiple, overlapping market segments. However, the limited number of larger businesses suggests that only a very few companies have developed the depth of experience or expertise to compete on a national or global scale.

The preponderance of small companies suggests that only a very few have developed the depth of experience or expertise to compete on a national or global scale.

Because many are so young, it is still unclear whether Hawaii-based technology companies will develop to an extent that they can serve national and global markets. In the short term,

Hawaii companies may need to consider how they might work together as collaborative networks to create the kind of presence and infrastructure to compete for these global markets.

WHAT DOES THE TECHNOLOGY SECTOR DO FOR THE STATE?

Hawaii has a small, but important technology sector. Relative to the rest of the U.S., Hawaii does not have a technology-intensive economy. While 3.6 percent of all workers in Hawaii are employed in the state's technology sectors, 4.6 percent of U.S. workers are employed in those same industries nationally. However, technology-related activities in the state are growing at a rapid pace. Hawaii's technology sector (including public- and private-sector employees) grew at an annual rate of 2.9 percent between 2002 and 2007. This outpaced the U.S. growth rate of 2.3 percent for these same industries. Hawaii's private tech companies did particularly well between 2002 and 2007 and added jobs at a rate of 3.3 percent annually. By comparison, the U.S. private-sector added jobs at a rate of 1.8 percent annually during the same period.

The sector contributed significantly to per capita income growth in the state. Although workers in the technology sectors accounted for 3.6 percent of total employment in 2007, they generated 5.4 percent (\$2.1 billion) of Hawaii's total earnings. While the state has a relatively easy time attracting postsecondary students, it also has a relatively difficult time retaining knowledge workers. According to a recent study, the state loses a net of 15 percent of its associate-degree holders and breaks even in retaining bachelor's-degree candidates.⁴⁰

40. NCHEMS, "Investment in State Post-Secondary Education: Hawaii," September 2007. Data is from 2001 to 2003 and from the 5 percent Public Use Microdata Samples (PUMS) produced from the 2000 Census.

Statewide, Hawaii's workers earn about 94 percent of the U.S. average, but the state's private-sector technology workers earn 72 percent of the U.S. average for the same industries.

One important reason is that the state's technology workers earn less than their counterparts on the Mainland. Statewide, Hawaii's workers earned about 94 percent of the U.S. average for all workers in 2007, but the state's technology workers earned 77 percent of the U.S. average. This disparity was even greater for private-sector technology workers, who earned 72 percent of the U.S. average for the same industries.

WHAT IMPEDES THE SECTOR'S GROWTH?

Hawaii firms often experience difficulty retaining skilled workers, particularly those from the Mainland. As noted above, wage differences are an important reason, but that difference is further exacerbated when Hawaii's relatively high cost of living is taken into account. This difference could be explained—to some degree—by Hawaii's relative concentration of technology industries. For instance, sectors such as ocean sciences and agricultural biotech are relatively lower-paying technology sectors, but those sectors are more important in Hawaii than they are in other parts of the U.S. However, the pay disparity holds through most of the technology-intensive industries, with the possible exception of professional, technical, and engineering services. In this one industry, the pay is nearly at parity with the national average for engineering/professional services.

One reason for the pay disparity is that Hawaii has more small firms as a proportion of all companies. Smaller firms tend to offer lower wages and fewer

benefits than larger ones. In Hawaii, the average technology firm—with 15.8 employees—had about two-thirds the workers of an average Hawaii firm.

At the same time, many Hawaii technology companies prefer to remain small. Some suggest that many companies intentionally do not seek market opportunities outside Hawaii because they prefer the lifestyle associated with a smaller enterprise. Only a very few technology companies look outside the state for growth prospects. Some maintain that their relative isolation from the Mainland or Asia inhibits access to those markets. With a limited number of competitors, local companies in some specialty areas do not need to aggressively compete for business. Although there are exceptions, many companies in the technology sector tend to react to local needs but are seldom proactive in identifying and pursuing opportunities that may have global

Hawaii companies may need to consider how they might work together as collaborative networks to create the kind of presence and infrastructure to compete for global market share.

growth implications for their firms. This local focus also tends to create a natural ceiling on the size to which Hawaii tech companies potentially grow employment. Certainly, many of the technology challenges that Hawaii companies are exploring exist outside the state—such as finding alternative energy sources, addressing environmental remediation needs, or developing customized computing or networking solutions to meet military needs. However, it seems that few local companies have identified how to pursue growth opportunities outside the state. Fewer still have successfully and effectively developed outside markets. This is not to say that

companies are disinterested in exporting opportunities. A few export successes can be found in Hawaii—companies seeking increased sales, licensing opportunities, contracts beyond the state, or closer ties to larger Mainland corporations. However, many of these companies (or local corporate offices) still rely heavily on serving the Hawaii market first.

Taking advantage of these other market opportunities will be vital to efforts aimed at minimizing the threat posed by any potential reduction in defense spending in Hawaii. In 2007, the Defense Department contracted with companies to provide \$2.13 billion in goods and services in Hawaii, representing 3.5 percent of the state's gross domestic product. This amount also represented an 11 percent increase in procurement from 2006 and a 25 percent increase from 2004. With such a high rate of growth, it is easy to become dependent on Defense Department spending. Should federal policy priorities shift and defense spending decline in the state, the economy could be severely impacted and the technology sector could be particularly hard hit. Lessening this dependence will be easiest during periods in which the national and state economies are growing. In addition to defense-related activities, the state has developed small niches in technology areas due in no small part to its unique location, climate, and society. For instance, the state has developed a cluster of companies in astronomy, renewable energy, and ocean sciences that has evolved due to the Islands' relative isolation from the rest of the world as well as its unique geography and geology.

Many suggest, however, that this same tradition has impeded growth of the state's technology sectors. Bottlenecks result during the land-use planning process and frequently they occur due to a lack of clarity or transparency in the

Implications for Policy

development process. At the same time, inadequately structured development approval processes make it difficult for companies or investors to understand with certainty whether or how long it will take for state or local approvals to occur. That said, Hawaii's strengths in certain technology areas are also due in part to its unique society. Whereas many parts of the world rely on public regulatory policy to help drive markets, Hawaii can tap both its remoteness as well as its societal respect for the land and sea as sources for driving niche developments in environmental remediation and renewable energy resources.

In part, this lack of structure or clarity is also directly tied to reticence among some in Hawaii about whether technological change reflects true human progress. As one interviewee noted, "The host culture of Hawaii through the ages has been in the forefront of technological advancement for the land and people's benefit. The wayfarer, the discoverer, the navigator, the healer, and the farmer were all intricate disciplines of society. Likewise, the land management system—ahupuaa—made sure that all people from the mountains, forests, rivers, streams, deserts, and ocean were providing for one another. The Hawaiians were also fast to adapt, incorporating new language and the written word." In addition, it was noted that, in the 1880s, Hawaii was the most literate nation in the world, and King David Kalakaua had electricity installed at Iolani palace before the White House. The king also asked Thomas Edison to explore ways to power Oahu with geothermal energy from the volcano on Hawaii Island. Understanding this perspective and aligning the goals of technology growth and development with the ideals of Hawaii's traditional

culture will be critical as Hawaii's technology economy emerges as an increasingly instrumental part of the state's future.

HOW DO THE NEIGHBOR ISLANDS PARTICIPATE IN THE TECHNOLOGY ECONOMY?

While about 28 percent of all workers were employed on the Neighbor Islands last year, only 17 percent of all technology-related jobs were located there. Also, about 6 percent of public-sector technology-related jobs were found on Hawaii, Maui, and Kauai combined. The Defense Department represents fully half of the state's public technology sector and that agency has concentrated the lion's share of those scientists, researchers, and engineers on Oahu. Furthermore, defense procurement also drives a significant portion of the private-sector technology activity on the island. In 2007, \$1.924 billion (or 90 percent of DOD procurement activity) in Hawaii occurred on Oahu.

Even so, Hawaii and Maui Counties each accounted for about 1,900 technology-related jobs and Kauai had another 1,000 jobs in technology industries in 2007. Certainly, the astronomy-related activities are important to the islands of Hawaii and Maui and defense-related activities are critically important to Maui and Kauai. Even though these public investments are relatively smaller on the Neighbor Islands, they still represent the nucleus around which technology activities are occurring there.

WHAT KINDS OF JOBS ARE BEING CREATED IN THE TECHNOLOGY ECONOMY?

The state's technology companies are creating jobs in a number of key occupations, including management analysis (i.e., consultants), computer networking and systems programming,

as well as engineering. These rapidly growing occupations all require a minimum four-year degree, often in a STEM-related academic discipline. These occupations tend to offer wages and earnings that are well above average. Shortages are likely to exist in the number of new graduates from doctoral programs in STEM-related fields, from baccalaureate and advanced physical and life sciences degree programs, as well as business degrees with supplementary background in STEM-related disciplines. In addition, there is a documented shortage in the computer sciences for information technology professionals, especially those with baccalaureate degrees.

Other jobs available do not necessarily require a four-year degree, but they do demand knowledge and abilities involving STEM-related disciplines often acquired in postsecondary career and technical education institutions. For instance, many technical sales representative or customer service managerial positions demand familiarity with STEM subjects. Successful incumbents in these careers must understand and anticipate customer needs and be able to identify potential technological solutions. That's why these occupations tend to pay relatively well, especially when compared to sales and service jobs in other industries.

Other jobs are more related to general business management—especially targeted to entrepreneurial businesses in the technology areas. In those companies, even fast-growing occupations in management, administration, and finance require an understanding of the company's products and services and the unique issues facing small technology businesses. These business-related occupations also require successful workers to have a strong knowledge of, and familiarity with, the STEM disciplines.

Recommendations

In synthesizing the findings of this report into a cogent set of key recommendations, it is notable that the state's relatively small science and technology base has the potential to become a significant player in driving the state's economic future. For Hawaii, the sector has depended in no small part on public-sector investment, particularly federal resources. Consequently, future success will likely rely on the state's ability to leverage those federal R&D dollars in combination with an increasingly knowledge- and information-driven private-sector interest in science, technology, engineering, and math.

This report provides a baseline of Hawaii's technology economy, profiles its scope, depth, and important characteristics, and identifies issues and challenges in facilitating its growth and development. The following recommendations are designed to address some of those issues, but it is not anticipated that they will be comprehensive. Indeed, they should be placed within the context of a strategic plan approach to fostering technology as an integral element in the state's future economic growth.

1. **Develop and implement a strategic plan, then monitor progress in achieving greater development of technology and innovation in the state, in collaboration with private- and public-sector stakeholders.**

The plan developed for Hawaii should review baseline information about the technology economy presented in this and other reports with stakeholders, examine their concerns and create a consensus on state priorities aimed at fostering stronger growth in technology

and innovation among all Hawaii firms. An integral part of this strategic planning process should be the validation of appropriate benchmark indicators (developed from among the metrics DBEDT has already identified as well as others that reflect the concerns and interests of key stakeholders). The purpose of tracking these indicators is to help guide strategy development as well as provide a mechanism for tracking economic progress.⁴¹

2. **Diversify the state's technology base by encouraging private investment in non-defense activities and by increasing local commercialization of technology developed with DOD funding.**

Defense-related spending has been a significant stimulus to techsector growth in Hawaii, but if federal funding decreases significantly an overdependence on defense spending could prove problematic. Dual-use strategies aim to help companies find commercial application and markets for defense-related technologies, but a true diversification effort goes beyond this strategy. Taken alone, a "dual-use" strategy would focus on "technology push" efforts—finding market opportunities for existing products or services. However, a balanced effort to diversify the economy would also use a "technology pull" approach—finding market opportunities and then developing or deploying technologies to meet those needs. Those market opportunities certainly may exist in Hawaii, but they also may be found anywhere in the world. For instance, Hawaii-based firms that are developing energy-related technologies (algae,

OTEC, etc.) license those technologies to firms in other regions where they have commercial potential.

3. **Support existing trade and professional group efforts to develop cluster networks that support the key technology market segments.**

Increasingly, companies will learn more about market opportunities or potential partners to meet market needs through their relationships with other firms. The state has a number of small industry networks designed to share information, but those nascent groups require further support to realize their full potential. These networking groups could help to bring together smaller Hawaii companies to form collaborative arrangements that would allow them to better compete with larger Mainland companies for federal contracts and in private markets. In addition, these interrelationships are likely to result in more creative uses of existing technologies.

The state should begin to examine the technology partnership networks—focused on certain industries or clusters in which the state has a competitive advantage. One exemplary program being implemented in Pennsylvania supports local efforts to create "industry partnerships" focused in selected industry sectors. The Pennsylvania networks are not tied to technology sectors, but are focused on "organically developing" groups of companies that come together to address common problems.

In this proposed initiative, these partnerships would facilitate greater interfirm interaction and market collaboration. These collaborations

41. For more information on indicators please see Technical Appendix Measuring Innovation at <http://www.HISciTech.org/Information>.

Recommendations

could result in increased joint proposals for federal, state, and private-sector research and development. Efforts should also continue to be made to build formal mentoring networks for prospective technology entrepreneurs. These networks should connect entrepreneurs with experts in developing business plans, pursuing risk capital, identifying potential market opportunities, and marketing their products.

4. Assist with the formation of risk capital at all levels and continued private-sector investment in technology and innovation.

In conducting the research for this report, companies and policy makers alike frequently cited the importance of public policy efforts in influencing business investment decisions. While capital formation is not the focus of this report, private-sector representatives frequently noted the value of current state programs but also implied that many operated on an *ad hoc* basis.

As the private-sector increasingly moves to the forefront as a key driver of technology development in the state, existing state programs intended to encourage private-sector investment—in terms of direct assistance as well as tax incentives—must produce ever greater outcomes. One way to achieve this success is to better integrate existing programs into a more cohesive and strategic financing mechanism designed to leverage resources, but this must be done in the context of enhanced demand for transparency and accountability.

In particular, state efforts to promote capital formation must effectively address the needs that entrepreneurs encounter during the development life

cycle—from pre-commercialization to company formation and expansion. To do so, the state's technology programs must respond more systematically. For instance, entrepreneurs frequently need access to pre-seed and seed capital to prove that their ideas have commercial merit as well as mezzanine and venture capital to support the growth that would allow them to bring those ideas to market. Many leading states also make substantial and consistent resources available to support R&D assets that represent the source for many new innovations.

The state should use its resources to leverage both existing investments and leadership available in the public and private-sectors within a defined strategic framework that results in a public benefit as well as private growth. The most successful strategies balance the proposed public-sector investments with significant, high profile private-sector participation. Engaging the expertise and perspectives of those taking entrepreneurial risks is vital to success so Hawaii must do whatever it can to increase collaboration among the state's small technology companies as well as enhance industry/university partnership opportunities aimed at solving applied, market-relevant problems.

By coordinating resources and filling identified gaps, Hawaii could offer additional seed grants and loans to complement existing programs and leverage greater private-sector, federal, and/or university research dollars. This would entail that the state implement an intentional, thoughtful, and transparent tax policy aimed at promoting capital formation supplemented with dedicated matching grants aimed at leveraging private participation and investment.

This is especially important for Hawaii companies or research consortia seeking to compete in markets outside the state, build on existing technology strengths, as well as diversify the state's current research base.

5. Design a comprehensive technology workforce retention strategy to reduce turnover and keep talent in Hawaii.

Hawaii residents benefit from the opportunity to explore academic and career opportunities in other places, but this often means that the state loses some of its most talented workers to the Mainland. Rather than trying to eliminate out-migration, Hawaii should focus on targeted efforts to retain the most talented of these individuals as well as reinforce its efforts to bring Hawaii-born talent home and work to attract world-class scholars to the state.

One element of this strategy should focus on the state's labor market. This strategy should use multiple approaches developed in collaboration with businesses, government, and employees. First, company executives note that it is easy to attract talent in part because Mainlanders view their time in Hawaii as part of an extended vacation; but ultimately, the vacation ends. As Hawaii implements its talent recruitment efforts (including the Kamaaina Come Home™ initiative), it will be important to develop a more thorough understanding of what motivates those individuals who are initially attracted to careers in Hawaii. For instance, many employers indicated that their most committed workers were those that had a strong affinity for the sea and the surf. With additional research, it might be possible to develop more detailed profiles of personal interests that match with what Hawaii has to offer.

Second, business leaders must become more aware of the wage disparities between similar occupations offered in Hawaii and on the Mainland. In technology jobs, workers are much more likely to explore national or global opportunities, so Hawaii companies and agencies must recognize that wages and benefits must compare favorably with those offered on the Mainland. In emerging industries of particular importance to the state's future, the state may even want to consider tax benefits to state residents who work in certain in-demand (or "critical") occupations as a preventive strategy designed to keep Hawaii residents from leaving the island for better-paying jobs elsewhere.

Finally, one theme that was highlighted by a number of newcomers to Hawaii was that, while the people in the state are very tolerant and welcoming, these newcomers felt that it is very difficult to become a part of the local community. This may be a residual effect from Hawaii's transient culture. Certainly, with so many travelers (tourists and military personnel alike), it is not surprising that the state would have a difficult time developing a sense of place for so many newcomers, but their talent will be critical to sustaining a growing technology sector. Social and professional networks can play a crucial role in helping these new Hawaii residents to feel part of the community. One way to help establish these ties to the state is through the support of existing and emerging formal networks, in the form of young professional groups, technology councils, or similar organizations established to provide social and professional links among newcomers with residents who have established Hawaii ties.

6. Monitor the contribution of the state's technology sector to the

overall economy, and especially the state's growth opportunities in global technology value chains.

This report provides an overview and framework for analyzing the state's technology economy, but it raises many questions about the dynamics of the companies in those key technology sectors. The study identifies several industries that are growing rapidly—including defense, computer systems design, and research and development—and market segments with potential for growth—including defense/aerospace, information technology, and engineering. However, much more in-depth qualitative and quantitative analysis could help better understand the core drivers in each of these market segments and related core industries. Furthermore, this would also help to better understand key linkages to other parts of the Hawaii economy.

This research defines the linkages (discussed at length in Technical Appendix 3: Value Chains, on www.HISciTech.org/Information), but it should also be used to inform Hawaii companies about existing and potential market opportunities, especially related to dual use for defense technologies, licensing of renewable energy technologies, and custom computing solutions that Hawaii tech firms might offer companies in its broader economy (such as travel and tourism) or to market niches on the Mainland and internationally.

Work has already begun to identify the key core industries, including scientific research and development, computing services, engineering, information management services, and technical consulting. The research agenda should include gaining insights from

companies about their innovation activities (including process, product, and organizational plans), business growth challenges, workforce issues, and relevant policy impediments. This research may involve the development of new primary data collection activities focused on providing deeper understanding of the innovation activities across the entire economy.

7. Assess how well the state's entire business incentive portfolio has fostered private-sector investment in technology, innovation, and related value chains.

Like any state investment strategy, the state should devote resources to promoting technology growth using a variety of approaches—including tax policy, equity investment tools, and information-sharing initiatives.

To make the link between the state's economic progress and the success of its investments, the state should conduct an evaluation of how well Hawaii's entire portfolio of state technology development programs—including all tax incentives as well as economic development investment programs—are doing in influencing business investments.

8. Enhance workforce programs designed both to increase internships with technology companies and provide information about STEM careers.

The Hawaii Workforce Development Council, the High Technology Development Corp., the Hawaii Science & Technology Council, and other partners (including Kamehameha Schools, the S.T.E.M. Hawaii Project, the Women in Technology Project on Maui, and others) should build their collaborative efforts to create

Recommendations

a comprehensive technology career internship and information program designed to match small tech companies with current and future workers interested in STEM careers. In particular, the partners should identify and help create paid and non-paid internship opportunities within Hawaii companies that target high school, community college, and university students interested in computing, engineering, information management, and scientific research. The program might provide a supplemental stipend to help subsidize the hourly wage benefits that companies offer.

In addition, a special program would also be created for incumbent workers (with special emphasis on those working in lower-wage industries) to help Hawaii residents go back to school as well as gain exposure in relevant business management, researcher, technician, and sales careers. The programs would be developed in close collaboration with key industry networks and initially focus on careers in fast-growing technology industries. Special emphasis would be placed on helping to build relationships with students or companies located on the Neighbor Islands.

9. Systematically examine how two-year and four-degree programs at UH and the private universities can better meet industry needs and expand or develop new programs to meet those needs.

The University of Hawaii system in collaboration with the Workforce

Development Council and DBEDT should conduct an in-depth assessment of the existing university and community college programs, partnering with industry to determine how they respond to industry needs in the state. This analysis would examine all academic degrees, continuing education, and outreach programs to determine their pertinence to Hawaii's economic future. A key element of this assessment would be to explore how well the state's postsecondary institutions are preparing students for careers in the STEM disciplines. An important element of this analysis would include an assessment of how well the academic programs are encouraging multidisciplinary research and teaching as well as the integration of STEM into all curricula, particularly those related to business management. Furthermore, the study would explore the career paths of graduates, especially from STEM-related disciplines, as well as the business community's perceptions of the quality of graduates. In addition, the analysis should explore the role that private postsecondary institutions play in attracting students and helping to retain the state's existing workforce. Ultimately, this analysis should go beyond the university's efforts to enhance its research credentials. It should address the question of: How well are the state's postsecondary institutions preparing people to manage and work in Hawaii's emerging technology-intensive economy? Furthermore, how well is Hawaii preparing that workforce to foster innovation in traditional industries?

10. Develop a community consensus-building process designed to establish greater understanding among technology advocates and the state's traditional business leadership.

One recurring issue that was raised by technology company executives, policy makers, and citizen leaders alike was the ongoing tension between rapid change and tradition in Hawaii. This is illustrated in the form of interminable approval processes for planned developments as well as resistance to the placement of larger telescopes on Haleakala, Mauna Kea, or Mauna Loa. It is also illustrated in the disinterest by many Hawaii citizens in the opportunities available from many technology-related occupations. The effort would build an ongoing line of communication and provide a structure for dialogue that respects the opinions of all parties and develops appropriate compromises to move the state forward. Tapping leaders with varied perspectives, this group would be assigned the task of balancing the need to respect Hawaiian culture with the desire to encourage economic prosperity for all. The initiative would also involve developing customized training for public-sector officials, development professionals, company executives, and community leaders on more transparent government processes that would allow for innovative, balanced progress while also protecting key Hawaii priorities of sustainability and tradition.

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Appendix 1: Stakeholder Participants

We wish to thank all the participants of the interviews and focus groups, including those we were not able to list here, for sharing their insights and contributing to this study.

Agricultural Biotechnology:

- Stephanie Whalen, Hawaii Agriculture Research Center (HARC)
- Cindy Goldstein, Pioneer Hi-Bred International
- Gary Karr (formerly with) Oceanic Institute
- Paul Koehler, Monsanto

Astronomy

- Rolf-Peter Kudritzki, UH Institute for Astronomy (IFA)
- Mark McGuffie, Hawaii Economic Development Board
- J.D. Armstrong, University of Hawaii, Institute for Astronomy (IFA)

Biotechnology/Life Sciences

- Michael Coy, Cellular Bioengineering Inc.
- Bruce Stevenson, Pacific Health Research Institute (PHRI)
- Brad Perkins, Tissue Genesis Inc.
- Elliot Parks, Hawaii Biotech Inc.

Defense/Aerospace

- Rick Holasek, NovaSol
- Chuck Jones, Booz Allen Hamilton
- Tim Dolan, Raytheon Co.
- Larry Lieberman and David Brauer, Referentia Systems Inc.
- Robert Lytle, Boeing LTS, Maui

Renewable Energy

- Warren Bollmeier, Hawaii Renewable Energy Alliance
- David Leonard, Imperium Renewables Hawaii
- Mawae Morton, Hawaii BioEnergy LLC
- Barry Raleigh, HR BioPetroleum
- John Ray, SunFuels Hawaii
- Michael Kaleikini, Puna Geothermal Venture
- Joelle Simonpietri, Kuehne Agrosystems

Environmental

- Matthew Neal, Element Environmental
- Selena Tarantino, ReUse Hawaii
- Robert Bourke, Oceanit

Film/Digital Media

- Rick Galindez, Galindez Tjioe

Information/Communication Technology

- Dale Aiello (Association of Information Technology Professionals) and Gartner
- Lou Darnell, Hawaii Telecommunications Association and ComTel Inc.
- Alan Yamashiro (Project Management Institute) and Project Professionals LLC.
- Todd Lawson, Akimeka LLC
- Lianne Yoshida, Maui High Performance Computing Center (MHPCC)
- Norman Johnson, Referentia Systems Inc.

Ocean Sciences

- Michael Cahinhinan (formerly with) Oceanic Imaging Consultants Inc.

- Rick Hess, National Defense Center of Excellence for Research in Ocean Sciences (CEROS)
- Liz Corbin, Department of Business, Economic Development and Tourism (DBEDT)

Engineering/Professional Services

- Rick Smith, Westin Solutions
- Todd Barnes, Army Corp of Engineers
- Curt Leonard, Oceanit

Research, Education and Commercialization

- Kevin Kelly, University of Hawaii System
- Vassilis Syrmos, University of Hawaii System
- Gary Ostrander, University of Hawaii System
- Michael Hamnett, Research Corporation of the University of Hawaii
- Alexander Shor and Paul Bienfang, School of Ocean & Earth Science and Technology (SOEST), University of Hawaii
- Jo-Ann Leong, Hawaii Institute of Marine Biology, University of Hawaii
- Peter Crouch, Dean, College of Engineering, University of Hawaii
- Michael Rota and Cheryl Chappell-Long, University of Hawaii, Community Colleges
- John Chock, (formerly with) Hawaii Strategic Development Corp., State of Hawaii
- Mark Ritchie, Enterprise Honolulu
- James Gaines, University of Hawaii System



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