HAWAII'S

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ECONOMY

A Report from the Department of Business, Economic Development & Tourism

In This Issue

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Hawaii's Emerging Technology Industry

Hawaii is making a strong effort through infrastructure support, university research, labor force training and other means, to support the growth of advanced technology enterprise in the State. The effort is developing as a partnership between the private and public sectors and is structured around Hawaii's existing technology resources and competitive advantages. The goal of this effort is to help advanced technology become a major growth sector in the State's economy.

Hawaii is well positioned to compete in a broad range of science and technology-based endeavors. Given our State's strategic mid-Pacific location, we are ideally situated to serve as a bridge to Asia-Pacific markets. Our Trans-Pacific fiber optic and satellite connectivity make our island community an increasingly important node on the global information superhighway. Our high-speed data processing and super-computing facilities give us parallel processing capabilities that can serve a broad range of industries (e.g., medicine, astronomy, global climate modeling and coastal resource management). We are home to the world's premier sites for research, demonstration, and development in astronomy, oceanography, and land-based geophysics. Our state serves as a national leader in many research and development efforts related to renewable energies, ocean resources, telecommunications, and other technology-based industries.

Given these particular strengths, as well as technology development already underway, it appears that Hawaii's best prospects for the development of an advanced technology sector lie in the following areas:

- *Information Technology*
- *Telecommunications*
- *Biotechnology*
- *Health Care & Medical Technology*
- *Astronomy & Space Science*
- *Ocean Research and Development*
- *Environmental Technology*
- *Renewable Energy*
- *Engineering Research and Development*
- *Dual Use (military/civilian) Technology*

This report on technology begins with a look at these ten areas of specialization and the significant activity occurring in each.[1]

Information Technology

High Performance Computing to Interactive Entertainment

Information technology covers the spectrum of advanced technical activity used to develop and process information to serve the economic, social, and personal needs of society. It includes the computer and software industries and

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[1] This article is an edited version of the January 1999 DBEDT publication *Science & Technology, The Key to Hawaii's Economic Future*. The entire report is available on the DBEDT web site at: http://www.hawaii.gov/dbedt/ert/key.html

Why Hawaii Must Pursue Technology Development

By Dr. Seiji Naya, *Director*
Department of Business,
Economic Development & Tourism

Hawaii's economic future may be determined in large measure by how well we can use science and technology to increase our productivity and become a center for technological innovation in the Pacific. As tourism settles into an era of more modest growth, an expanded technology sector could become Hawaii's new growth engine. This would generate new export products, raise Hawaii's profile in the worldwide technology community and help attract interest and investment in Hawaii as a site for serious scientific and technology activity. Moreover, an expanded technology sector can help support the spread of new technology into Hawaii's industries, which is critical for ensuring a competitive economy in the 21st century. Because of its importance and promise, the development of Hawaii's technology capabilities has become Governor Cayetano's top economic policy goal.

Seiji Naya

Hawaii's Economic Transition

The last eight years has been a period of change and restructuring in our economy. As most of us know, Hawaii's post-statehood boom era, based on high tourism growth, large inflows of foreign capital and high labor immigration, came to an end in the early 1990s. The State met this challenge with an aggressive program to reinvigorate economic growth, including government streamlining, reduced regulation in the economy and the nurturing of new economic activity that can take advantage of Hawaii's unique resources and assets. The private sector has also made significant progress in improving productivity, raising the competitiveness of the economy and refocusing on areas where Hawaii companies have a competitive edge.

Now, for the first time in a number of years, economists in Hawaii are expressing genuine optimism about the near-term future of our economy. Most economic indicators have, or are beginning to turn positive and 1999 will likely show solid economic gains. It is, therefore, an appropriate time to focus on the future, particularly the kinds of economic activity and policies that will define Hawaii's economy in the 21st century.

Technology's Role in the Economy

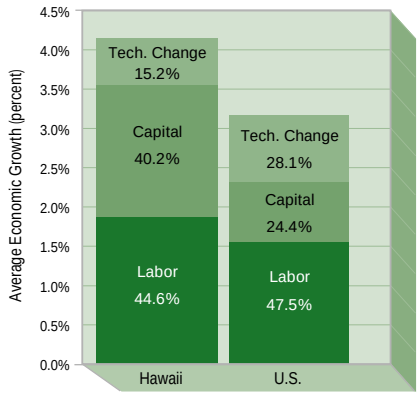
Technology will be an important cornerstone in defining Hawaii's economy in the 21st century. Certainly other industries like tourism, the military, agriculture and others will continue to be vitally important activities. However, technology development will be the key to boosting the State's productivity and competitiveness in the economy of the future. Let me explain why technology is so important.

Research over the past several decades has shown that the impact technology has on productivity is a major factor in how fast economies grow and how well they can compete in national and international markets. Technology has immense impact on the economy. It is estimated that as much as half of all economic growth in the U.S. in recent decades has been due to the application of technology in the economy.

At DBEDT we have tried to identify the role technology has played in the State's economic growth over the years. Using some tools of economic analysis, we estimated the individual contributions of capital, labor and technology to Hawaii's economic growth since the early 1970s. The results were surprising. They helped explain why we have had difficulty adjusting to the end of the post-statehood boom as well as highlight why technology development is so vital.

The chart in Figure 1 shows the economic growth for Hawaii and the U.S. from 1970 to 1990, broken down by the contributions of capital, labor and technological change.

Figure 1. Contributions to Economic Growth
1970 to 1990



Source: DBEDT

The figure shows that during this period of Hawaii's tourism-driven economic boom, the State's economy grew a full percentage point more on average than the U.S. economy. While the contribution from employment growth in the workforce was similar for Hawaii and the U.S., the story is very different for capital growth and technology. Hawaii's economic growth depended nearly twice as much on increases in the capital stock than did the U.S economy. On the other hand, the contribution to total economic growth by technology was twice as much at the national level. Increases in technology accounted for an estimated 29 percent of U.S. economic growth over the period, but only 15 percent for Hawaii.

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Hawaii's Emerging Technology Industry

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increasingly the entertainment industry. Hawaii's resources for advanced computing, communications, and data management infrastructure have established the State as a national leader in the development and application of information technology.

Pioneering research being conducted at the University of Hawaii's Departments of Electrical Engineering and Computer Sciences is producing advanced computer programs for intelligent image processing and strategic resource management. The University also houses the Hawaii Software Service Center, which provides strategic market information

Final Fantasy VII
Square Co. Ltd.

and business development resources for companies that create, sell, use or support software-based products.

Other facilities across the state afford a wealth of resources that continue to support new developments in information technology. The Manoa Innovation Center on Oahu and the Maui Research & Technology Center (MRTC) at Kihei provide high-tech "incubator" services linking start-up companies with university R&D organizations, many of which are developing algorithms for data imaging and compression. The Hawaii Telecommunications & Information Resource Center, located at the Maui Research and Technology Park promotes development and use of information technology to facilitate technology training, business expansion, commercial spin-offs, exporting, high-speed connectivity to MHPCC, and the attraction of outside investment. One of five national NASA Regional Validation Centers has been established at MRTC to transfer NASA-developed hardware and software that may be used and applied by private industry, government agencies, and educational institutions.

Software development has been a growing activity in Hawaii for some years. However, a quantum boost in the activity was generated through the entertainment software company Square USA and its recent relocation to Honolulu. Staffed by employees from California, Tokyo, Europe, and Hawaii, the company plans to expand into computer-generated film production, which represents the next generation of interactive entertainment. The company also donated equipment and software valued at more than $700,000 to the University of Hawaii, with the goal of training Hawaii students to meet the firm's long-term staffing requirements.

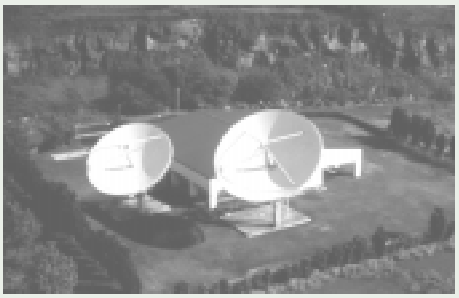
Telecommunications

Fiber Optic & Satellite Hub

Telecommunication is an essential counterpart to information technology and is a basic infrastructure requirement for an advanced technology sector. Fortunately, Hawaii is situated at a diversified hub of trans-Pacific fiber optic cables, satellite links and cellular and wireless networks, which affords a full range of telecommunications services to all domestic and foreign destinations. More than 29,000 miles of intra- and inter-island fiber optic cable link the Islands with the rest of the world. An undersea cable "super-carrier" increases total capacity by 130 thousand circuits and provides a separate, redundant backup for the entire fiber cable network in the Pacific.

In 1998, 100% of local telephone lines were converted from analogue to digital switching, and a new inter-island fiber optic cable system was established, affording customers competitive choice and pricing for telephonic service. High speed data links with more than 30 state-of-the-art telecommunications satellites complement Hawaii's fiber network, and provide rapid connectivity to remote locations throughout the Asia-Pacific region.

The residents of Hawaii in general have moved swiftly into new telecommunications technology. Hawaii has the highest per capita use of cellular telephones in the nation, and a wide range of cell services are now provided by companies statewide. Cable television extends to 97% of residents on Oahu, and cable franchises operate on all major islands, which can be used to support a wide variety of digital services. Hawaii's state-of-the-art telecommunications infrastructure and



Kapolei Teleport
Photo by Gary Hofheimer,
Courtesy, Estate of James Campbell

capabilities are complemented by a progressive State regulatory framework, recognized as one of the best in the nation. A high level of competition in Hawaii's telecommunications market helps keep costs in check throughout the State.

Biotechnology

Virus Resistant Papaya to Third-Generation Clones

The scientific world of biotechnology was rocked last year by the announcement through national media that University of Hawaii researchers had developed a technique for cloning several generations of mice from adult cells. The "Honolulu Technique" provided strong evidence that cloning is not only immediately possible, but may also be commercially feasible for projects ranging from breeding special kinds of cattle to using pigs to grow organs for human transplantation.

The biotechnology revolution is changing the world as we know it. The University of Hawaii may be leading the way in the strategic aspect of cloning technology. A number of favorable conditions give Hawaii a strong comparative advantage for much wider participation in this rapidly expanding field. First, Hawaii's highly favorable climate and ocean setting make it well situated to grow and experiment with many different kinds of terrestrial and ocean plants for which markets exist on a global scale. Second, the state is home to hundreds of trained researchers with expertise in agricultural and marine research. This provides a rich base of resident scientists and researchers readily able to transform the offshoots of R&D into commercial products.

Finally, Hawaii is developing a strong private sector base for biotechnology. Local

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Hawaii's Incentives for Technology-Driven Development

Tax Incentives Through Act 178:[1,2]

Hawaii Internet Tax Freedom Act. Imposes a six-year moratorium on any "discriminatory tax" on electronic commerce or Internet access under the income tax law, general excise tax law, and use tax law (Patterned after Federal ITFA).

Income received from stock options by an employee from a "qualified high technology business" that would otherwise be taxed as ordinary income or as capital gains will be exempt from the income tax beginning tax year 2000 (no sunset date).

Royalties and other income derived from patents and copyrights will be exempt from the income tax beginning in year 2000 (no sunset date). Patents and copyrights must be won by an individual or "qualified high technology business" and developed and arising out of the "qualified high technology business."

High-technology business investment tax credit provides a nonrefundable income tax credit for an investment in a "qualified high technology business." The credit is equal to 10% of the investment made, up to a maximum credit of $500,000 per year per business. Credit can be taken against the income tax, insurance premium tax, and franchise tax (financial institution) for tax years 1999-2005 for investments on or after July 1, 1999.

New R & D credit conforms Hawaii law to the federal R & D income tax credit under section 41 of the Internal Revenue code (IRC) with some modifications. The credit is based upon a percentage of certain research expenses and is available for tax years 2000-2005.

General State Tax Benefits:

Businesses which satisfy all requirements will qualify for the following state tax benefits for up to seven consecutive years:

- 100% exemption from the General Excise Tax (GET) and Use Tax every year. (The GET exemption applies only to gross revenues from EZ-eligible business categories within an EZ.)
- Contractors are also exempt from GET on construction done within an EZ for an EZ-qualified business.
- An 80% reduction of state income tax the first year. (This reduction goes down 10% each year for 6 more years.)
- An additional income tax reduction equal to 80% of annual Unemployment Insurance premiums the first year. (This reduction goes down 10% each year for 6 more years.)

The above two income tax reductions combined cannot exceed 100% of income tax due.

County Benefits:

Each county will offer eligible businesses additional benefits that may include one or more of the following:

- Priority permit processing
- Zoning or building permit waivers or variances
- Property tax adjustments
- Priority consideration for federal job training or community development funds

Energy Tax Credits:

- Corporate income tax credit allows a company a credit of 35% of the cost of equipment and installation of an active solar system.
- Individual income tax credit of 35% of the cost of equipment and installation of a residential solar system for heating and electricity generation. The maximum allowable credit is $1,750 for single family homes and $350 per unit in a multi-unit complex.
- Individual and corporation tax credit of 20% of the cost of equipment and installation of a residential or non-residential wind energy system.
- Tax credits of 50% for ice storage systems that are installed and placed in service after December 31, 1990, but before July 1, 2003.
- Individual income tax credit of 20% of the cost of equipment and installation of a single- or multi-family building. The maximum allowable credit is $400 for single-family homes and $200 per unit of a multi-unit complex.

Other Assistance

- Marketing support (cooperative tradeshow exhibits and advertising, etc.) through DBEDT Oceans Program to assist ocean technology firms to export products and services.
- State-funded Millennium Workforce Development Training Program to provide the education and training for high technology workers. Under development by the State Department of Labor and Industrial Relations (DLIR) and the University of Hawaii (UH).
- UH Office of Technology Transfer and Economic Development authorized to expend up to $4 million for the Discoveries an Inventions Revolving Fund.

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[1] The purpose of Act 178, passed by the 1999 Hawaii State Legislature, is to spur economic development and foster the growth of knowledge-based industries in Hawaii by consolidating the State's high technology agencies, integrating technology with the tourism industry, focusing on work force development programs, providing access to the Internet for the University of Hawaii and public schools, and enacting tax incentives.

[2] The tax provisions of Act 178 are based on definition of terms that vary depending on the tax provision at issue. For example, the term "qualified high technology business" is limited to a Hawaii based business for the high-technology business investment tax credit, but not for the income tax exemption for royalties and stock option.

Hawaii's Emerging Technology Industry

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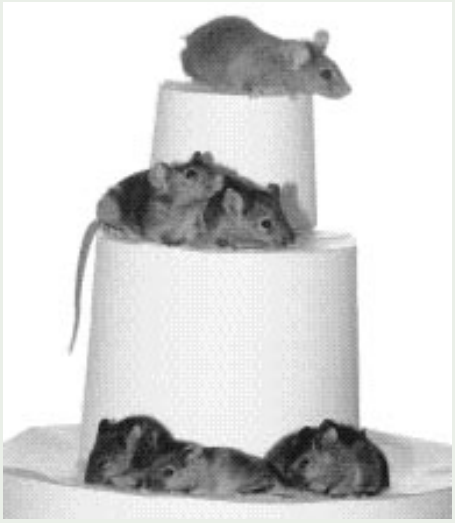

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biotech firms are conducting both basic and applied research in molecular and nuclear biology, immunochemistry, and botanical genetics, leading to the genetic engineering of antibodies and other high-value, complex proteins for commercial production.

Healthcare and Medical Technology

Healthcare Center for the Asia-Pacific Region

Hawaii is the Healthcare State. Over 85% of its citizens are insured and have their choice of several health care plans that compete to provide high-quality personalized care, employing leading-edge health care concepts and technologies. With its mild subtropical climate, multi-cultural environment, multiple tourism attractions, and state-of-the-art medical facilities, Hawaii also provides a congenial venue for patients from all over Asia and the Pacific, as well as an attractive, less stressful environment for their families.

Hawaii is one of the first states to facilitate telemedical applications using its advanced telecommunications infrastructure. Governor Cayetano launched a comprehensive statewide telemedicine network in 1998 through the Hawaii Health Systems Corporation, which operates a 3,000-employee, 12-hospital acute, long-term, and rural healthcare system throughout the state. Major healthcare providers throughout the Islands are utilizing network and internet

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Selected On-Line Technology Links & Resources

General Resources	
High Tech Hawaii (HTDC)	http://www.hitechhawaii.com/
Science & Technology in Hawaii	http://www.hawaii.gov/dbedt/ert/key.html
Technology & Services Export Directory	http://www.hawaii.gov/dbedt/ert/heeetsed.html
High Technology Business Directory	http://www.htdc.org/busdir/
Hawaii High Tech Job Link	http://www.htdc.org/joblink.html
Hawaii Small Business Innovation Research Grant Program	http://www.htdc.org/sbir/sbir.html
Opportunity in Hawaii; Business & Technology in Paradise	http://www.hawaii.htdc.org/
TIGRNet (Targeted Industries Growth Report)	http://www.tigrnet.org
State Agencies	
Hawaii High Technology Development Corporation	http://www.htdc.org/index.html
DBEDT Energy Resources and Technology Division	http://www.hawaii.gov/dbedt/ert/ert_hmpg.html
University of Hawaii	
University Connections	http://www.hawaii.edu/connections/
Office of Technology Transfer & Economic Development	http://www.mic.hawaii.edu/
Research at the University of Hawaii	http://www.hawaii.edu/research/
Department of Education	
Hawaii Dept of Education Home page	http://www.k12.hi.us/technology.html
Content & Performance Standards	http://www.hcps.k12.hi.us/
E- Academies	http://www.k12.hi.us/~atr/e_academy/contents.htm
E-Schools	http://www.eschool.k12.hi.us/
Facilities	
Maui High Performance Computing Center	http://www.mhpcc.edu/
Natural Energy Laboratory of Hawaii	http://bigisland.com/nelha/
Manoa Innovation Center (HTDC)	http://www.htdc.org/mic/mic.html
Funding Sources & Information	
Hawaii Small Business Innovation Research Grant Program	http://www.htdc.org/sbir/sbir.html
Hawaii Strategic Development Corporation	http://www.htdc.org/hsdc.html
Associations	
Hawaii Technology Trade Association	http://www.htta.org
Pacific Telecommunications Council	http://www.ptc.org/index.html
Association for Information and Image Management	http://www.aiimhawaii.org/
Hawai'i Venture Capital Association	http://www.hvca.org/
Association of Information Technology Professionals Hawaii	http://www.pixi.com/~teroger/aitphome.htm
Conferences & Meetings	
Hawaii High Tech Business Opportunities, Meetings & Announcements	http://www.htdc.org/htdcopp.html
HTDC Conference Tracker	http://www.htdc.org/htdcconf.html

Source: DBEDT compilation

Financing Technology

In addition to purely private financing, two major state programs bring to bear the resources of the State, Federal and private funding to support advanced technology start-ups.

- **The Hawaii Strategic Development Corporation** (HSDC) is a state agency designed to provide capital, mainly to technology-oriented businesses, from public and private sources. The HSDC provides both seed and venture capital through limited partnerships. HSDC's general partners for seed and early stages are Keo Kea Hawaii, HMS Investments and Hawaii Venture Fund. For Mezzanine and later stage funding, the general partner is Tangent Growth Hawaii. HSDC is also working with several new venture funds being formed for investment in Hawaii-based firms. More information is available at the HSDC web page, http://www.htdc.org/hsdc.html, or contact John A. Chock, President, stratdev@pixi.com, (808) 587-3829

- **The Hawaii Small Business Innovation Research Grant Program** provides grants to Hawaii companies that receive the Federal Phase I SBIR awards - maximum $25,000, for research that is performed in the State of Hawaii. The program is administered by the High Technology Development Corporation. For more information, email sybilt@htdc.org or call Sybil at (808) 539-3845.

Hawaii's Technology Export Initiatives

The State is increasing Hawaii's international exports of energy, environmental and other sustainable technologies and related services. DBEDT, through its Energy, Resources, and Technology Division has developed a Strategic Technology Marketing and Development Program that focuses on the high growth potential of the Asia-Pacific markets as they recover economically and restructure for better long-term stability. The program helps facilitate sustainable, technology-related economic development in Asia while creating higher valued jobs, and export opportunities for Hawaii and U.S. technology firms.

In particular Hawaii is seeking to facilitate U.S. exports of technologies and related services in:

- Renewable energy
- Information Technologies
- Energy efficiency
- Health Care
- Advanced efficient fossil energy
- Ocean Science & Technologies
- Recycling, reuse, and remanufacturing
- Environmental management, control, protection, and remediation

U.S. technologies and services lead the world, but competition for projects in the Asian region is fierce. Genuine partnerships and cooperation between industry and the public sector are an essential part of Hawaii's program. Hawaii partners with industry by way of country market assessments; technical exchange and business trade missions; government-to-government contacts throughout Asia — often at the ministerial level — and by helping industry develop business contacts and leads through workshops and conferences in Hawaii.

The many initiatives spearheaded by Hawaii in support of technology trade development between Asian nations and U.S. firms are detailed within the DBEDT web site at http://www.hawaii.gov/dbedt/ert/stmad.html. One initiative in particular is important to note:

Center for Asia-Pacific Infrastructure Development (CAPID).

The Center was established to help foster sustainable economic development throughout the Asia-Pacific region through energy, environmental, transportation-related and other infrastructure technologies and related services available from Hawaii and U.S. companies. CAPID is assisting Hawaii and Mainland companies to establish relationships crucial to successfully entering markets in the Asia-Pacific. Through seminars such as *Business Opportunities in the Asia-Pacific and 1998 Year of the Tiger: Opportunities for Trade* and *Investment in China,* the Center has assisted American firms establish direct lines of communication for negotiating and developing infrastructure projects in Asia.

CAPID's seminars have also provided the structure for policy makers, infrastructure project planners, developers and financiers from the Asia-Pacific region, to learn about the latest innovative options for infrastructure project development. The Center's programs are helping attendees shape priorities, determine feasibility, prepare finance strategies, and partner with the appropriate organizations—especially U.S. companies—to help develop the region's infrastructure. The Asian Development Bank has expressed keen interest in supporting CAPID, and Hawaii officials have met several times in Manila to develop ADB funding and support.

For more information contact Mr. Maurice H. Kaya, P.E. Energy, Resources, and Technology Program Administrator. Phone: (808) 587-3812; e-mail: mkaya@dbedt.hawaii.gov.

Hawaii's Emerging Technology Industry

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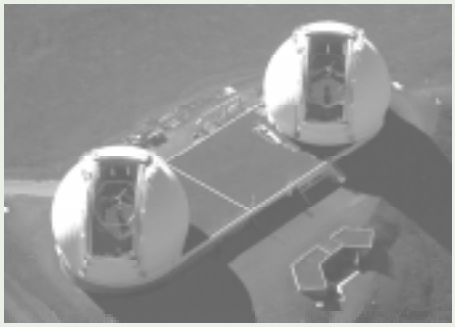
One of the most powerful Positron Emission Tomography (PET) Scanners in the world is in use at Queen's Medical Center, Honolulu. Teresa Hanifin/Queen's Medical Center

technology to transmit the results of medical tests, and medical imagery. Queen's Medical Center has even established a pilot project to facilitate teleconsultations between Molokai General and Queen's Medical Center to support emergency room services. Soon such technology could put the finest medical experts from around the world into operating rooms in otherwise remote locations. As technology progresses, remote communications and precision robotics will allow such experts to actually perform complex surgical procedures "on line."

Astronomy & Space Science

Hawaii's Eyes on Space

The clear skies and stable air above Hawaii have made the state a premier location for astronomy and astrophysics. Astronomers and other scientists from around the world pursue mysteries of the Universe with the world's most farsighted, deep-penetrating astronomical instruments, which have been put in place on the summits of Mauna Kea on the Island of Hawaii and Haleakala on Maui. Hawaii's role in astronomy and space science began in about 1964 with the construction of the Mees Solar Observatory atop Haleakala on Maui. Today, the islands host the largest collection of professional telescopes anywhere in the world, with more than a half billion dollars invested so far. By the end of 2000, the total investment in observatories and support facilities at Haleakala and Mauna Kea on the Island of Hawaii will surpass $800 million. Also by the end of 2000, the Mauna Kea and Haleakala Observatories will employ over 500 people and infuse some $80 million annually into the local economy.



Ocean Research & Development

Deep Water Marine Research to Coral Reef Management

Hawaii's strategic mid-Pacific location

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Table 1. Hawaii's Astronomy and Space Science Assets

Facility	Year Operational	Costs ($ million) Capital/Operating	Number of Employees
MAUNA KEA OBSERVATORIES			
University of Hawaii (0.6m—Optical)	1969		
University of Hawaii (2.2m—Optical/Infrared)	1970	5/1.2	10
NASA (3.0m—Infrared)	1979	10/2.5	12
Canada–France–Hawaii (3.6m—Optical/Infrared)	1979	30/6.2	54
United Kingdom Infrared (3.8m—Infrared)	1979	5/2.7	29
Caltech/NSF (10.4m—Submillimeter)	1986	10/2.1	11
James Clerk Maxwell UK, Canada, Netherlands (15m—Submillimeter)	1986	32/3.5	39
W. M. Keck I Caltech, U. of California (10m—Optical/Infrared)	1992	107/5	37
Very Long Baseline Array NRAO, AUI, NSF 1 (25m—Radio)	1992	7/0.25	3
W. M. Keck II Caltech, U. of California (10m—Optical/Infrared)	1996	91/5	37
Gemini Northern U.S., U.K., Canada, Argentina, Australia, Brazil, Chile (8m—Optical/Infrared)	1999	88/5	35
Submillimeter Array Smithsonian, Taiwan (8x6m—Submillimeter)	1999	170/10	50
MAUNA LOA OBSERVATORY			
Solar Observatory (0.3m—Optical)	1965	6/1.5	9
HALEAKALA OBSERVATORIES			
Mees Solar Observatory	1964	0.5/0.5	9
Lunar Ranging Facility	1976/1984	3.3/0.6	12
Maui Space Surveillance Site	1984	200/11	120
Advanced Electro-Optical System	1997	50/10	0
SUBARU Japan, National Astronomical Observatory (8.3m—Optical/Infrared)	1999	300/10 est.	46 est.

Source: DBEDT

Hawaii's Emerging Technology Industry

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and diverse geologic and marine resources combine with the state's advanced technology infrastructure, and professional expertise to make the islands an unparalleled natural laboratory for ocean research and development. Lying within the second-largest U.S. Exclusive Economic Zone, Hawaii affords clear legal access to vast living and mineral resources, as well as a time zone that enables communications with both eastern and western hemispheres within the same business day.

Over the past two decades, Hawaii's ocean R&D industry has been growing at twice the national average, with direct annual revenues in excess of $85 million. Hawaii ranks high nationally in the receipt of Federal ocean R&D dollars. The University of Hawaii's School of Earth Science and Technology alone accrued more than $40 million in 1997. The State government supplements funding grants and loan programs with a combined total revolving fund of approximately $14.6 million.

The State's ocean R&D strengths are also attracting increasing investments from both private and government sectors in such diverse areas as Japan, Korea, Singapore, Venezuela, American Samoa, Australia, Canada, England, and Taiwan. Hawaii's economy currently gets an average of $2- to $3 million annually from Chinese, Japanese, and Korean groups prospecting for marine minerals on the sea bottom south and east of Hawaii. The State serves as headquarters for the Pacific Science Association and PACON International, which organizes the biennial Pacific Congress on Marine Science and Technology. Non-profit organizations such as the Oceanic Institute, renowned for its pioneering work in aquaculture and oceanography, and the Pacific International Center for High Technology Research, provide expertise supporting applied ocean R&D projects worldwide.

Environmental Technology

Technologies for Pollution Control

Environmental problems are often the byproduct of producing and consuming energy, related to the transportation system, the workplace and the home. This critical link between Hawaii's fragile island ecosystem and its economy, have encouraged numerous innovations in environmental technology.

Hawaii's high-tech engineering is embodied in this twin-hulled SLICE vessel.
Pacific Marine

Highly efficient combined-cycle oil-fired generators, as well as a state-of-the-technology coal-fired power generator, are producing extremely clean electricity in Hawaii. The State is also a leader in the use of highly efficient electro-technologies for lighting, cooling, and other demand-side applications. Bio-waste conversion to fuel and by-products, waste-to-energy incineration, and biomass-fired electricity production are additional examples of the advanced technical facilities and expertise available in Hawaii.

The State-run Hawaii Natural Energy Institute (HNEI) serves as a catalyst for cooperation among academic, government, and industrial partners in developing resource system packages in harmony with the natural environment. The HNEI is currently focused on the development of biofuels, ocean resources, materials applications, and conducting pioneering work on developing hydrogen from renewable resources and technologies for its production and storage.

Renewable Energy

Resources from Sun, Earth, and Ocean

Hawaii has emerged as a world leader in the demonstration and use of renewable energy as an alternative to imported oil. Export potential is being developed in solar technologies and systems for island applications. Additional prospects reside in the development of biomass gasification, wind energy, alternative transportation fuels, and ocean thermal energy conversion technologies. Hawaii's assets, such as a highly developed bio-energy infrastructure, resident technical capability in research and engineering, and benign, year-round growing season, offer unique advantages for developing these state-of-the-art systems.

Hawaii has the highest per capita use of solar water heating in the United States. Hawaii is also a leader in the development of applications of photovoltaics, wind, and geothermal engineering, as well as in sophisticated computer modeling of its statewide energy system. Several solar engineering firms in the state are active in both solar thermal heating and photovoltaic equipment applications servicing clients in the Pacific Islands, South America and the Mainland U.S. Other firms are marketing hybrid solar products, including a patented solar pasteurization process for water purification.

Engineering Research & Development

Ocean Engineering to Image Intelligence

With access to some of the world's most advanced computer and telecommunication technologies and services right here in Hawaii, local engineers and design professionals are involved in numerous R&D specialties. The University of Hawaii's engineering programs take advantage of these resources and have developed renowned expertise particularly in ocean engineering. UH R&D programs are also at the forefront in the engineering of systems and applications using parallel computing and distributed networking.

Beyond the University, Hawaii's private sector engineering firms have been innovators in such techniques as pre-stressed concrete construction, sea-floor surveying of deep-water ocean outfalls and geotechnical engineering for the construction of foundations in tropical soils. Private sector expertise often partners with the resources of the University of Hawaii to support a broad range of applied engineering development projects, including auxiliary wastewater treatment facilities, innovative air conditioning systems, and new high-tech systems to protect steel from corrosion in tropical environments. Among the more notable engineering accomplishments for local firms have been the construction of state-of-the-art telescope facilities atop the peaks of Mauna Kea and Haleakala, on Hawaii and Maui islands respectively.

Dual-Use Technologies

National Defense to Civilian Innovation

The term *dual-use technologies* refers to the application of defense-funded technolo-

gies to civilian and commercial use. This activity affords multiple opportunities for entrepreneurial business development in Hawaii, and a number of technology training and transfer centers and programs statewide are spurring new growth in a wide range of industries. A major example of duel-use technology is the Maui High Performance Computing Center (MHPCC) on Maui Island, home to one of the world's most powerful parallel processing supercomputers. This computing power supports a broad range of R&D projects, including the Pacific Disaster Center at the Maui Research and Technology Center and the Advanced Electro-Optical System atop Haleakala. Another example is the Navy's Pacific Missile Range Facility (PMRF) on Kauai. This facility provides state-of-the-art telemetry, tracking, and data management technologies to support surface, subsurface, air and space operations.

Pacific Missile Range Facility, Kauai

Hawaii's Key Technology Assets

- **University of Hawaii at Manoa:** A first-class research university, within which the "Honolulu Technique" for genetic cloning was pioneered. The UH runs a multitude of scientific, engineering, oceanographic and technology programs.
- **The world's finest astronomical observatory,** atop Mauna Kea on the Island of Hawaii, managed by the University of Hawaii and including 13 telescopes – 8 of them exceeding 8 meters in diameter.
- **The Maui High Performance Computing Center's IBM SP Super Computer** located in the Maui Research and Technology Park. One of the most powerful computing centers in the world, serving more than 900 academic and commercial clients.
- **Before the end of 2000 Hawaii will have six undersea fiber-optic transpacific cables providing 1.6 million voice equivalent circuits between Hawaii and U.S./Asian markets.** Hawaii has more than 29,000 miles of intra- and inter-island fiber optic cable. All phone lines on digital switching.
- **Major medical facilities pioneering advances in tele-medicine,** supported by the University of Hawaii's John A. Burns School of Medicine.
- **Research and Development centers/parks** on Oahu, Maui and Hawaii provide support for startup technology firms.
- **New technology tax and investment incentives,** venture capital funds and workforce development programs to support advanced technology industry.
- **A growing list of world class technology firms** including Square One USA, Uniden and ESS Technologies. Homegrown firms have including Digital Island, Cyanotech, Probio, Ltd., and many others.
- **Major international call centers** on the Islands of Oahu and Hawaii.
- **Educated, multilingual workforce**
- **Mid Pacific location,** permitting real-time communication with Asia and the U.S. Mainland during the same working day.

What is "Technology"?

Most people think of "technology" as computers, cell phones, automated tellers, the internet, etc. But these are really just products of technology rather than technology per se. Technology is actually the sets of knowledge, skills and procedures that were used to create these and all other products of economic activity. In fact "Technology" originally came from the Greek word *tekhne*, meaning "skill." Technologies range from the "low tech" needle-and-thread method of attaching buttons to a shirt, to the very "high-tech" activity of building and operating interplanetary space probes.

There is a wide range of technologies in use throughout the economy. The characteristic that most separates simple or standard technologies from the most advanced technologies is the role of scientific research. Advanced technologies incorporate the latest knowledge emerging from the physical and life sciences, aided by engineering and mathematics. Moreover it usually takes technology to get technology. For instance, technologies for gene splicing and cloning cannot be developed without equipment and trained staff made possible by information, telecommunications and engineering technologies coupled with intensive training in the tools of these technologies.

Because technologies are ways of making products, rather than products themselves, it is difficult to define technology industries. We cannot easily measure ways of producing things. Consequently, what we end up measuring as "high tech" tends to be products and services that contain a very high content of leading-edge technology.

From an economic standpoint, there are two primary reasons why we are interested in advanced technology. First, the development of new technology and products based on leading edge technology represent very high-valued export potential. A base of advanced technology export activity brings sales revenues and new investment into the State. Second, the infusion of leading edge technology into traditional industries and other export activity, can improve productivity and make the State's industries more competitive in overseas markets.

A New Measure of Hawaii's Advanced Technology Sector

In cooperation with other agencies dealing with advanced technology and labor statistics, DBEDT has developed a measure of the technology sector in Hawaii. The measure indicates that *private* sector advanced technology activity in Hawaii encompasses nearly 13,000 workers, more than 800 firms and has an annual payroll of $560 million. These figures do not include Hawaii's health/medical sector, which also plays an important role in the growth of advanced technology in the Islands. Health/medicine activity is compiled as a special category apart from what we would normally consider to be the "core" technology activities in the economy. This is because of the limitations on identifying technology-intensive activity in the very large, health/medical sector. (See the accompanying side article for a description of the definition, data and methods used to construct the measure)

Table 1 shows the data components for the core measure of advanced technology along with a measure of the health/medical sector.

The data represent firms, employment and earnings in nearly 60 sub industries in which Hawaii's technology activity is emerging. Data for the sub industries have been regrouped to meet disclosure requirements. However, the list of Standard Industrial Classification (SIC) code industries making up the sector appears on page 14.

Because the most recent data available are for 1998, the measure undoubtedly understates the current size of this rapidly growing sector. The measure is also limited to private sector activity due to the difficulty of measuring technology activity in the government sector.

The technology *core* sector represents about 3 percent of all private sector jobs and 5 percent of total private sector payroll (Figure 1). The health/medical sector, which contains both advanced- and standard-technology activity, accounts for another 4 percent of private sector employment and 6 percent of payrolls.

Overall, firms in the core technology sector averaged slightly over 15 employees per firm. This is higher than the

Figure 1a.
Advanced Technology's Share of Jobs

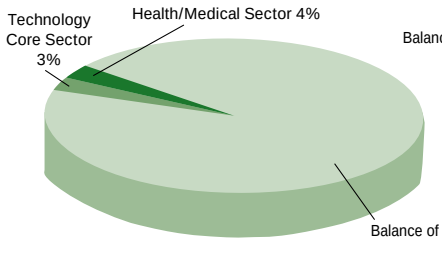


Figure 1b.
Advanced Technology's Share of Wages & Salaries

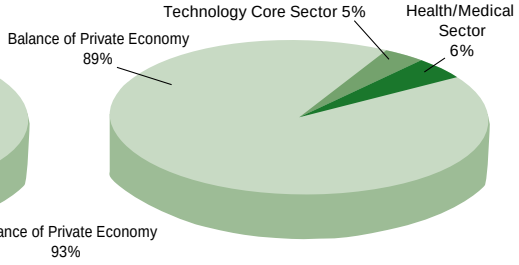


Table 1. Hawaii's Emerging Advanced Technology Sector: 1998

Groupings	Firms[2] No.	Firms[2] Percent change from 1990	Ave. jobs per firm	Average Annual Earnings	Employees No.	Employees Percent of Core Sector	Employees Percent change from 1990
By Category							
Bio Technology[3]	22	144.4%	23.1	$26,413	508	4.0%	202.4%
Information Technology	547	63.3%	6.9	$49,192	3,779	29.8%	16.3%
Telecommunications	116	78.5%	48.4	$45,702	5,611	44.3%	-13.1%
Research, Development & Testing[4]	148	48.0%	18.9	$37,385	2,782	21.9%	-3.8%
Total: Advanced Technology Core Sector[1]	833	63.7	15.2	$44,144	12,680	100.0%	-0.7%
By Type of Output							
Goods	32	100.0%	22.5	$37,098	720	5.7%	136.7%
Services	801	62.5%	14.9	$44,568	11,960	94.3%	-4.0%
Health/Medical Sector	71	24.6%	259.3	$36,457	18,413	NA	11.8%
Expanded Technology Measure:							
Core Technology plus Health & Medical	904	59.7%	34.4	$39,592	31,093	NA	6.4%
Balance of Private Sector Industry	30,349	13.6%	13.0	$26,722	395,161	NA	-2.1%
All Private Sector	31,253	14.6%	13.6	$27,661	426,255	NA	-1.5%

Source: DBEDT, Dept. of Labor & Industrial Relations, US Dept. of Labor

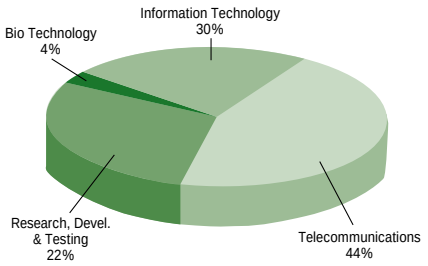
[1] Data represent all activity in standard sub-industries identified by either DBEDT or falling within the definition of American Electronics Association.
[2] Includes only private sector firms with payroll. Excludes self-employed and firms without paid employees.
[3] Growth rates may be somewhat inflated due to reclassification of some firms from among the 4-digit industries of R&D and Biotech between 1990 and 1999.
[4] Growth may be somewhat understated. See 3 above.

average for the rest of the private sector, which was about 13 employees per firm in 1998.

Components of the Technology Sector

The core technology sector has been divided into four sub-sectors — biotechnology, information technology, telecommunications and research and development activity. These correspond to several key areas of technology that are identified in the first article in this report. Unfortunately, the underlying industry data do not permit measurement of such categories as *dual use, energy and environmental* technology. Those activities are, however, integrated into the four categories that are measured. It is also likely that some ocean and space technology activity is also present in the four measurable categories. However, since ocean and space activities are conducted mainly by the public sector, the overall measure cannot adequately capture the bulk of that activity.

Figure 2. Private Sector Advanced Technology Jobs by Activity, 1998
Total Jobs: 12,680



Source: DBEDT

As shown in Figure 2, biotechnology is the smallest of the core technology areas, amounting to about 4 percent of employment in the sector. However, it was the fastest growing over the past decade, with employment roughly tripling in size from 1990. Part of this growth was due to the rapid expansion of the seed corn industry in Hawaii, which is using genetic research to develop new varieties of corn for overseas commercial farm operations. Biotechnology activities at the Big Island facilities of the Natural Energy Laboratory of Hawaii also contributed to the growth. Biotechnology had the second highest firm size in the core technology sector with an average of 23 employees per firm. This could be the result of one or two large firms significantly raising the average.

Research, development and testing activity represent 22 percent of employment in the core technology sector. Information technology was the third largest concentration at 30 percent of employment, while telecommunications topped the sector with 44 percent of total employment.

Health Medical Technology

In addition to being very large in relation to the core technology sector, the health/medical sub sector is dominated by larger organizations. Average employment in this sector was nearly 260 per firm in 1998, reflecting the dominance in the statistics of the major hospitals. Future growth in the health/medical sector will primarily reflect the demand for medical services. Growth is expected to be above average due to the aging of the population. Further growth may occur as a result of efforts to market Hawaii as a medical treatment, health and wellness center for the Asia-Pacific region. As the sector grows, so too will the sector's technology component.

Goods vs. Service

Another way of viewing the technology sector is to distinguish between the production of goods and the provision of services. Hawaii has traditionally been a service-oriented state. The technology sector reflects this service sector bias. As the table shows, only about 6 percent

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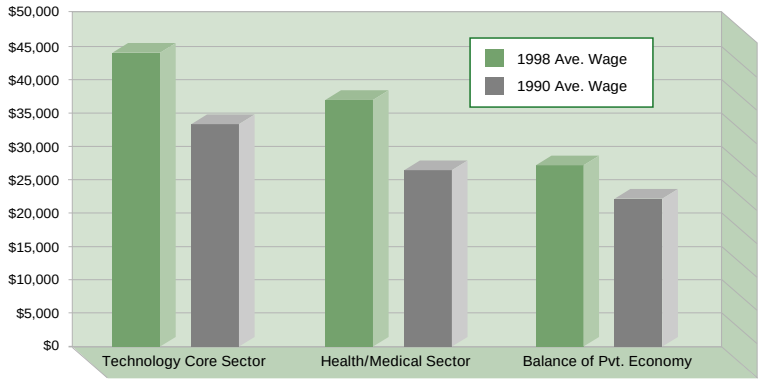
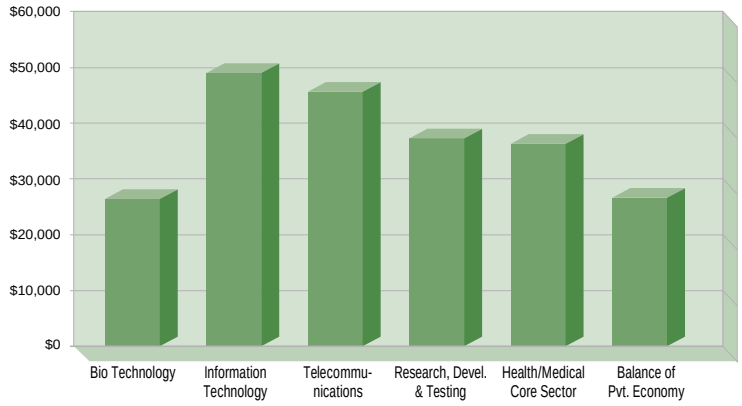
Figure 3. Average Wage for Technology and Non-Technology, 1990 & 1998



Source: DBEDT

Figure 4. Average Wages, 1998



Source: DBEDT

A New Measure of Hawaii's Advanced Technology Sector

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of employment in the advanced technology sector is in goods producing industries, with more than 94 percent in the services. However, from 1990 to 1998, the goods producing area of advanced technology showed significant growth, more than doubling over the period. Over the same period service-oriented technology actually declined somewhat, due to the sluggishness in the economy overall.

Wages & Salaries

As shown in Figure 3, advanced technology and the health medical sector showed higher than average annual wage levels in both 1990 and 1998. Among the individual areas, information technology had the highest average wage level at about $49,200 in 1998 (Figure 4). This was nearly twice the average of the non-technology, balance of the economy which was $26,700. Somewhat surprisingly, the only area of technology showing an average wage less than the economy wide average was biotechnology at $26,400. This may have been due to the agricultural component of biotechnology, including seed corn development. Despite the sophistication of its technical methods, agricultural biotech may still require a good deal of lower paying, labor-intensive fieldwork.

Limitations and Future Refinements

As the accompanying technical article indicates, all measures of the technology sector are somewhat arbitrary. On one hand, all industries use advanced technology to some degree. On the other hand, very few industries are exclusively devoted to producing new technology. The question is always one of what activities should be counted.

Based on standard industry data rather than custom surveys, this new measure of technology in Hawaii's economy represents a compromise between the narrow vs. broad definition. Being *industry* rather than *company* based, it unavoidably includes a certain amount of economic activity that may not be advanced technology. However, the new measure is narrow enough that future growth in the sector should reflect primarily the influence of the technology companies and their activity.

This initial effort to construct measures of Hawaii's core, advanced technology sector and the more technologically intensive areas of health and medicine, will continue to undergo refinement and improvement in the future. Growth in the industry data will be compared with growth in key firms within the sector to ensure the measure is truly reflecting an increase in advanced technology rather than other factors. In any case, the measure will eventually need to be revised to reflect a new industry classification method called the North American Industrial Classification System (NAICS). This system replaces the long-standing, Standard Industrial Classification Code and is being phased in for Federal statistics programs over the next several years.

Measuring Advanced Technology

It is less straightforward than it seems to identify and measure *advanced* technology. Most economic activity is classified and measured by the nature of what is produced —the *output*. For instance, even though farm equipment and automobiles use much the same material inputs and production processes, they are distinctly different industries based on the differences in the products that are produced.

The problem with identifying a "technology" industry is that technology is generally an *input* into production rather than an output. Moreover, it is hard to draw the line on what is to be excluded from a technology definition because just about every business and product incorporates advanced technology to some degree. Given this difficulty, it is not surprising that there has not yet emerged an *official* definition of "advanced" or "high" technology for the nation. Partly because there is no common definition, there has been no comprehensive economic census to measure the size and scope of technology activity. Nevertheless, it is important that a measurement of the activity in Hawaii be established in order to gauge progress in developing this industry.

DBEDT began the effort to develop a measure of advanced technology by establishing a few important goals for the measure. These goals were to:

- Develop a measure that will mirror the growth in advanced technology over time.
- Ensure that the measure reflects Hawaii's unique mix of specialties, as well as broader, more generic technology components important nationwide.
- Develop a measure that will allow calculation of some historical data as well as permit some comparisons with U.S. technology activity.
- Develop a cost-effective measure that will permit tracking the growth of the sector on an ongoing basis, with limited staff resources and without the need for consultant assistance or special surveys.

Fortunately, there have been some efforts to quantify an advanced technology sector. While the results of these efforts have been mixed, they have served as a guide for developing a comprehensive measure relevant to Hawaii.

The three primary measures reviewed as potential models for the DBEDT measure (AEA, Arizona and BLS) are highlighted in the next side bar. Each of these measures used selected subindustries of the Standard Industrial Classification (SIC) code to define an advanced technology sector. The measures differed mainly with respect to their criteria for choosing what sub-industries to include. Using standard industry statistics makes it easier and faster to prepare and update the measure. It also has the advantage of consistency and comparability over time. However, even at the fairly detailed, 4-digit SIC level, the data include activity that may not be strictly advanced technology but which cannot be easily separated from the technology activity. There is also the problem that the existing measures of advanced technology industry are not necessarily appropriate for all regions of the country.

An alternative method to standard industry statistics is to conduct special surveys of companies doing advanced technology. The Hawaii High Technology Development Corporation uses this method, which has the advantage of focusing more precisely on firms conducting intensive technology activity and excluding firms using standard technologies. However, this method can be an expensive and time-consuming effort. It also will include non-technology activity conducted by the firms surveyed. Moreover, since many companies choose not to participate in such voluntary surveys, the results are often incomplete.

It was decided that a measure based on selected SIC codes would be the most cost effective and efficient approach. It is not an accident that the three measures reviewed also used an SIC-based approach. However, none of the three measures reviewed met the goals DBEDT had set for the development of a measure. Consequently, DBEDT created a hybrid definition that combined a suitable national definition with locally generated information on technology activity.

The American Electronics Association (AEA) definition was chosen to cover one major component for Hawaii's measure of technology. The AEA definition focuses on SIC industries in *information technology* (computers, equipment, software and programming) and *telecommunications* (equipment and communications services). This sector represents a key group of activities with a high content of advanced technologies found more or less throughout the nation. The other two definitions reviewed included more specialized activity, including the manufacture of automobiles, commercial aircraft, defense weaponry and other aerospace related hardware, which are not appropriate to Hawaii or for national comparisons. Even for some AEA-identified technology industries, Hawaii had little or no activity according to the latest statistics. However, Hawaii generates activity in most of the AEA industries and there is considerable overlap between the AEA and DBEDT/HTDC identified industries discussed below.

To the list of SIC codes contained in the AEA definition, READ added more SIC-based industries reflecting Hawaii's evolving technology sector. The two main sources of information for these industries were the directory of technology companies in Hawaii prepared and maintained by the HTDC and firms identified in the 1999 DBEDT report, *Science & Technology: The Key to Hawaii's Economic Future*, prepared by DBEDT's ERT Division. Not surprisingly, many of the same companies were identified in both the HTDC and ERTD reports.

It was also decided that the definition and measurement would be based on private sector activity. This was mainly due to the lack of available data on technology activity conducted by state (mainly university) and federal government in Hawaii. However, even if a public sector measure were available, there is no counter part measure at the national level for comparison. If the goal is to measure *growth* in technology, the lack of public sector data is unfortunate but not a major shortcoming. Ultimately, it is *private sector* employment and diversification of the economy that the State is trying to accelerate.

Four-digit SIC industry codes were identified for the Hawaii companies in cooperation with the State Department of Labor and Industrial Relations. SIC codes in which advanced technology firms were a very small part of the total were not included in the measure, to avoid including an excessive amount of non-technology activity. Also, SIC codes in which factors unrelated to technology activity were the driving force in industry growth were excluded where possible.

The remaining 4-digit industries that appeared to best represent advanced technology grouped rather nicely into four major categories of interest for Hawaii — biotechnology, information technology, telecommunications, and research & development. Unfortunately, such areas as ocean related technology, astronomy, dual-use technology and environmental activity, tend to overlap and blend with these more measurable categories, particularly the R&D and biotech categories. Moreover, areas such as ocean research, space and astronomy cannot be measured as yet, since they are primarily government or university activities.

The identification of healthcare and medical technology posed a dilemma. This sector was not included as part of the technology core measurement because it is not possible to separate the technology and non-technology activities within the health and medical SIC codes. The focus of medical technology is the leading edge diagnostic and treatment capabilities of the major hospitals. But hospitals in Hawaii employ many thousands of workers, most of who are not involved in the application of leading

continued on next page

Measuring Advanced Technology

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edge technology. On the other hand, the expansion of the health care sector and medical technology is a focus of State technology policy and there clearly is significant technology activity occurring in this industry.

The dilemma was resolved by adding the most technology-relevant segments of health and medicine as an addendum to the core technology measure. In this way users may choose a basic or expanded definition of technology depending on the importance of health-medical technology to their needs.

Definitions for Hawaii's Advanced Technology Categories

	Bio Tech	Info-Tech	Telecom	R&D	Health/Medicine
Description of activities	Crop & animal biotech, medicinals, botanicals, diagnostic substances & organic chemicals	Computer & Data processing equipment, software and related facilities, sales, services & repair	Radio, TV, telephone, cable and other communications equipment & services	Research & testing devices. Commercial physical & bio research & testing serv.	General & special medical & surgical hospitals, labs & dialysis.
4-digit Standard Industrial Classification (SIC)	0115, 0182, 0919, 0273, 2833, 2835, 2865	8243, 3571, 3652, 3861, 7371-76, 7378-79, 5045, 5065, 5734	3663, 3669, 4812-13, 4822, 4841, 4899	3844, 3829, 8731, 8733-34	8062, 8069, 8071, 8092

Source: DBEDT

The detailed SIC codes used to measure advanced technology in Hawaii were then grouped to avoid the possibility of disclosing information on specific firms. Unfortunately, disclosure rules preclude release of the detailed information by each SIC code. However, the 4-digit SIC code numbers used in defining the four sub-sectors of technology are shown in the table.

Three Definitions of Advanced Technology

Three national efforts to define and measure advanced technology were reviewed as possible models for DBEDT's Hawaii measure. These were: (1) a definition adopted by the American Electronics Association (AEA), (2) the definition developed in a study of high technology in Arizona, and (3) a definition recently used in an article in the U.S. Bureau of Labor Statistics' (BLS) *Monthly Labor Review.*[2]

The accompanying table summarizes the elements of those three national definitions of advanced technology industry reviewed by DBEDT as models for a Hawaii-based measure.

The AEA and Arizona definitions are straight-forward assumptions about what industries should be considered in the advanced technology sector. The BLS definition is a little different. The industries in this definition were selected by their high proportion of advanced technology occupations. This captured a much broader selection of economic activity, including some not usually associated with advanced technology such as the auto industry and public relations.

How the Three Definitions Compare

	American Electronics Association (AEA)	State of Arizona	Bureau of Labor Statistics (BLS)
Definitional Basis. How industries or parts of industries were defined as advanced technology.	Judgement	For manufacturing, industry included if met 5 of 9 pre-existing definitions. For services, judgement was used.	First, technology-oriented occupations were identified judgmentally. Industries then defined as advanced technology if proportion of research & development and technology-oriented occupations exceeded twice the average proportion for all industries.
Number and type:	45, 4-digit SIC	22, mix of 3- and 4-digit SIC	31, 3-digit SIC
Number of 1997 establishments:	171,416	157,310	422,330
Percent manufacturing (1997):	12.9	27.2	16.4

Source: DBEDT

[2] The AEA definition is used in its periodic industry reports *Cyberstates* and *Cybernation*. Information about these reports can be found at http://www.aeanet.org/aeanet/Public/research/index.html. The Arizona definition comes from Charney, Alberta and Julie Leones (October 1995), "Impact of High Technology Industry on the Arizona Economy." The Bureau of Labor Statistics definition is in Hecker, Daniel (1999), "High-technology employment: a broader view," *Monthly Labor Review* pp. 18-28 (June).

How Technology is Changing Work

Concern about the effect of technology on jobs goes back at least 200 years to the time when the introduction of textile equipment in Britain began threatening the jobs of weavers. There has been a general fear by workers ever since that technology will destroy jobs and replace people through mechanization and electronics.

There is certainly evidence that technology eliminates some jobs; even jobs in the technology industry itself as better technologies emerge. But the evidence also shows that the introduction of technology creates many more jobs than are eliminated. For instance, many economists have attributed the last several years of sustained economic growth in the U.S. to the rapid introduction of new technology and associated productivity gains. Yet rather than eroding the employment base, this technological surge has caused the number of new jobs to soar for the U.S. as a whole, and the unemployment rate to fall to its lowest level in a generation. Thus, for every job that technology renders obsolete, it generates more jobs elsewhere.

But creating new jobs is just the tip of the technology iceberg. Perhaps more significantly, technology dramatically changes the *way* people work. For example, many autoworkers who used to weld seams and tighten bolts, now oversee computers and robotic machines that do this job much more effectively. Most office workers no longer compose longhand memos, type letters or maintain paper account ledgers. Now they develop, proof and send by e-mail such documents, all on their desktop computers. Thus in addition to creating and eliminating jobs, technology is demanding increased flexibility and adaptability by today's workforce.

Expected Growth of High Tech jobs

But specifically what effects are technological advances having on *Hawaii's* workforce? Several studies have used national data to assess how high technology has affected jobs, and how technology has changed the projections about which jobs will grow and which will decline in the future. Based on these methodologies, DBEDT has conducted a similar analysis for Hawaii.

The U.S. Bureau of Labor Statistics' (BLS) *Occupational Outlook Quarterly* notes that nationally, there is a shortage of workers with technology skills.[3] Indeed, over the 10-year period 1996 to 2006, the expected increase in employment for some computer-related occupations is expected to more than double while total employment in all occupations will rise by only 14 percent.

Table 1 shows a portion of the BLS employment growth projections for some key technology occupations the Bureau has identified, along with similar projections for Hawaii from the State Department of Labor and Industrial Relations (DLIR).

Table 1.
BLS Employment Projections for Some Occupations

Occupation	Projected Change 1996-2006	
	U.S.	Hawaii
Total, All occupations	14%	14%
Database administrators, computer support specialists, & other computer scientists	118%	109%
Computer engineers	109%	46%
System analysts	103%	82%
Computer programmers	23%	25%

Source: Occupational Outlook Quarterly, Fall 1998, p. 47; and State of Hawaii Employment Outlook for Industries and Occupations, 1996-2006, March 1999.

An interesting feature of this outlook is the relatively modest increase projected in employment for computer programmers. This is primarily because past projections for this category were higher than actually experienced. Consolidation of computer applications, the popularity of packaged software, and the development of programming tools and languages has limited growth in the demand for programmers.

The BLS projections also indicate that new information technology jobs will not be confined to "high tech" or "information tech" industries such as computer equipment or telecommunications. Increasingly, the skills associated with high technology permeate the U.S. economy.

As Table 2 shows, advanced technology occupations are spread throughout Hawaii's economy also. The data show that about 3 percent of Hawaii occupations in 1996 could be classified as "technology-oriented" by BLS standards. For the most part, these jobs were spread more or less evenly across the state's major industries. The exception is government, which showed a much higher share of advanced technology occupations than the rest of the economy. This may reflect concentrations of scientific and technology occupations in State and Federal agencies.

The projections information in Table 2 indicates that between 1996 and 2006, advanced technology occupations are expected to grow about 50 percent faster than the average for all occupations. The growth in technology occupations is projected to be particularly strong in services and trade activity. The technology-intensive government sector will add technology occupations faster than it will other occupations over the decade.

However, there is a concern that while the demand for high technology skills is expected to rise, the supply of those skills may lag behind at the national level. For example, the BLS notes that the number of computer and information science bachelor's degrees awarded has declined from about 41,900 in 1985-86 to 24,400 in 1994-95. Some attribute this to the academic challenges of these majors while others think it is a reaction the downsizing of information technology staffs during the 1990s. More recent surveys reported by BLS indicate sharply rising enrollments in computer science and engineering fields in 1996 and 1997, so the trend may be reversing.

Examples of Declines in Technology Occupations

Despite the expectation that the technology sector in the economy will expand rapidly in the coming years, how the technical occupations will share

continued on next page

[3] Veneri, Carolyn J. (1998), "Here Today, Jobs of Tomorrow: Opportunities in Information Technology," (Fall) pp. 45-57.

How Technology is Changing Work

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Table 2. Hawaii's Advanced Technology Occupations: Share in 1996 and Projected Growth

	Advanced tech. as % of all occupations, 1996	Projected growth 1996-2006	
		Advanced Tech. occupations	All occupations
All Industries	3.1%	21%	14%
Agriculture	1.2%	0%	4%
Mining & Construction	2.0%	9%	9%
Manufacturing	1.6%	26%	6%
Transportation, Communications, & Utilities	2.5%	18%	13%
Wholesale & Retail Trade	0.3%	35%	12%
Finance, Insurance, & Real Estate	2.3%	26%	8%
Services	2.5%	37%	22%
Government	8.2%	12%	3%

Source: U.S. Bureau of Labor Statistics

in this growth is not yet clear. From 1984 to 1995, some advanced technology occupations grew much slower than expected and even declined. These appeared to be occupations associated with the aero-space and defense industries, many of which were severely downsized after the collapse of the Soviet Union. An accelerated shift from manufacturing to services may have been responsible for sluggish growth in some technology occupations.

Even technology itself impacted on technology occupations. For instance, growth in the demand for word processing specialists was much slower than projected because of innovations in computers and software that increased productivity in the processing of documents. Employment of mainframe computer programmers and operators grew more slowly than expected because changing technology in the 1990s favored small computers and prepackaged software over centralized, mainframe computers. Such occupations as electrical and electronics engineers, data entry keyers, and peripheral EDP equipment operators had all been expected to grow much faster than average between 1984 and 1995. However, employment in each of these areas actually declined.

These patterns suggest that simply acquiring skills in advanced technology specialties may not be sufficient to guarantee long-term employment at the same job. The types of skills acquired and the changing demands for technical skills are important factors. People must be able to learn new skills or to adapt existing skills to new problems in order to manage successful careers.

Building a Technology Workforce:

How can Hawaii make sure that it can supply the skilled workers to support growth in the advanced technology sector? This question has received a considerable amount of attention by the public and private sectors over the past several years. Out of this effort has evolved educational and workforce initiatives, a number of which are addressed in Act 178, of the 1999 Legislative session.

The Millennium Workforce Development Initiative

Unveiled by Governor Cayetano in his January 1999 State-of-the-State address, the primary goal of the Millennium Workforce Development Initiative is to create work force training programs for technology. The initiative will focus training efforts on specialty niche areas that have great potential for Hawaii, but which require the support of an expanding corps of workers with the required skills. These niches were initially identified as healthcare, biotechnology, telecommunications, environmental sciences, and other areas of advanced technology as appropriate.

The short-term goal of the initiative is to put in place or augment education and training programs to train workers in the technology niche areas. The longer-term goal is to expand the diversity of jobs available in the State, increase the competitiveness of local industry in world markets and help attract new investment to the State.

Act 178 provided initial funding for the Millennium Workforce Development Initiative and charged DLIR with the task of implementing it. The Initiative has been adopted by the State Workforce Development Council, an organization of private and public sector representatives that is administratively attached to DLIR and which was established to coordinate efforts to develop Hawaii's workforce.

Through Act 178, DLIR and the University of Hawaii have been funded at $50,000 and $436,000 respectively to begin developing Millennium Initiative programs. Workgroups of the initial Millennium Workforce Task Force appointed by the governor have drafted

Computer Use

Perhaps the most obvious way technology has changed lives and jobs is through the growing use of computers at home and at work. The National Telecommunications and Information Administration recently reported survey results of households with information about the presence of a computer and internet use. Table 3 indicates that Hawaii households are no different, and perhaps slightly more likely, to have a computer at home and to use the Internet than in the nation as a whole. Moreover, both for the U.S. and Hawaii, usage increased significantly just between 1997 and 1998.

Table 3: Percent of Households with a Computer and Internet Use

	Computer		Internet Use	
	U.S.	Hawaii	U.S.	Hawaii
1997	36.6	34.6	18.6	NA
1998	42.1	42.3	26.2	27.9

Source: NTIA, Falling Through the Net: Defining the Digital Divide, July 1999 and Falling Through the Net II: New Data on the Digital Divide, July 1998. http://www.ntia.doc.gov/ntiahome/digitaldivide.

preliminary reports on training needs for each of the niche areas.

Technology education

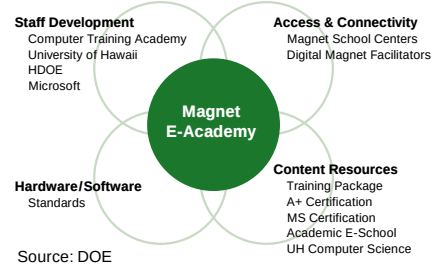
Technology skills training is most effective among those who already possess hands-on familiarity with the leading-edge products of advanced technology. But even those who will not be training for technology occupations must understand technology and the increasing role it will play in 21st century society.

With this in mind, the Department of Education is taking aggressive and impressive steps to integrate technology education into elementary and high school curricula. The strategy for developing future generations of technology-savvy, Hawaii workers is embodied in the DOE's new content and performance standards. Among the standards are a set of six areas for technology literacy that aim to teach students both the technical and the human side of technology (see side bar). Specific performance standards have been established for each grade level from kindergarten through 12th grade.

Two other innovations gathering momentum in DOE's effort to accelerate technology literacy of both students and educators are *Magnet E-Academies* and *E-Schools*.

• *E-Academies*

Magnet E-Academies will explore the development of new teaching methods and learning environments using emerging information and telecommunications technology. More than 20 schools statewide were offering E-Academy courses as of the Fall of 1999. The focus of the E-Academy programs are on math, science, engineering and technology, combining the best practices of technology-aided on-site instruction and on-line learning through the internet and educational networks.



Source: DOE

• *E-Schools*

The Electronic School or "e-school" program offers academic courses over cable television and on the Internet. About 20 courses were offered in the Fall of 1999 in subjects ranging from math and technology to history and journalism. Some of these courses carry Advanced Placement (AP) college credit.

Playing an increasing role in an effort to build an understanding of technology among students and staff is the DOE Office of Information and Telecommunications Services (ITS), particularly the Advanced Technology Research unit. The ITS has partnered with a number of private and public sector organizations to bring the expertise needed into the schools and sought-out Federal grant monies to accomplish their mission.

Conclusion

Technology can create whole new occupational opportunities and also eliminate some occupations. The faster the pace of technological change, the more challenging is the task of restructuring education and training programs as well as retraining and upgrading the skills of affected workers. The key to helping the workforce adjust to technological change is for the education and training system to anticipate the needs of the technology sector and the impact technology will have on existing industries in the future.

Hawaii Department of Education Statewide Standards for Educational Technology

Content Standards Overview	
BASIC OPERATIONS AND CONCEPTS	Students demonstrate a sound understanding of the nature and operation of technology systems. Students are proficient in the use of technology.
SOCIAL, ETHICAL AND HUMAN ISSUES	Students understand the ethical, cultural, and societal issues related to technology. Students practice responsible use of technology systems, information, and software.
TECHNOLOGY AS A TOOL FOR PRODUCTIVITY	Students use technology tools to enhance learning, increase productivity, and promote creativity. Students use productivity tools to collaborate in constructing technology-enhanced models, preparing publications, and producing other creative works.
TECHNOLOGY AS A TOOL FOR COMMUNICATIONS	Students use technology to communicate, to collaborate, publish, and interact with peers, experts, and other audiences. Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
TECHNOLOGY AS A TOOL FOR RESEARCH	Students use technology to locate, evaluate, and collect information from a variety of sources. Students use technology tools to process data and report results. Students evaluate and select new information resources and technological innovations based on the appropriateness to specific tasks.
TECHNOLOGY AS A TOOL FOR PROBLEM-SOLVING AND DECISION-MAKING	Students use technology resources for solving problems and making informed decisions. Students employ technology in the development of strategies for solving problems in the real world.

Hawaii Department of Education (DOE), Standards for Educational Technology, Hawaii Content and Performance Standards, DOE internet web site, http://www.hcps.k12.hi.us/

Growing Hawaii's Technology Industry

By Joseph F. Blanco
Executive Assistant to the Governor and Special Advisor for Technology Development

The explosion that's taking place in the worldwide technology industry holds tremendous potential for Hawaii. As the Governor's Special Advisor for Technology Development, my job is to ensure that the islands develop a strong and vibrant technology sector and that we take full advantage of the many opportunities technology industries can provide. But while the state government must and will, play a key role, it is Hawaii's technology businesses that will be the driving force in facilitating the growth of our emerging technology sector.


Joseph F. Blanco

Of course, there are already strong, well-established centers of technology around the country including Silicon Valley in California, the Silicon "forest" in the Northwest, and nearly a dozen others. But, Hawaii can be every bit as competitive as these other centers if we focus on selected niche markets that can thrive on the unique assets and resources found in Hawaii. Our top-notch talent, strategic location as America's "gateway" to Asia, technology infrastructure assets funded by the state and federal governments, our unparalleled quality of life, and even our unique geology and climate, can make Hawaii the "location of choice" for many important areas of advanced technology.

technology niche markets can thrive on the unique assets and resources found in Hawaii

For example, Square USA Hawaii's latest computer generated film project, being created in the company's cutting-edge, Honolulu design studios, will rival or exceed the quality of products put out by industry giants like George Lucas' Industrial Light and Magic or Disney's Pixsar Studios.

we have been listening to what Hawaii's technology leaders have to say

Homegrown companies like Aquasearch and Cyanotech are developing dietary supplements and pharmaceuticals from microalgae on the Big Island that are better and produced at less cost than anywhere else in the world. The work being done by these companies has the potential to generate hundreds of millions of dollars in new revenues for Hawaii.

Another example is the PET scanner at Queen's Medical Center, which is one of the most advance medical imaging systems today. Right now, this is one of only two such scanners of comparable power in the world.

The areas in which Hawaii is developing its own unique brand of advanced technology were highlighted

Responsibilities of the Special Advisor

Act 178 of the 1999 Hawaii State Legislature established the position of Special Advisor to the Governor for Technology Development. Mr. Blanco was appointed to this position on August 27, 1999, by Governor Cayetano. The duties of the Special Advisor as set out in Act 178 include:

- Developing, coordinating, and implementing short- and long-range state policies and directions to enhance the development of high technology industries in Hawaii;
- Coordinating all state high technology agencies while developing a plan for reorganization or consolidation of these agencies in the interests of greater efficiency and cost effectiveness;
- Advising the private sector in the development of high technology activities and resources and providing technical or other assistance to private industry upon request;
- Creating, disseminating, and updating a listing of all high technology assistance programs in the State and where they can be reached;
- Pursuing appropriate public-private sector business partnerships;
- Coordinating the State's promotion and marketing of the high technology industry, including a review of current marketing efforts;
- Arranging for the conduct of research through contractual services with the University of Hawaii or any agency or other qualified persons;
- Encouraging the development of educational, training, and career programs in high technology industries; and
- Performing other necessary or desirable functions to facilitate the intent of the Act.

earlier in this report. Topping the list are information and communications technology, biotechnology, health and medial technology and astronomy, ocean, energy and environmental research and technology. While all areas of technology are important, we think these areas have particular promise for the islands. For many of them there is no place else in the world that can offer what Hawaii offers, from the standpoint of either resources or location.

But what do we need to do to grow these niches and shift Hawaii's effort to become a technology leader into high gear? And more specifically, what will I be doing as the Governor's Special Advisor for Technology Development?

My first step has been to *listen* to what our technology leaders have to say. My team and I have been meeting with dozens of technology companies throughout Hawaii, soliciting their input and ideas. Many of them have already told us, loud and clear, what they need to keep growing their particular businesses. We deeply appreciate and value this input, and will continue to seek it out, and act on it.

With that input in mind, we are committed to helping technology companies grow and become increasingly competitive through a number of efforts.

Making it easier for Technology firms to do business in Hawaii

Our technology companies must be able to compete globally. This means they must be able to operate as cost-effectively as possible. Let me give you two examples of how we're helping Hawaii's technology companies remain cost effective and competitive. Through Act 178 of 1999, (the Technology Omnibus Bill) Hawaii now has one of the most "high-tech friendly" tax structures in the nation. In fact, when we shared the details of Act 178 with some technology companies in California, their only question was how soon could they move here!

Hawaii now has one of the most 'high-tech' friendly tax structures in the nation

We're also working to make more, low-cost financing available to Hawaii's technology companies. In doing so, a new pool of attractive financing will be available to local technology companies to help them grow and expand their physical facilities. Our goal is to create a $100 million bond facility for Hawaii's technology companies.

Ensuring that Hawaii has a Top-Flight Technology Workforce

We know that in order to compete, Hawaii's technology companies must be able to draw from the best and the brightest employees available. The good news is that our universities and colleges are already producing what are widely recognized as some of the nation's top technology graduates. And, the quality of technological research and development that's taking place at the University of Hawaii is unparalleled. We need to do more, however, to help create more technology job opportunities that will allow our young people to remain here at home.

The quality of technological research and development that is taking place at the University of Hawaii is unparalleled.

We understand the importance of teaching strong science, math and computer skills at an early age and we'll be doing more to expand technology education and training programs into the lower grade levels. The Department of Education's new "E-Academies" and "E-schools," which teach science, math and engineering subjects through "virtual" schools statewide is just one of the ways we'll be working toward that goal.

Creating a Technology Image for Hawaii

We will work to help create an exciting and dynamic new image for Hawaii and help unify Hawaii's marketing efforts. Our current marketing efforts have already branded Hawaii as one of the world's most desired vacation spots. We must do the same for our technology image.

We believe strongly that this plan must include all of Hawaii's assets, including our state and federally funded assets and programs which give Hawaii another significant advantage over many of our competitors. Our goal is to work with Hawaii's technology industry to forge a unified statewide marketing strategy, so that instead of having many separate marketing plans for IT, biotech, medical research, etc., we'll have an integrated marketing plan and message that brands and sells Hawaii first. This marketing and public relations campaign will target a national and international audience and is designed to focus attention on Hawaii's advantages as a preferred location for technology. The campaign will showcase Hawaii's unique assets and existing technological expertise.

We will be placing special emphasis on making "Hawaii" synonymous with intellectual property protection in the technology community, just as Delaware is for corporate registrations in the corporate community. Governor Cayetano envisions Hawaii as a place where the best and brightest from around the world will want to come to test new ideas and where technological breakthroughs in many disciplines can take place.

Our goal is to work with Hawaii's technology industry to forge a unified statewide marketing strategy

Toward that end, the Governor recently led the charge to block extremely damaging federal legislation that would hurt - not help - American inventors. The Governor's action, which included writing all 49 of his fellow governors, urging them to join him in opposing the bill, has caught the attention of several nationally prominent independent inventors who are now taking a more serious look at Hawaii as a place to do business.

Two important upcoming events in Hawaii will provide excellent opportunities for Hawaii to tell our story and demonstrate our competencies. The Pacific Basin Economic Council (PBEC)

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Models of Advanced Technology Development

View of the Governor's Task Force on Science and Technology

The significant progress that has been made in developing Hawaii's advanced technology sector during the past several years has been due in part to the work in 1996 and 1997 of Governor Cayetano's Task Force on Science & Technology, chaired by Lt. Governor Mazie Hirono. Many of the financial, educational and coordination elements of Act 178 and the Economic Revitalization package enacted the year before can be traced to recommendations of the Task Force. (The full report may be reviewed at http://www.hawaii.gov/ltgov/scitec.html.)

The Governor's Task Force also looked at numerous models of technology development around the country and what distinguished the most successful among these. The most instructive of the models reviewed by the Task Force were those of Silicon Valley in California and Route 128 in Massachusetts. Route 128 is generally acknowledged to have been the premier U.S. center for technology innovation in the 1970s. However since then, Silicon Valley has achieved phenomenal success, as a center for technology development, while Route 128 has arguably faded. This is despite the fact that each center has had roughly equal resources in terms of academic, industry and government support.

Silicon Valley, located at the south end of San Francisco Bay, is just outside the doorstep of Stanford University and very close to the University of Southern California at Berkley. It is also within the major San Francisco labor market. Route 128 rings the metropolitan Boston-Cambridge area and encompasses MIT and Harvard Universities. Route 128 was the center of the minicomputer revolution of the 1970s through such companies as DEC, DataGeneral and Wang Laboratories. But it was Silicon Valley that became home for Xerox, Hewlett-Packard, Intel and countless others, leading into the age of broad-based personal computing, applications software and connectivity in the 1990s.

The eventual dominance of Silicon Valley was, according to the Task Force, mainly the result of pro-active efforts on the part of key faculty at Stanford University to nurture the development of start-ups, provide facilities and expertise, and facilitate financing for the fledgling private technology sector as it evolved. By contrast, MIT in the Route 128 area maintained the traditional, arms-length relationship with the private technology sector.

The collaborative nature between Stanford University and Silicon Valley technology firms made all the difference, in the Task Force' view. The Task Force noted that others have been able to emulate the Silicon Valley formula, including the UC San Diego-San Diego Economic Development Council's well-regarded "CONNECT" program and to a degree the Austin "Miracle" in Texas, anchored by the University of Texas. Each area specializes in somewhat different technologies. But the Silicon Valley formula for successfully growing a technology sector dependent on heavy input from scientific research and development, appears to cross cut all niches.

The Task Force concluded that for Hawaii to emulate the success formula, there are two essential ingredients.

1. A first-rate research university.
2. A concerted effort to develop interlocking networks of talent, information exchanges, and marketing for advanced technology firms.

The Task Force made six recommendations designed to selectively strengthen the University of Hawaii's capacity to serve as such a catalyst for the development of an advanced technology sector in Hawaii. These were:

- ✔ Encourage entrepreneurial activity by faculty;
- ✔ Imbed technology transfer activity more broadly within the research intensive units;
- ✔ Reward technological innovation by including it in the criteria for tenure and promotion;
- ✔ Provide incentives for research leadership to interact with local companies;
- ✔ Allocate positions, rewards and resources for disposal by research managers as performance-based incentives; and
- ✔ Establish a super-scale of remuneration, or find other means to compensate those new and existing faculty whose superstar status is sought for designated programs.

The Task Force also concluded that a coalition was needed among the UH and private sector firms to provide the technical and business training, information exchange, technology transfer, access to financing and venture capital and marketing of Hawaii's location for high-tech start ups.

The University has moved aggressively to address the need for leadership in technology development. It has expanded its role in technology transfer and established the "University Connections" program, inspired by the San Diego CONNECTS program.

Growing Hawaii's Technology Industry

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annual meeting here in March 2000 will bring hundreds of CEO's and captains of industry from throughout Asia-Pacific and the mainland US. Hawaii will also be hosting the Western Governor's Association Annual Meeting in June 2000, which will bring together governors from all the Western and Pacific states to Maui.

Hawaii will become synonymous with intellectual property rights

Using Technology More Efficiently Within Our State Government

Government needs to become just as technology savvy as the private sector in order to better serve our business customers and residents, and we are moving rapidly in that direction. For example, our planned e-commerce internet portal for the State of Hawaii called *Access Hawaii* is expected to save Hawaii's businesses considerable time and money by allowing them to access information, file documents and pay fees — all without ever having to stand in a line. Governor Cayetano has targeted the first phase of this project, on-line business registrations and licensing, to be up and running within a year.

We will also be using technology to help us do everything in government faster and more efficiently, from processing payroll to paying our vendors. Our goal is to provide Hawaii's citizens with government that is more accessible, more responsive and more customer-service oriented in the future.

The State's e-commerce, internet portal 'Access Hawaii' will permit companies to interact with government on-line for most routine matters

Partnership for Action

The development of Hawaii's technology industry is critical to our future economic prosperity. Fortunately, Hawaii currently enjoys potential competitive advantages in a number of unique technology niche areas. These niche areas have tremendous growth potential.

But technology is perishable. We must move quickly to organize a collaborative effort among stakeholders to build an environment conducive to a competitive technology industry and develop a strategy for success. Public-private partnerships are critical to the effort. I am convinced that it will be the degree of stakeholder collaboration that will determine our future success.

We must move quickly in an organized, collaborative effort to build a competitive technology industry

By creating the position of Special Advisor for Technology Development, Governor Cayetano has signaled the state's commitment to work with the private sector to grow Hawaii's technology industry. With the leadership of the private sector, and the close collaboration of education and government, I am confident we can accomplish the goal of creating a technology industry in Hawaii of world prominence.

(e-mail Mr. Blanco at blanco@aloha.net)

Goals of the Special Advisor's Office

Industry Development:

- Position Hawaii as synonymous with Intellectual Property Protection.
- Capitalize on existing tourism marketing efforts to promote Hawaii as a locale for advanced technology.
- Foster and facilitate many public-private partnerships.
- Foster the creation of an entrepreneurial environment.
- Facilitate the focus of education providers on the workforce needs of advanced technology industry.
- Attract $100 million in private venture capital and debt financing.
- Establish a $100 million Special Revenue Bond Facility for "brick & mortar" investments.

Industry Coordination & Support

- Complete an industry needs assessment
- Complete an inventory of public and private technology assets.
- Facilitate development of a statewide Technology Strategic Plan with all stakeholders.
- Consolidate state government agencies to best serve the private sector.

Why Hawaii Must Pursue Technology Development

continued from page 2

The results show that Hawaii's post-statehood economic boom was fueled mainly though large inflows of overseas investment and labor but not very much through the application of new technology to the economy. As a result Hawaii's economy grew faster than the national economy, but did not show the productivity increases that technology contributed at the national level.

Moreover, when the post-statehood boom ended in the early 1990s and the inflows of capital and labor stopped, the limited role of technology deteriorated significantly. As shown in Table 1, the net contribution of technology from 1990 to 1995 was actually negative. What this means is that the small contribution being made by new technology was not able to overcome other inefficiencies in the economy that were causing overall productivity to fall, even though labor and the capital stock were increasing.

The improvement in the contribution of technology shown for the 1995-98 period reflects the effort to improve efficiency by both the private and public sectors. The private sector increased its efficiency, introduced newer technology and began to focus on areas where it could be more competitive. The State's program of budget restraint, regulatory reform and business stimulation instituted by Governor Cayetano in 1995, has also been an important factor in improved productivity. The improvement illustrates the potential boost that technology can provide to the economy. Technology development permits the economy to expand, even when capital and labor growth are modest.

Table 1. The Role of Labor, Capital and Technological Change in Economic Growth (share of percentage growth accounted for by each source)*

	1990 to 1995		1995 to 1998	
Component of growth	Hawaii	U.S.	Hawaii	U.S.
Labor	0.7	0.8	1.1	1.0
Capital Stock	0.6	0.5	0.4	0.7
Technology	-1.0	0.9	0.3	1.1
Total (% change in economic growth)	0.3	2.2	1.8	2.8

* average for period

Source: DBEDT

We Have the Foundation for Technology Development

It is important to note that Hawaii already has an established base of technology-related activity to build on. In fact, with little fanfare, that base has had a positive impact on the economy in recent years, even helping to cushion an otherwise flat or declining job count in other industries. For instance, from 1990 to 1997, the number of jobs in business computer services nearly doubled in the state. This helped jobs in the broader business services industry to show a growth of more than 85 percent for the same period. Jobs in the economy as a whole increased only one-half percent over the period and would have been even lower without the boost from technology activity. Another example is Hawaii's technology-intensive, health care industry. This sector has also contributed to the economy, boosting jobs 20 percent since the beginning of the decade. The health care industry now provides nearly as many jobs as the entire hotel industry in the state, and more than hotels when public sector health care is included.

Hawaii has also had some significant accomplishments in the development of science and technology. Most notable has been the development of the "Honolulu" genetic cloning technique by researchers at the University of Hawaii. We have also attracted such international firms as Uniden and Square USA (which now employs 300 people in Hawaii).

The islands have a number of important advantages and niche opportunities which can help us be competitive in technology development. Conditions are unparalleled in Hawaii for research and technology related to biotechnology, astronomy, oceanography, energy, and vulcanology, to name a few. Hawaii's mid-Pacific location and first-class research University attract scholars and research projects from around the Pacific Rim. The physical and social environment for doing research and technology couldn't be better.

Government's Role in Technology Development

Clearly, technology is important to the economy and Hawaii now has a sound base to build upon. But is there a need for state government to be involved in the development of the technology sector? My preference as an economist, is to allow the private economy to decide what industries are best rather than government making this choice. However there are a number of activities that are potentially very valuable to the economy and the community but which, for various reasons, the market system produces less than the socially optimal amount. Technology development is one of these and some other examples are education, public safety, and public health. These activities benefit the community greatly but cannot be easily charged for by those who pay for the activity in the first place.

For example, more educated citizens provide additional value to the community that is not reflected in the return they earn on their educational investment. This additional value ranges from raising the general productivity of the economy to their community leadership roles. Thus, the more that people invest in their education, the better off society will be in general. However, people tend to invest in only enough education to satisfy their own goals, not the community's goals. By subsidizing basic and advanced education, government is able to encourage more investment in education, which results in future benefits to the community that more than make up for the subsidy.

Technology investment is similar to education investment in that the potential

The Hawaii Technology Trade Association

The Hawaii Technology Trade Association was formed in 1999 to "foster and facilitate a healthy business, funding, educational and governmental environment for the technology industry in Hawaii." The association is a statewide private-sector membership organization. The association provides an umbrella under which more established but fragmented technology interest groups can come to together and pursue mutual goals.

The goals of the association are:

- Become the "voice" for Hawaii's technology industry
- Lobby for pro-technology legislation and policies
- Identify and link members with venture capital and other sources of funding.
- Provide networking, resources and information.
- Help market Hawaii's *high tech* image.
- Help Hawaii's high tech companies compete.

The organization has a web site at http://www.htta.org, for further information.

Why Hawaii Must Pursue Technology Development *continued from page 22*

benefits to the community go far beyond the sales value of technology products. However, the expense and risks involved in technology development are much greater than in education. Consequently, the private economy will tend to *under* invest in technology development. Thus, in technology development there is an important role for government in establishing incentives for technology firms to engage in research, development and commercialization. Like the education example, assistance provided by the community to encourage more technology development will lead to long-run benefits to all individuals and businesses.

Because of the tremendous positive impact that scientific research has on technology and economic development, the Federal government has, for decades, invested public resources to encourage scientific research and development. What the taxpayer has received in return for this support is the most technically advanced society on the planet, with arguably the highest standard of living.

Technology Development is a Cooperative Effort

The state is very active in encouraging the further development of Hawaii's technological resources. Governor Cayetano's direct participation and leadership has been a pivotal factor in this effort through scores of face-to-face visits with the CEOs of fast-growing technology firms on the Mainland and Asia.

To supplement this effort, we are engaged in a cooperative partnership among the private technology sector, the University, and agencies of the State to pursue technology development as well as the physical and human resource infrastructure to support it. We are promoting our potential by acquainting high technology companies with what Hawaii can offer and seek their counsel about how we can best develop our technology sector. We are also promoting the products of Hawaii's technology sector — particularly energy technologies — in trade missions to Asia.

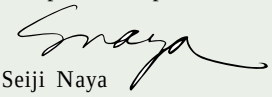
To further support these efforts, the Administration secured the passage of Act 178 through the 1999 Legislative session. This act established a number of incentives, institutional changes and innovative programs that the industry and government will use to begin a new era for technology development in Hawaii.

Among the many elements of Act 178 are tax changes and incentives that will encourage firms to engage in more research and development that will ultimately benefit the State as a whole. The act also established the Millennium Workforce Development Initiative. This program will help develop a work force with the technical skills needed by both technology companies and companies who must adopt new technologies in order to stay competitive. The Act provides for the establishment of virtual, site-based schools in the DOE (E Academies) and authorizes a special advisor to the Governor for Technology Development, as a first step in a process to streamline the agencies dealing with technology development.

Final Thoughts

It is important for the community to understand that the State's determination to develop the technology sector is not a pipe dream, political rhetoric, or simply following a fad. We are pursuing it in the sincere belief that it is essential to the future of Hawaii in the next century. Research clearly shows that the application of technology, innovation and labor skills to the production of goods and services can significantly increase productivity and competitiveness in the economy. This leads to higher incomes and a rising standard of living.

Although technology development is an area in which government must exercise leadership to ensure the best progress, the effort must be in cooperative partnership with the private sector. In addition to the rewards of a healthy economy, the common thread that unites the partners is the knowledge that the future of our children and their children in these islands may depend upon how well our partnership succeeds.



Seiji Naya
Director

Selected Economic Indicators

Series	Period (calendar year basis except for taxes)			Percent change from same period of previous year		
	1998 (12 mo.)	Jan-Oct 1999	October 1999	1998	Jan-Oct 1999	October 1999
Civilian Labor Force (persons) [1]	597,050	599,150	599,000	0.0	0.5	0.3
Civilian Employment	559,750	565,050	567,800	0.2	1.3	1.2
Civilian Unemployment	37,300	34,100	31,150	-2.3	-10.1	-14.0
Unemployment Rate (percent) [2]	6.2	5.7	5.2	-0.1	-0.7	-0.9
Total Wage & Salary Jobs	537,550	536,350	538,650	-0.2	-0.1	0.5
Taxes ($thousands, state fiscal year 1998-99)						
Total State Tax Collections	3,367,700	2,800,890	248,854	3.6	-0.9	-4.0
State General Fund Tax Revenues [3]	2,889,291	2,372,644	214,022	4.8	-1.8	-2.2
(Selected taxes)						
Transit Accommodations Tax Revenue	125,882	127,464	10,049	-0.8	20.9	22.5
General Excise & Use Tax	1,436,654	1,210,194	103,161	0.3	1.2	-7.4
Personal Income Tax Collections	1,093,241	876,113	83,150	11.0	-3.3	0.1
Corporate Income Tax Collections	50,113	58,462	10,811	-11.9	1.9	1,084.0
Visitor Arrivals (persons)	6,738,230	5,750,150	563,630	-2.0	1.9	6.5
Westbound Visitors	4,245,280	3,776,350	388,240	4.1	6.5	11.0
Eastbound Visitors	2,492,950	1,973,800	175,390	-10.9	-6.0	-2.1
Hotel Occupancy Rates (percent) [2]	71.8	74.1	73.7	-1.9	0.5	5.1

[1] Labor force and jobs averages are based on monthly rounded data. Labor force data were also rebenchmarked in March 1999.
[2] Change is expressed in percentage points rather than actual percent change of the rates shown.
[3] If tax period ends on a weekend some of the collections may be shifted to the next period.
Note: Most data are preliminary and subject to revision.

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