

Hawai'i Innovation Assets Report

2014-15

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HAWAI'I BUSINESS ROUNDTABLE

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INTRODUCTION

This report was commissioned by the Hawai'i Business Roundtable to identify key innovation assets in the state of Hawai'i to stimulate dialogue among its stakeholders as they work to grow Hawai'i's innovation economy and to recognize and nurture existing resources and talent to help develop an innovation-based economy. The following organizations supported the research and content of the Hawai'i Innovation Assets Report:

- City and County of Honolulu
- Chamber of Commerce Hawai'i
- Hawai'i Business Roundtable
- Hawai'i County
- Kaua'i County
- Maui County
- Pacific Resource Partnership
- State of Hawai'i - Department of Business, Economic Development and Tourism (DBEDT)
- University of Hawai'i

The Hawai'i Business Roundtable (HBR) is a statewide public policy organization made up of the leaders and senior executives of companies headquartered or maintaining significant operations in Hawai'i. In total, HBR members lead businesses that account for more than \$25 billion in gross revenue in Hawai'i each year, and employ more than 80,000 people on all islands.

Since its founding in 1983, education and the economy continue to be the Roundtable's major concern. HBR believes that the University of Hawai'i, through its Hawai'i Innovation Initiative, can play a critical role as a catalyst for economic development and we will work closely with the University toward this end.

CONNECT San Diego¹ was engaged to assist the HBR and its partners to research and produce the Hawai'i Innovation Assets Report based on CONNECT's experience with assessing regional innovation ecosystems. San Diego was identified by the Hawai'i Innovation Report task force partners as a potential model for Hawai'i in terms of how to develop the state's innovation economy.

THE GROWTH OF SAN DIEGO'S INNOVATION ECONOMY – A POSSIBLE MODEL FOR HAWAI'I

San Diego's economy in the 1980's was similar to that of Hawai'i today with a reliance on tourism and military sectors to fuel the economy. The end of the Cold War brought a decline in military spending to prime contractors and growth in the uniformed military base personnel. The tourism and convention industry faced increasing competition from other regions and slowing in the growth and thus capacity of the visitor plant in San Diego.

In response to these pressures and in conjunction with the development of new technologies in the research universities and institutes in San Diego, a number of clusters formed around innovative new technologies began to coalesce and grow. From research produced at University of California San Diego grew the wireless communications technology and biotechnology clusters. The number of companies in these sectors grew substantially over the next twenty years and the San Diego region saw the emergence of industry trade organizations, business accelerators and capital investment organizations.

¹ CONNECT is a regional program that catalyzes the creation of innovative technology and life sciences products in San Diego County by linking inventors and entrepreneurs with the resources they need for success. Since 1985, CONNECT has assisted in the formation and development of more than 3,000 companies. The leadership of CONNECT attributes its success to the unique culture of collaboration between industry, capital sources, strategic partners and research organizations that CONNECT has sought to foster in the region. See <http://connect.org/about-connect/>.

Hawai'i's Existing Economy

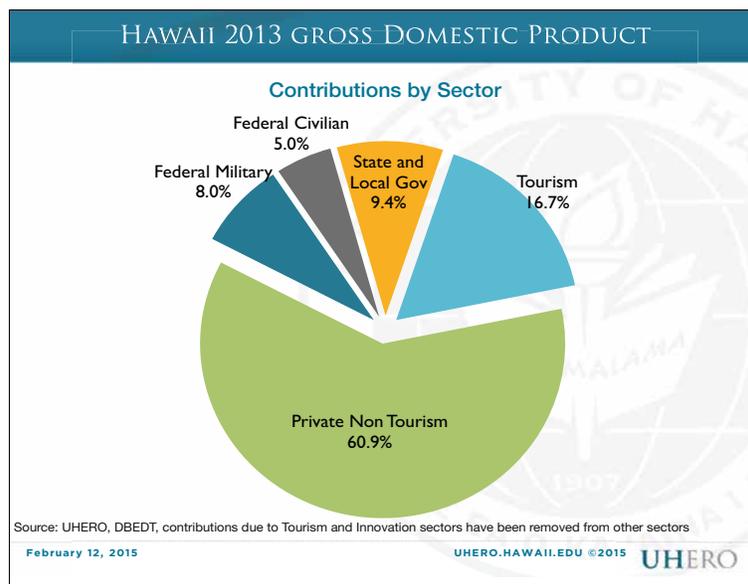


Hawai'i's Existing Economy

Hawai'i's economy has been fueled by a small number of sectors over the years. The tourism and military sectors represented more than a quarter of the state's total gross domestic product (GDP) in 2013. Historically, tourism has been Hawai'i's largest industry and accounts for about 17 percent of the state's economy. The federal military and civilian sectors represent about 15 percent combined.²

Hawai'i's economy is centered on the tourism industry: transportation, accommodation and food services, and retail trade sectors represent a significant fraction of total jobs. Tourism will always be a mainstay of Hawai'i's economy. The state's climate, natural beauty and its well-developed hotel, recreation and supporting service industries attract billions of dollars to the local economy.

About a fifth of the Hawai'i's jobs are in the government sector with both state and federal civilian components, as well as a large military component. Non-tourism service sectors such as health care, business, administrative and professional fields have generally grown faster than the economy overall, contributing to gradual diversification of the state economy³.



HAWAII'S VISITOR PLANT UNLIKELY TO SHOW SIGNIFICANT GROWTH

The tourism sector has shown limited growth over the past decade and volatile visitor spending. The majority of tourists to Hawai'i hail from the U.S. mainland. Visitors from the Western U.S. comprise roughly 40 percent of total arrivals, and visitors from the Eastern U.S. comprise about a fifth of all arrivals. The number of Japanese visitors peaked in the mid-1990s and has declined considerably since then. The share of visitors from markets other than the U.S. and Japan, including China, Korea, Australia, New Zealand, has increased from roughly 12 percent of total visitors a decade ago to close to 20 percent today. Yet prospects for growth in Hawai'i's visitor industry remain muted. "Despite a pickup over the summer of 2014, visitor arrivals have been soft this year, and the period of robust visitor spending increases is behind us. A mixed global economic environment and limited visitor industry capacity will keep a lid on future gains."⁴

² DBEDT, "The Innovation Sector in Hawai'i", 2012, p. 4.

³ UHERO Data Portal.

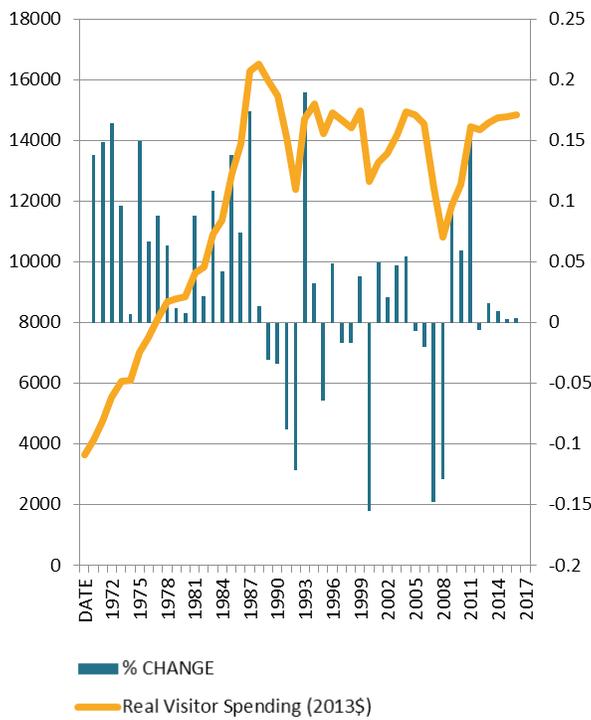
⁴ UHERO State Forecast Update, Public Summary October 24, 2014; <http://uhero.hawaii.edu/assets/14Q4StateUpdatePublicSummary.pdf>, accessed October 26, 2014.

Hawai'i Economic Indicators Year-Over-Year Percent Change

	2012	2013	2014	2015	2016	2017
Visitor Arrivals	9.7	1.7	1.2	1.9	1.0	1.1
U.S. Visitor Arrivals	5.2	0.7	0.5	1.9	1.2	0.8
Japan Visitor Arrivals	18.0	3.6	-1.1	1.0	-0.1	1.5
Other Visitor Arrivals	17.6	3.2	5.7	2.8	1.4	1.6
Non-farm Payrolls	2.2	2.1	1.4	1.4	1.3	1.2
Unemployment Rate (%)	5.7	4.8	4.4	4.1	3.9	3.8
Inflation Rate, Honolulu MSA (%)	2.4	1.8	1.3	2.1	3.1	3.9
Real Personal Income	2.2	0.6	2.8	2.8	2.4	2.1
Real GDP	1.5	1.9	2.9	3.5	2.7	2.3

Note: Source is UHERO. Figures for 2014 are UHERO estimates. Figures for 2015-2017 are forecasts. Non-farm Payrolls for 2013 and 2014 are UHERO estimates of the benchmark revision.

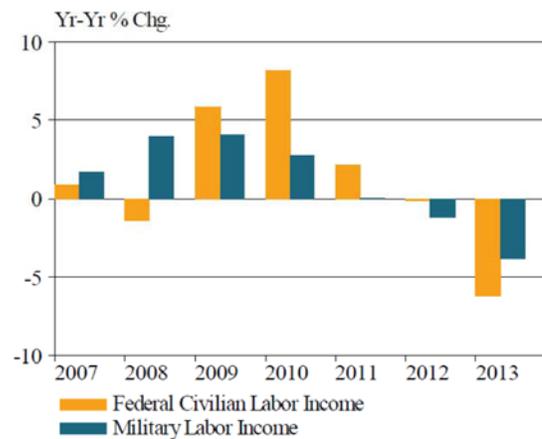
Real Visitor Spending



Source: UHERO

Military in Hawai'i

Future defense spending cuts may negatively impact the state's economy. In 2014, federal government jobs continue to fall, although the pace of decline has slowed somewhat in the summer months. "Since peaking in late 2012, federal government employment in the state has fallen by nearly 2,000, with most of the losses concentrated in civilian Department of Defense positions."⁵



FEDERAL DOWNSIZING HAS BEEN A MAJOR DRAG ON INCOME GROWTH IN RECENT YEARS.

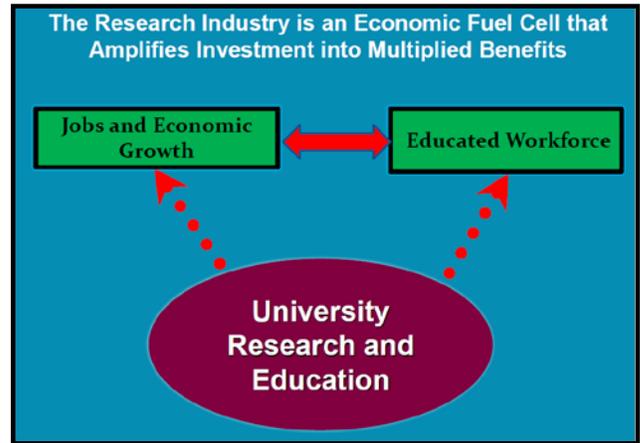
5 UHERO State Forecast Update, Public Summary October 24, 2014; <http://uhero.hawaii.edu/assets/14Q4StateUpdatePublicSummary.pdf>, accessed October 26, 2014.

Hawai'i's Emerging Innovation Economy

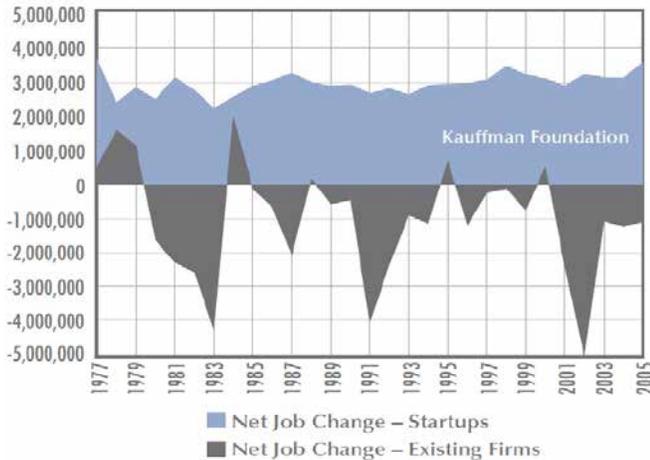


Hawai'i's Emerging Innovation Economy

The Hawai'i Innovation Assets Report highlights the richness and diversity of the state's innovation economy. The state has a strong foundation in research through the discoveries and innovation activity of the University of Hawai'i and a broad range of science, technology, engineering and math (STEM) related educational programs promoting and supporting the growth of a technically skilled workforce.

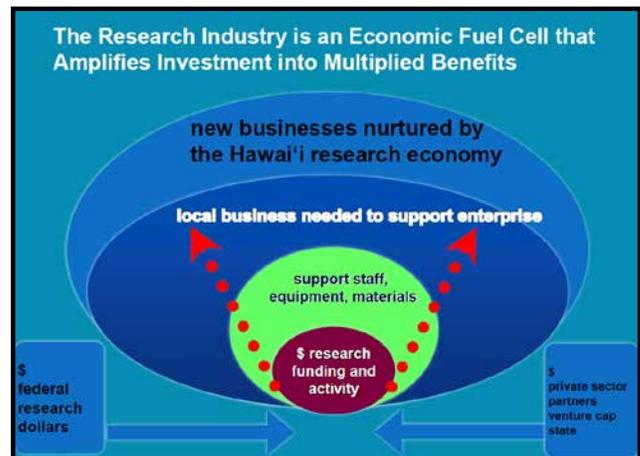


Startups Create Most New Net Jobs in the United States



This report shows that approximately 200 new companies were established in 2013 in the innovation sectors in Hawai'i. These early stage companies represent an opportunity for rapid economic growth for the state as such companies have been shown to be engines of job creation and high value added economic impact.⁶

There is a dynamic in firm birth that is necessary to understanding job creation—specifically, the unique effect of new firms, or startups—without startups, there would be no net job growth in the U.S. economy. This fact is true on average, but also is true for all but seven years for which the United States has data going back to 1977. Notably, data shows that, during recessionary years, job creation at startups remains stable, while net job losses at existing firms are highly sensitive to the business cycle.



⁶ Tim Kane, Kauffman Foundation Research Series: Firm Formation and Economic Growth the Importance of Startups in Job Creation and Job Destruction, 2010; http://www.kauffman.org/~media/kauffman_org/research%20reports%20and%20covers/2010/07/firm_formation_importance_of_startups.pdf, accessed October 14, 2014.

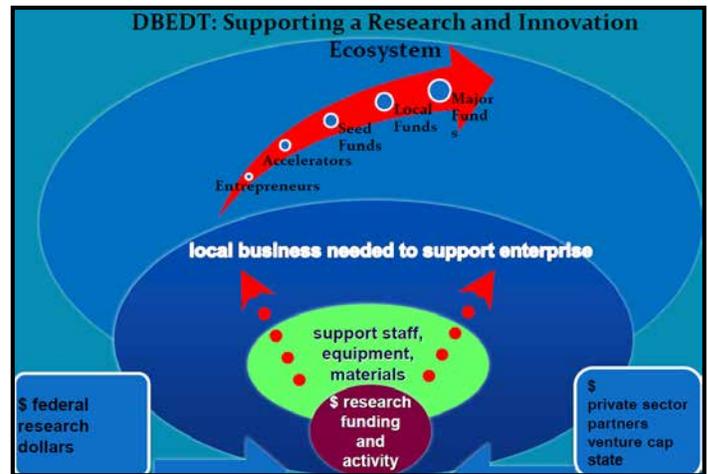
In addition, this report shows that there are almost 4,000 establishments total in the state's innovation economy accounting for more than 40,000 jobs (>64,000 jobs if extended proprietors are included). More than 1,500 of these are what the authors of this report refer to as "core" technology companies. These establishments are primarily engaged in research and development, the manufacture of technology-based products or the provision of scientific or technical services.

Establishments in the biotechnology, pharmaceuticals and biomedical product development, communications technology and information services, computer and electronics manufacturing, software development, aerospace, defense and energy technology are included in the "core" category. These establishments provide employment for more than 20,000 highly skilled workers.

Another 1,100 are establishments from a broad number of industry sectors that use technologies and facilitate their application to providing goods and services in the economy but do not develop novel or next generation technologies themselves. Examples of these establishments include medical laboratories, wireless communication carriers, broadcasting and publishing, and engineering services. These establishments employ more than 14,000 skilled workers.

Hawai'i has a vital creative, artistic and cultural economy that promotes innovation and includes establishments in such sectors as film and television production, music, digital media products such as gaming and mobile applications, animation and workforce development in these areas. In these sectors (and others like them) the creative economy overlaps with what this report calls Hawai'i's innovation economy and accounts for more 9,000 workers.

Fostering innovative technology companies is challenging. To grow, these young companies often requires investment capital, access to a skilled and educated workforce and can benefit from mentor-



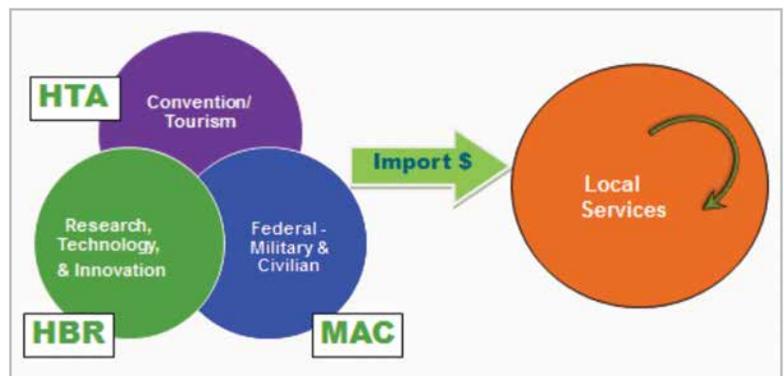
ing programs and business incubators and accelerators that can help these new companies scale their businesses and contribute to the overall productivity of the economy.

This report highlights a select number of these emerging companies as well as established organizations from diverse industries such as ocean science technologies, biotechnology, material science technology, energy technology, defense/ security and medical devices.

The Department of Business Economic Development and Tourism (DBEDT), the University of Hawai'i and other organizations have taken a leadership role in establishing accelerators, incubators and funding sources for these emerging companies as may be seen in the *Start Up Activity in Hawai'i* section of this report. The following graphic depicts the key elements needed to support a research and innovation ecosystem in Hawai'i.

CREATE A COMMUNITY-SHARED GROWTH PLAN

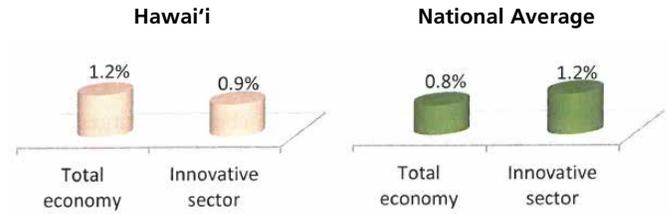
The innovation economy is made up a number of industry sectors that can provide opportunities for Hawai'i to diversify and strengthen productivity in the face of economic downturns or stagnating growth in the traditional established sectors of the economy.



Innovation - A New Engine of Growth

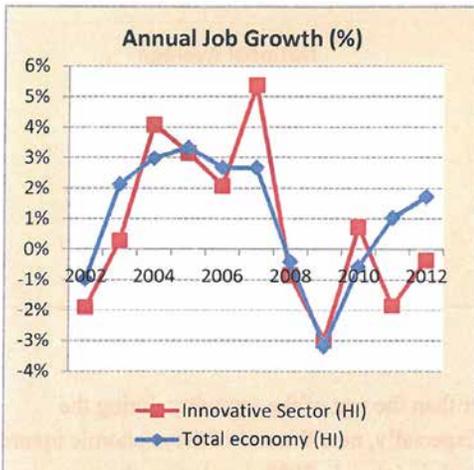
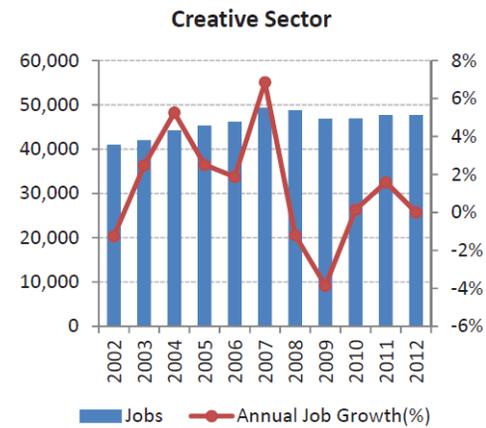
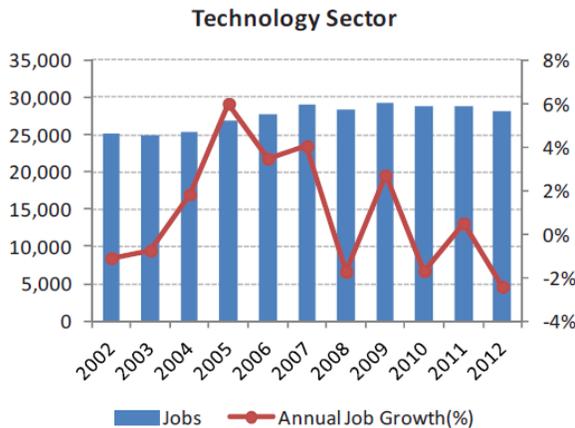
The innovation economy in Hawai'i is currently small relative to the developed industries of tourism, military, construction and manufacturing, however, the innovative sector is poised for growth and can offer diversity for the state's economy. Over the past decade the innovation economy has not performed as well as the rest of the Hawai'i's economy.

In their initial report on Hawai'i's innovation economy⁷, DBEDT defined the innovative sector as being comprised of industries related to both the technology and creative industries (123 industries in all at the six digit level of the North American Industry



Classification System or NAICS). The study found that the innovation economy lagged the total economy in annual job growth over the period 2002 through 2012.

ANNUAL JOB GROWTH, HAWAI'I VERSUS NATIONAL AVERAGE (2002-2012 AVERAGE)



The innovation economy outperformed the total economy in the few years prior to the recession, but has shown a slower recovery after the recession.

In addition, the pronounced fluctuations in the innovation sector were attributed to ups and downs in sub-sectors such as alternate power generation and film production.⁸

The technology sector showed an average annual growth of 1.2 percent during the period 2002 through 2012, slightly lower than the civilian economy, whereas the creative sector grew faster than the civilian economy with 1.5 percent growth over the ten year period.⁹

Annual earnings in Hawai'i's innovation economy averaged just over \$50,000 in 2012 or seven percent higher than the average of \$47,300 for the overall Hawai'i economy.¹⁰ In both the DBEDT study and the current *Hawai'i Innovation Assets Report*, the innovation economy included both technology and creative industry sectors.¹¹ Technology sector jobs show a higher average annual earnings compared to the average for Hawai'i's economy.

7 DBEDT, The Innovation Sector in Hawai'i, 2013, pg. 5.

8 Ibid.

9 DBEDT, Hawai'i's Targeted & Emerging Industries, December 2012; accessed October 6, 2014.

10 DBEDT, The Innovation Sector in Hawai'i, 2013, pg. 12.

11 Note: The Hawai'i Innovation Assets Report includes a subset of the creative sector industries DBEDT designated as being part of the innovation economy. See appendix for a more detailed explanation of the methodology.

According to a report by DBEDT¹², the average annual wage earnings in Hawai'i's technology sector was \$70,500 or 56 percent higher than that of the overall economy. Although the technology sectors annual earnings were higher than the average wage, they were below those of the U.S. average for those industry sectors. Biotechnology shows relatively high annual earnings in other regions such as San Diego and the nation overall, but was slightly more than \$50,000 in Hawai'i. The authors of the study suggest this may be due to the number of the field workers employed in the corn seed research industry that makes up part of the state's biotechnology sector.¹³

HAWAI'I'S TECHNOLOGY SECTOR JOBS AND EARNINGS

	Jobs per Estab			Avg. Ann. Job Growth		When U.S.=100%		
	Jobs (2012)	Estabs (2012)	Avg. Annual Earnings (2012)	2002-2012	above or below U.S.	Concentration ¹	Jobs per Estab	Avg. Ann. Earning
Total Civilian Jobs	806,581	21.2	45,101	1.3%	0.4%	100%	109%	90%
TECHNOLOGY SECTOR	28,160	11.5	70,515	1.2%	-0.1%	61%	73%	75%
Technical Consulting Services	4,462	11.2	50,926	6.0%	-0.3%	63%	107%	72%
Biotechnology	1,967	34.5	52,896	4.6%	2.2%	250%	177%	45%
Medical and Diagnostic Testing	1,778	55.6	61,504	2.9%	0.1%	149%	350%	90%
Other Technology Mfg	607	12.1	57,415	2.8%	3.0%	10%	23%	57%
R& D Serv. (except Biotechnology)	1,955	13.0	83,356	2.7%	0.5%	78%	42%	77%
Alternative Power Generation	190	31.7	55,837	1.9%	7.6%	61%	61%	37%
Computer Serv. & Digital Media Prod	6,041	8.3	72,917	0.9%	-1.8%	63%	80%	77%
Engineering and Related Services	5,494	8.3	82,042	0.2%	-0.6%	80%	60%	96%
Technology Equip. Distribution	764	9.6	88,124	-1.1%	-0.6%	32%	64%	81%
Chemical & Pharmaceutical Mfg	152	25.3	72,663	-1.3%	-0.7%	8%	34%	58%
Information & Telecom Technology	4,750	17.0	77,273	-2.2%	-1.1%	62%	73%	81%

¹ Proportion of jobs in the activity in Hawaii compared to the proportion nationally

The creative sector jobs show lower average annual earnings compared to the technology sector. The average annual earnings were \$45,000 for the creative sector and were the same as the Hawai'i's national average in 2012.¹⁴

	Jobs per Estab			Avg. Ann. Job Growth		When U.S.=100%		
	Jobs (2012)	Estabs (2012)	Avg. Annual Earnings (2012)	2002-2012	above or below U.S.	Concentration ¹	Jobs per Estab	Avg. Ann. Earning
Total Civilian Jobs	806,581	21.2	45,101	1.3%	0.4%	100%	109%	90%
CREATIVE SECTOR	47,694	14.4	45,480	1.5%	-0.6%	85%	93%	68%
Marketing, Photography & Related	10,111	19.6	33,565	1.1%	-1.0%	88%	99%	74%
Performing and Creative Arts	9,178	36.3	19,942	0.9%	-1.0%	130%	98%	81%
Engineering and R & D	5,544	10.0	87,967	1.8%	0.1%	77%	55%	89%
Business Consulting	5,146	11.1	51,186	6.2%	1.0%	63%	109%	72%
Computer Serv/Digital Media	4,269	6.5	78,272	1.6%	-1.5%	44%	59%	75%
Cultural Activities	3,297	48.5	37,729	8.2%	6.4%	416%	335%	81%
Publishing & Information	2,106	16.2	50,013	-3.4%	-2.1%	60%	76%	68%
Film, TV, Video Production/Distrib	1,853	11.4	46,765	1.4%	1.4%	109%	60%	49%
Design Services	1,701	12.4	21,034	1.6%	-0.5%	83%	100%	59%
Architecture	1,696	7.5	67,910	-1.8%	-0.7%	128%	77%	108%
Radio and Television Broadcasting	1,183	26.3	52,404	-1.5%	-1.0%	101%	84%	72%
Music	1,015	14.9	24,804	0.1%	-1.0%	129%	110%	67%
Art Education	595	14.2	11,746	2.3%	-2.6%	60%	72%	118%

¹ Proportion of jobs in the activity in Hawaii compared to the proportion nationally

The earnings level is important for Hawai'i in that significant earnings gaps may fuel "brain drain" and make it challenging to retain skilled workers coming out of the state's educational system especially in STEM fields. In addition, skilled workers in the technology sectors who have job experience in their field may be attracted by higher paying jobs in their field outside of the Hawai'i.

¹² DBEDT, Hawai'i's Targeted & Emerging Industries. 2012 Update Report; accessed August 10, 2014.

¹³ Ibid.

¹⁴ Ibid.

Hawai'i Innovative Economy – Industry Sectors

As an extension and update to the previous data on technology sector jobs, CONNECT worked closely with the University of Hawai'i Economic Research Organization (UHERO) and the Department of Business, Economic Development and Tourism (DBEDT) to compile a list of industries defined by NAICS. Previous reports and studies by DBEDT and other organizations were reviewed in consideration of industries classified as technology or creative sectors. CONNECT's experience measuring the innovation economy in San Diego and other regions was the primary subjective determinant in designating industry sectors as "core tech," "peripheral tech" and "creative."

The industry codes and names come directly from NAICS. The industry sector grouping classification was created by CONNECT to create an "umbrella designation" for the various industry NAICS codes based on similar or related general business activities of the sub-industries. The industries included in the tables above were those whose NAICS codes showed more than ten employees.

The data shown in the following tables and charts are from EMSI Quarterly Census of Employment and Wages. The number of jobs by industry sector is shown (both excluding and including extended proprietors) as are the number of extended proprietors and the number of establishments.

Extended proprietors are workers who are counted as proprietors, but classify the income as peripheral to their primary employment. Many industries (primarily oil and gas extraction, finance and insurance, and real estate) include people who are considered sole proprietors or part of a partnership, yet have little or no involvement or income in the venture. And an increasing number of people fall into this category (e.g., those who do freelance work on the side, like writers or musicians and software application ("apps") developers).

CORE SCIENCE/TECHNOLOGY SECTOR

We define “core” industries as those that are primarily engaged in technology research and development of manufactured products as well as professional and technical services. Examples include industries such as biotechnology, pharmaceuticals and biomedical product development, communications technology and information services, commercial physical research/scientific, technical services, computer and electronics manufacturing, software development, aerospace and defense, and energy.

NAICS Code	Industry Name	Industry Sector Grouping
333314	Optical Instrument and Lens Manufacturing	Biomedical Products
339113	Surgical Appliance and Supplies Manufacturing	Biomedical Products
339115	Ophthalmic goods manufacturing	Biomedical Products
339116	Dental laboratories (manufacturing)	Biomedical Products
111150	Corn farming	Biotechnology, Pharmaceuticals and Chemicals
311223	Other oilseed processing	Biotechnology, Pharmaceuticals and Chemicals
325314	Fertilizer, mixing only, manufacturing	Biotechnology, Pharmaceuticals and Chemicals
325411	Medicinal and Botanical Manufacturing	Biotechnology, Pharmaceuticals and Chemicals
325412	Pharmaceutical Preparation Manufacturing	Biotechnology, Pharmaceuticals and Chemicals
541711	Research and Development in Biotechnology	Biotechnology, Pharmaceuticals and Chemicals
541712	Commrc'l Phys Rsrch	Commercial Physical Research/Scientific & Technical & Non-Technical Services
541990	All Other Professional, Scientific, and Technical Services	Commercial physical research/Scientific & Technical & Non-Technical Services
5182	Data Processing, Hosting, and Related Services	Computer & Electronics
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	Defense and Aerospace
336413	Other Aircraft Part and Auxiliary Equipment Manufacturing	Defense and Aerospace
221112	Fossil Fuel Electric Power Generation	Energy
221119	Other Electric Power Generation	Energy
334513	Instruments and Related Product Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	Environmental Technology
541620	Environmental Consulting Services	Environmental Technology
541614	Process, Physical Distribution, and Logistics Consulting Services	Other Business, Market and Technical Consulting Services
541690	Other Scientific and Technical Consulting Services	Other Business, Market and Technical Consulting Services
541910	Marketing Research and Public Opinion Polling	Other Business, Market and Technical Consulting Services
511210	Software Publishers	Software
541511	Custom Computer Programming Services	Software
541512	Computer Systems Design and Related Services	Software
3152	Apparel manufacturing	Sports and Active Lifestyle
339920	Sporting and Athletic Goods Manufacturing	Sports and Active Lifestyle
9110	US Federal (science, tech, engineering & math occupations only)	U.S. Federal (STEM jobs only)

PERIPHERAL TECH SECTOR

A broader sector includes industries that use technologies and facilitate their application to providing goods and services but whose focus is not developing new or next generation technologically. Examples here include medical laboratories, diagnostic imaging centers, wireless communications carriers, broadcasting and publishing, and engineering services.

In their 2012 study “Hawai'i's Technology Workforce Occupations and Projections”, DBEDT reported that while the core of the technology sector may be technical occupations, the technology sector is also highly dependent on administrative and managerial support occupations.

“For some key occupational groups, the technology sector is a major source of employment. For instance, the technology sector accounted for 44.9 percent of state total jobs in the computer and mathematical occupations, 36 percent total jobs in the architecture and engineering occupations, and 13.5 percent total jobs in the life, physical and social science occupations. This is important information for planning how the future occupational needs of technology can be met without unduly competing with other industries for key occupations.”

NAICS Code	Industry Name	Industry Sector Grouping
621511	Medical Laboratories	Biomedical Products
621512	Diagnostic Imaging Centers	Biomedical Products
813910	Business Associations	Business and Professional Associations
813920	Professional Organizations	Business and Professional Associations
541720	Research and Development in the Social Sciences and Humanities	Commercial physical research/Scientific & Technical & Non-Technical Services
5172	Wireless Telecommunications Carriers (except Satellite)	Communications Technology & Information Services
511110	Newspaper Publishers	Communications Technology & Information Services
511120	Periodical Publishers	Communications Technology & Information Services
511130	Book Publishers	Communications Technology & Information Services
511140	Directory and Mailing List Publishers	Communications Technology & Information Services
511199	All Other Publishers	Communications Technology & Information Services
515111	Radio Networks	Communications Technology & Information Services
515112	Radio Stations	Communications Technology & Information Services
515120	Television Broadcasting	Communications Technology & Information Services
515210	Cable and Other Subscription Programming	Communications Technology & Information Services
517110	Wired Telecommunications Carriers	Communications Technology & Information Services
517919	All Other Telecommunications	Communications Technology & Information Services
519110	News Syndicates	Communications Technology & Information Services
519190	All Other Information Services	Communications Technology & Information Services
541310	Architectural services	Engineering Services
541320	Landscape architectural services	Engineering Services
541330	Engineering Services	Engineering Services
541340	Drafting Services	Engineering Services

CREATIVE SECTOR

Although not the primary focus of this report in terms of highlighting key innovation assets in Hawai'i, the “creative” sector is included in terms of jobs and establishments that comprise Hawai'i's innovative economy. The uniqueness of Hawai'i's artistic and cultural sectors helps Hawai'i's creative products compete in worldwide markets, while also supporting visitor spending and developing the foundation of Hawai'i's creative economy. In addition, the creative industries and their workforce represent key sources of ideas, content creation for global export and provide the talent for Hawai'i's emerging technology and knowledge based industry sectors.

NAICS Code	Industry Name	Industry Sector Grouping
51219	Postproduction Services and Other Motion Picture and Video Industries	Audio & Visual Media Production & Distribution
51224	Sound Recording Studios	Audio & Visual Media Production & Distribution
512110	Motion picture and video production	Audio & Visual Media Production & Distribution
512120	Motion Picture and Video Distribution	Audio & Visual Media Production & Distribution
512210	Record Production	Audio & Visual Media Production & Distribution
512290	Other Sound Recording Industries	Audio & Visual Media Production & Distribution
541410	Interior Design Services	Design Services
541420	Industrial Design Services	Design Services
541430	Graphic Design Services	Design Services
541490	Other specialized design services	Design Services
541810	Advertising Agencies	Marketing & Related Services
541820	Public Relations Agencies	Marketing & Related Services
541830	Media Buying Agencies	Marketing & Related Services
541840	Media Representatives	Marketing & Related Services
541850	Display Advertising	Marketing & Related Services
541860	Direct Mail Advertising	Marketing & Related Services
541870	Advertising Material Distribution Services	Marketing & Related Services
541890	Other Services Related to Advertising	Marketing & Related Services
541921	Photography Studios, Portrait	Marketing & Related Services
541922	Commercial Photography	Marketing & Related Services
541611	Administrative Management Consulting Services	Other Business, Market and Technical Consulting Services
541612	Human Resources Consulting Services	Other Business, Market and Technical Consulting Services
541613	Marketing Consulting Services	Other Business, Market and Technical Consulting Services
541618	Other Management Consulting Services	Other Business, Market and Technical Consulting Services
611610	Fine Arts Schools (Private)	Performing Arts & Related Creative

The creative sector includes artistic and related technical activity resulting in artistic and entertainment products and services. These include not only live performances, but also digital products such as music, film, computer animation and computer gaming.

In its most recent update report on the creative economy in Hawai'i, DBEDT notes that the priority focus by the State of Hawai'i on the creative sector is now on a number of key activities for which Hawai'i has an established competitive advantage

as well as areas based on emerging technology that can generate valuable exports and high paying jobs; including:

- Film and TV
- Music
- Digital media products (such as games and mobile applications)
- Animation
- Workforce development

Hawai'i's Strengths and Weaknesses in Innovation

The Information Technology and Innovation Foundation (ITIF), a Washington D.C. based economic think tank, ranked Hawai'i 23rd out the 50 states based on an Innovation Capacity Index. This index is based on various innovation indicators shown in the table below. The state showed marked improvement in 2012 over the 2010 ranking of 41st.

INNOVATION CAPACITY INDEX: HAWAI'I'S STRENGTHS AND WEAKNESSES¹⁷

Most notable improvements were seen in the number of patents issued per 1,000 people in the workforce, which ranked fourth, industry research and development and the movement toward a green economy. Hawai'i's venture capital ranking fell as measured by the amount of venture capital invested as a percentage of worker earnings. Entrepreneurial activity ranking was down relative to 2010. Entrepreneurial activity was measured as the number of individuals starting new business as a percentage of the population.

Promoting greater entrepreneurial activity and supporting the startup and early stage sectors of the innovation economy should be seen as a goal for the state to ensure greater diversity in the economy and retain both managerial and technical workforce talent. An educated and skilled workforce and a strong research capacity are foundational assets for Hawai'i upon which to build its emerging innovation ecosystem.

Category	2012 State Rank	2010 State Rank	Rank Change
Patents	3	42	39
Movement Toward a Green Economy	16	24	+8
Non-Industry R&D	17	17	No Change
Industry R&D	27	44	+17
Scientists & Engineers	39	45	+6
High-Tech Jobs	40	41	+1
Broadband	26	19	-7
Venture Capital	45	36	-9
Entrepreneurial Activity	46	45	-1
Overall Innovation Capacity	23	41	+18

Source: ITIF 2012

¹⁷ DBEDT, "The Innovation Sector in Hawai'i, 2013, pg. 24. Data from ITIF (2012); accessed October 9, 2014.

STEM EDUCATION PROGRAMS

The development and growth of STEM education is vital to ensure a skilled workforce for the state's innovation economy. Recognizing this need, the Maui Economic Development Board (MEDB) created the Women in Technology (WIT) initiative in 1999 to build and strengthen Hawai'i's STEM education-to-workforce pipeline by facilitating partnerships between educators and businesses. Following MEDB's groundbreaking statewide effort, many organizations began to increase their support of STEM-related activities. Although there is an abundance of programs and initiatives to encourage students to enter the STEM pipeline, like robotics programming for K-12 students, most of these efforts are run independently of one another.

The Energy Excelerator at the Pacific International Center for High Technology Research (PICHTR) produced a comprehensive mapping of Hawai'i's STEM program. These findings highlight the wide range of existing programs and gaps that remain for the state to address to strengthen the pipeline of a skilled workforce for Hawai'i's innovation economy.

For the report, go to: <http://www.energyexcelerator.com/publications/>

RESEARCH

In addition, many of the state's research and education assets are highlighted in the following sections of this report. The University of Hawai'i is a core research asset for the state and produces world-class research, especially in the areas of astronomy and space sciences, ocean and earth sciences, and health sciences. Research can fuel innovative technologies that can be commercialized by both entrepreneurial ventures and existing industry.

INNOVATIVE TECHNOLOGY COMPANIES

A number of emerging and established innovation companies are featured in this report highlighting a broad range of technological innovation that is being produced in the state. These companies reflect a number of Hawai'i's emerging technology sectors spanning industries ranging from sustainable energy, engineering, defense, medical imaging, biotechnology, medical devices, biofuels from algae, ocean sciences, smart grid, nanotechnology, defense and space technologies (dual technologies), agriculture, information and computer technologies, as well as imaging (photonics) and sensor technologies.

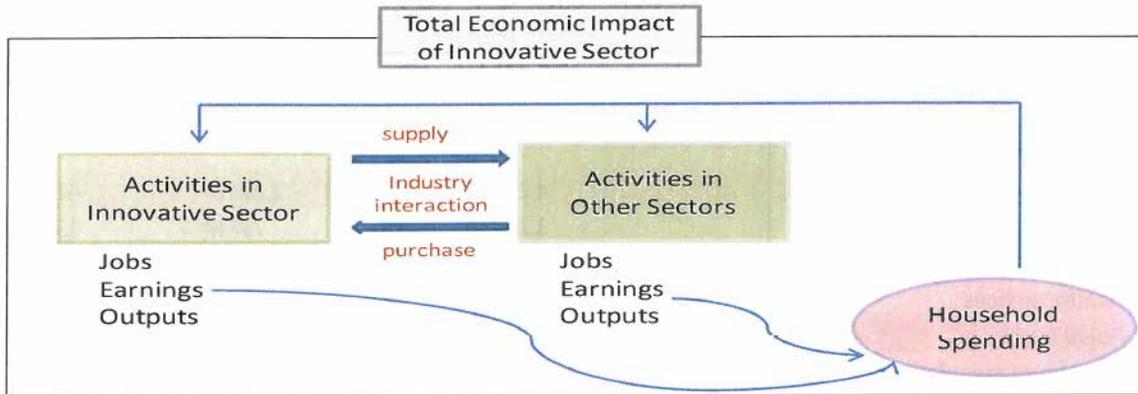
In this report these featured companies are grouped under these emerging technology sectors:

- Aerospace and Space Science
- Agricultural Biotechnology and Agribusiness
- Biotechnology and Biomedical Technology
- Information and Communications Technology and Cybersecurity
- Ocean Science and Technology
- Photonics and Sensor Technologies
- Renewable Technologies

The diversity of innovative technologies and their application in providing solutions to a wide array of problems and opportunities is promising. A number of these companies are commercializing research that was developed at the University of Hawai'i. This underscores the importance of continued support for research and discovery in the lab and the creation and development of capital funding, incubator and accelerator program support for early stage innovation companies.

IMPACT OF HAWAI'I'S INNOVATION ECONOMY

The impacts of the innovation economy (as a traded economy) are larger than the direct job and output impact of its activities. Intra- and inter-industry purchases of inputs that are related to the outputs and increased household spending create a larger impact on the overall economy.



In their 2012 study on the innovative sector¹⁸ in Hawai'i, DBEDT estimated the total impact of the innovation economy on Hawai'i's economic output to be almost \$16 billion in 2012. This represented 13.7 percent of the state's estimated economic output. The sector generated an estimated \$9.4 billion GDP impact accounting for 13.3 percent of total estimated GDP in 2012.¹⁹

	Impact ¹ of Innovative Sector on the Economy	
	Total Impact	% of total economy
Output	\$15,900M	13.7%
GDP	\$9,360M	13.3%
Total Job	118,300	13.8%
Earnings	\$5,400M	14.2%
State Tax	\$940M	15.1%

1. The estimated impacts include direct, indirect, and induced impacts of Innovative Sector

Including direct, indirect and induced impact the innovation economy accounted for an estimated 13.8 percent of total jobs (118,300), 14.2 percent of labor earnings (\$5.4 billion) and 15.1 percent of total tax revenue (\$940 million).²⁰

18 Note that the DBEDT study (2012) uses a broader range of sub-sector industries than that used in this Innovation Assets report (2014).

19 DBEDT, The Innovation Sector in Hawai'i, 2013, pg. 17. Data from ITIF (2012); accessed October 9, 2014.

20 Ibid.

Jobs in Hawai'i's Innovation Sector



Jobs in Hawai'i's Innovation Sector

In the state's innovation economy, the total number of jobs including extended proprietors is nearly 65,000. If extended proprietors are excluded, the total is approximately 44,000 or 6.5 percent of the total number of civilian workers in Hawai'i's economy in 2013.

The core tech sector accounted for almost half of Hawai'i's innovation economy jobs in 2013 (excluding extended proprietors) and included 1,552 establishments or almost 40 percent of the state's innovation economy establishments. When extended proprietors are included, the core tech sector accounts for one-third of the number of extended proprietors in the innovation economy and just over 42 percent of the jobs.

The peripheral tech sector accounted for one-third of Hawai'i's innovation economy jobs in 2013 (excluding extended proprietors) and included 1,156 establishments or almost 30 percent of the state's innovation economy establishments. When extended proprietors are included, the peripheral tech sector accounts for 10 percent of the number of extended proprietors in the innovation economy and 25 percent of the jobs.

The creative sector accounted for more than 20 percent of Hawai'i's innovation economy jobs in 2013 (excluding extended proprietors) and included 1,284 establishments or almost one-third of the state's innovation economy establishments. The creative sector accounts for almost 60 percent of the number of extended proprietors in the innovation economy and one-third of the jobs, when extended proprietors are included.

The breakdown of the "core technology," "peripheral tech" and "creative sectors" are shown in the table below.

Hawai'i Innovation Economy	Number of Jobs excluding Extended Proprietors	Jobs as a Percent of Total Innovation Economy Jobs	Number of Extended Proprietors	Extended Proprietors as a Percent of Total Innovation Economy EPs	Number of Jobs including Extended Proprietors	Jobs incl. EPs as a Percent of Total Innovation Economy Jobs incl. EPs	Number of Establishments	Number of Establishments as Percent of Total Innovation Economy Establishments	EP Ratio
Core Tech Sector	20,557	46.8%	6,703	32.6%	27,260	42.3%	1,552	38.9%	0.33
Peripheral/Facilitator Tech Sector	14,039	31.9%	1,987	9.7%	16,026	24.9%	1,156	29.0%	0.14
Creative Sector	9,350	21.3%	11,852	57.7%	21,202	32.9%	1,284	32.2%	1.27
Total Innovative Economy	43,946	100.0%	20,542	100.0%	64,488	100.0%	3,992	100.0%	0.47

The following table shows the number of jobs both excluding and including extended proprietors and the number of establishments by industry sector grouping. If one considers the innovation economy industry groups while excluding the extended proprietors, the industry groups accounting for the greatest number of jobs are communications and IT technology (6,140), engineering services (5,933), U.S. federal (STEM-related jobs, 5,841), software (4,194) and life sciences (biomedical, biotechnology, pharmaceuticals and chemicals, 3,987).

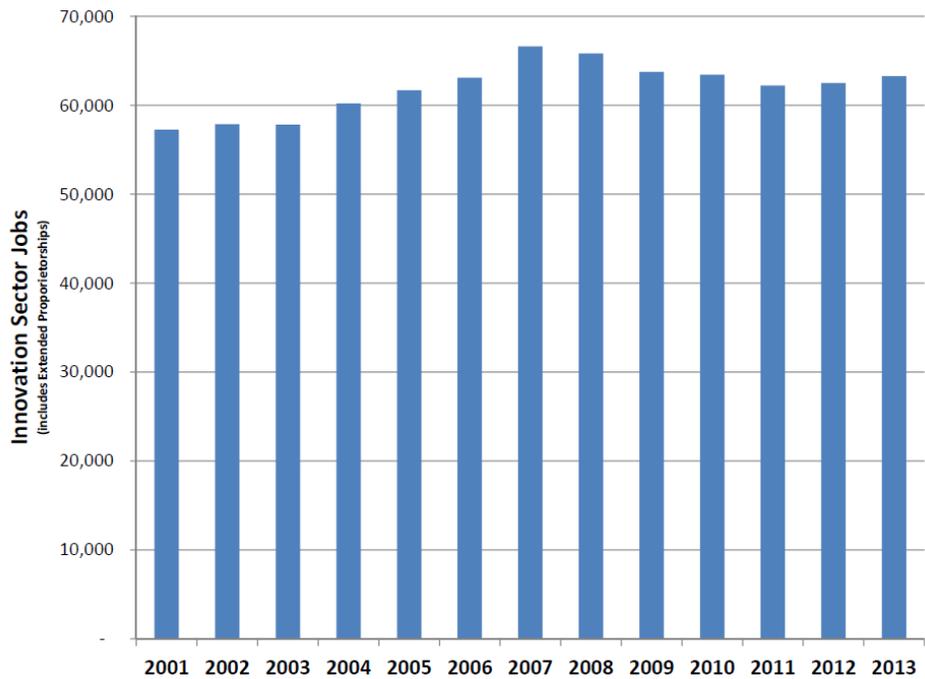
If extended proprietors are included in the job totals, the performing arts and related creative sectors with their relatively high percentage of extended proprietors come to the fore with 9,345 jobs. The same is true for commercial physical research and scientific and technical/non-technical services sector with 7,221 jobs including extended proprietors.

HAWAI'I'S INNOVATION ECONOMY								
Industry Sector Grouping	Number of Jobs excluding Extended Proprietors	Jobs as a Percent of Total Innovation Economy Jobs	Number of Extended Proprietors	Extended Proprietors as a Percent of Total Innovation Economy EPs	Number of Jobs including Extended Proprietors	Jobs incl. EPs as a Percent of Total Innovation Economy Jobs incl. EPs	Number of Establishments	Number of Establishments as Percent of Total Innovation Economy Establishments
Performing Arts & Related Creative	3,342	7.6%	6,003	29.2%	9,345	14.5%	247	6.2%
Communications Technology & Information Services	6,140	14.0%	1,107	5.4%	7,247	11.2%	300	7.5%
Commercial physical research/Scientific & Technical & Non-Technical Services	2,786	6.3%	4,435	21.6%	7,221	11.2%	227	5.7%
Engineering Services	5,933	13.5%	665	3.2%	6,598	10.2%	718	18.0%
U.S. Federal (STEM jobs only)	5,841	13.3%	-	0.0%	5,841	9.1%	-	0.0%
Other Business, Market and Technical Consulting Services	2,461	5.6%	2,937	14.3%	5,398	8.4%	558	14.0%
Software	4,194	9.5%	912	4.4%	5,106	7.9%	809	20.3%
Marketing & Related Services	2,163	4.9%	1,906	9.3%	4,069	6.3%	322	8.1%
Energy	2,311	5.3%	105	0.5%	2,416	3.7%	35	0.9%
Biomedical Products	1,993	4.5%	29	0.1%	2,022	3.1%	78	2.0%
Sports and Active Lifestyle	1,237	2.8%	784	3.8%	2,021	3.1%	95	2.4%
Biotechnology, Pharmaceuticals and Chemicals	1,994	4.5%	14	0.1%	2,008	3.1%	53	1.3%
Design Services	508	1.2%	1,077	5.2%	1,585	2.5%	122	3.1%
Audio & Visual Media Production & Distribution	1,522	3.5%	18	0.1%	1,540	2.4%	168	4.2%
Environmental Technology	503	1.1%	279	1.4%	782	1.2%	71	1.8%
Computer & Electronics	495	1.1%	195	0.9%	690	1.1%	89	2.2%
Business and Professional Associations	359	0.8%	47	0.2%	406	0.6%	91	2.3%
Defense and Aerospace	164	0.4%	29	0.1%	193	0.3%	9	0.2%
Total Innovative Economy	43,946	100.0%	20,542	100.0%	64,488	100.0%	3,992	100.0%

Hawai'i's innovation sectors have shown modest growth since 2001, with the total innovation economy expanding from 57,250 jobs in 2001 to 63,300 in 2013. That .84 percent annual growth was less than the 1.26 percent growth of the rest of Hawai'i's economy.

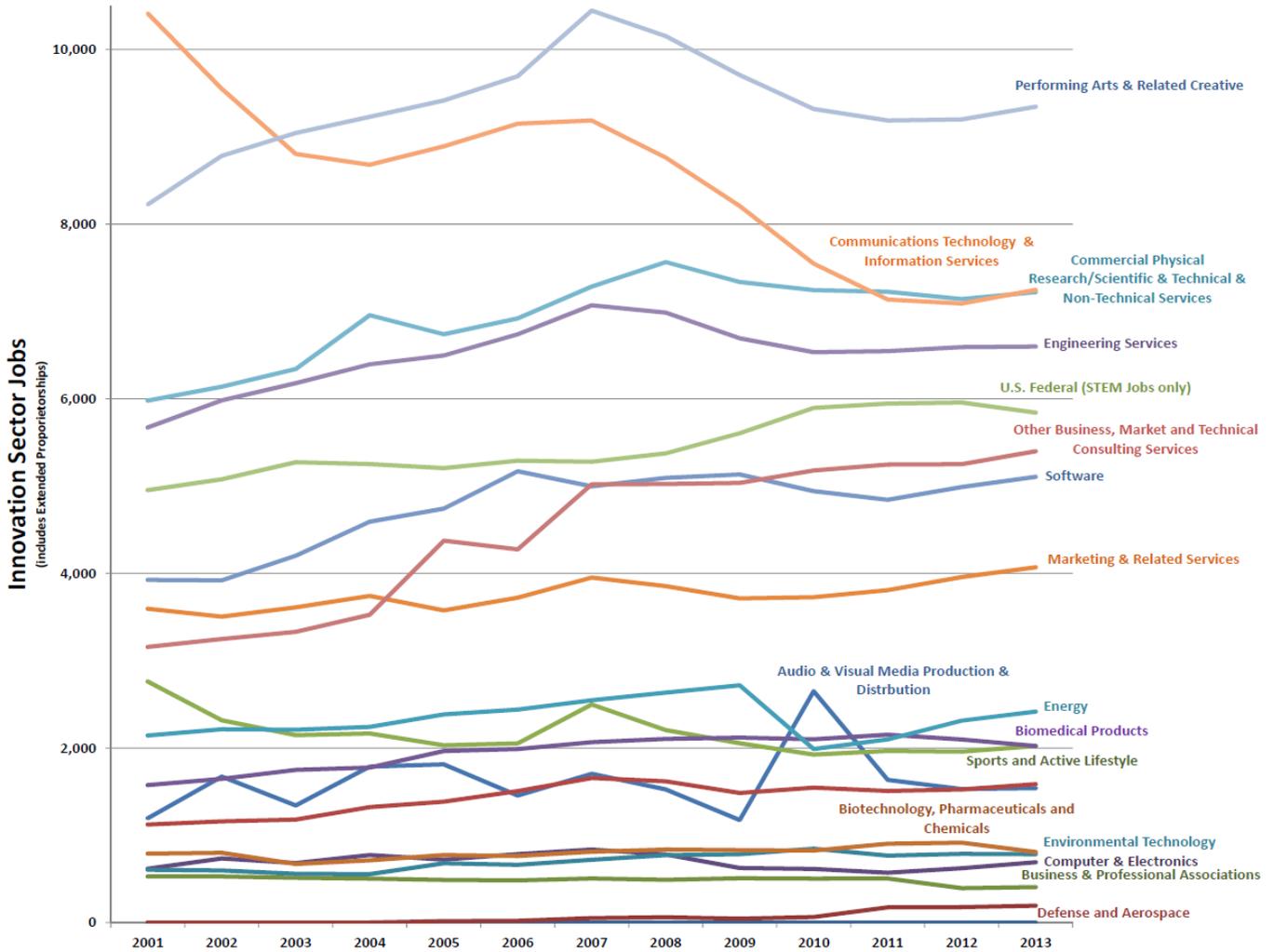
The following chart shows the change in jobs²¹ from 2001 through 2013 for the sectors of the innovation economy.

*Note: figures excluded corn farming, which accounted for 1,200 jobs in 2013 bringing the total number of jobs in Hawai'i's innovation economy to 64,488.



21 The employment figures include extender proprietors.

JOBS IN HAWAI'I'S INNOVATION SECTOR – BY INDUSTRY SECTOR

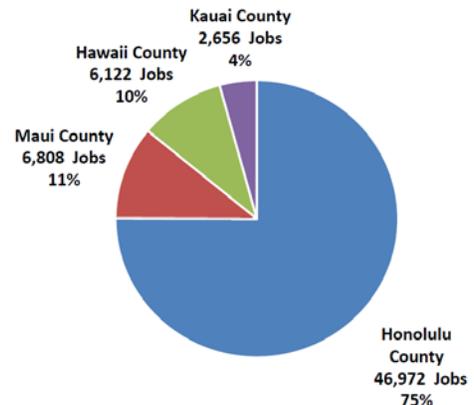


The creative sector is large in terms of the number of jobs, particularly in the performing arts. The communication technology and IT sector has shown a drop in the number of jobs since 2001. Commercial research and technical services has seen a steady rise in the number of jobs over the period as has business, market and technical consulting services and the software sectors. The energy sector showed a modest increase in the number of jobs up to 2009 before dropping in 2010. The number employed in the energy sector as grown steady between 2010 and 2013. The biomedical products sector showed modest growth as did design services. The remaining sectors showed relatively flat growth over the past decade.

INNOVATION ECONOMY EMPLOYMENT BY COUNTY

The majority of the jobs in Hawai'i's innovation economy are located in Honolulu County (75 percent). Maui County accounts for more than 6,800 jobs (11 percent), Hawai'i County 6,140 jobs (10 percent) and Kaua'i County 2,662 (four percent).

The tables and charts below shows the number of jobs (including extended proprietors), number of establishments and number of extended proprietors for each county.

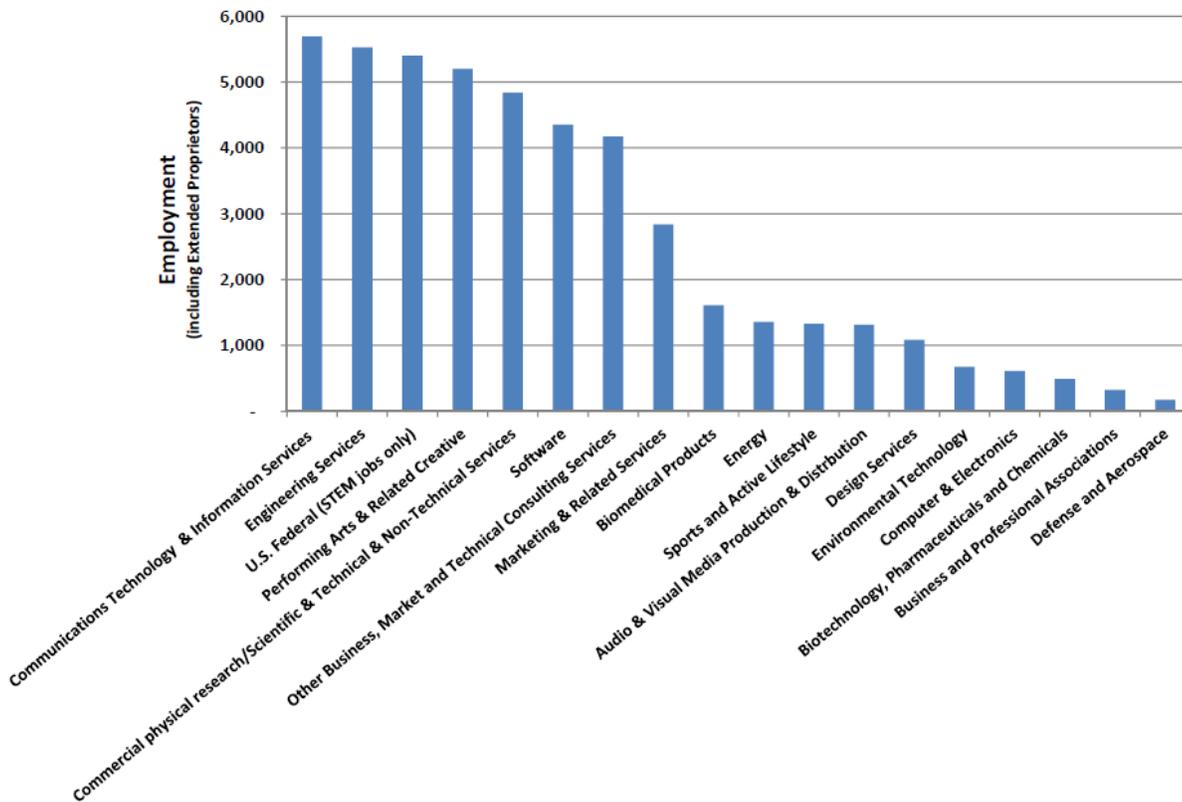


Honolulu County

HONOLULU COUNTY				
	Number of Jobs (incl. Extended Proprietors)	Number of Jobs as Percent of Total Innovation Economy Jobs	Number of Establishments	Number of Extended Proprietors
CORE TECHNOLOGY	20,187	32.1%	1,156	4,489
PERIPHERAL/FACILITATOR TECHNOLOGY	12,825	20.4%	827	1,338
CREATIVE SECTOR	13,960	22.2%	895	7,581
Total	46,972	74.7%	2,877	13,409

As one would expect given the relative size of Honolulu County, it accounts for most of the technology jobs and a large proportion of the creative sector jobs. The 74 percent share of total innovation jobs for Honolulu is the same as its share of the State's total non-farm job count. Communications technology and information services, engineering, and U.S. federal (STEM), performing arts and related creative, and commercial physical research and technical services account, software, and consulting services sectors account most of the innovation economy jobs. Marketing services (peripheral tech) account for almost 3,000 jobs. The biomedical products sector is several times larger than the more embryonic biotechnology sectors.

HONOLULU COUNTY JOBS BY INDUSTRY SECTOR

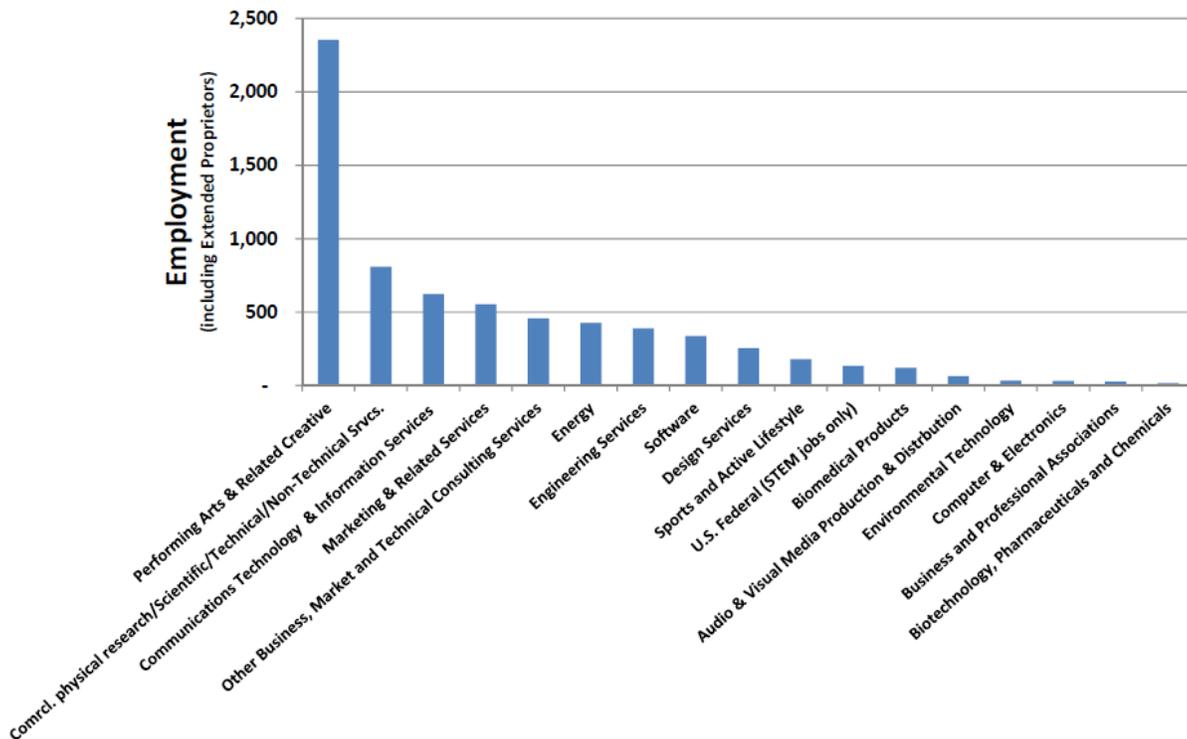


Maui County

MAUI COUNTY				
	Number of Jobs (incl. Extended Proprietors)	Number of Jobs as Percent of Total Innovation Economy Jobs	Number of Establishments	Number of Extended Proprietors
CORE TECHNOLOGY	1,892	3.0%	143	750
PERIPHERAL/FACILITATOR TECHNOLOGY	1,196	1.9%	128	188
CREATIVE SECTOR	3,720	5.9%	210	2,005
Total	6,808	10.9%	481	2,943

Maui County accounts for almost 11 percent of the state’s innovation economy jobs. The performing arts and related creative sectors account for a substantial percentage of the related innovation economy jobs in the county. Research, technical consulting and marketing services industries sectors comprise the next tier of industries ranked by jobs. Maui County has several hundred engineering, software, design services and sports and active lifestyle jobs as well.

MAUI COUNTY JOBS BY INDUSTRY SECTOR

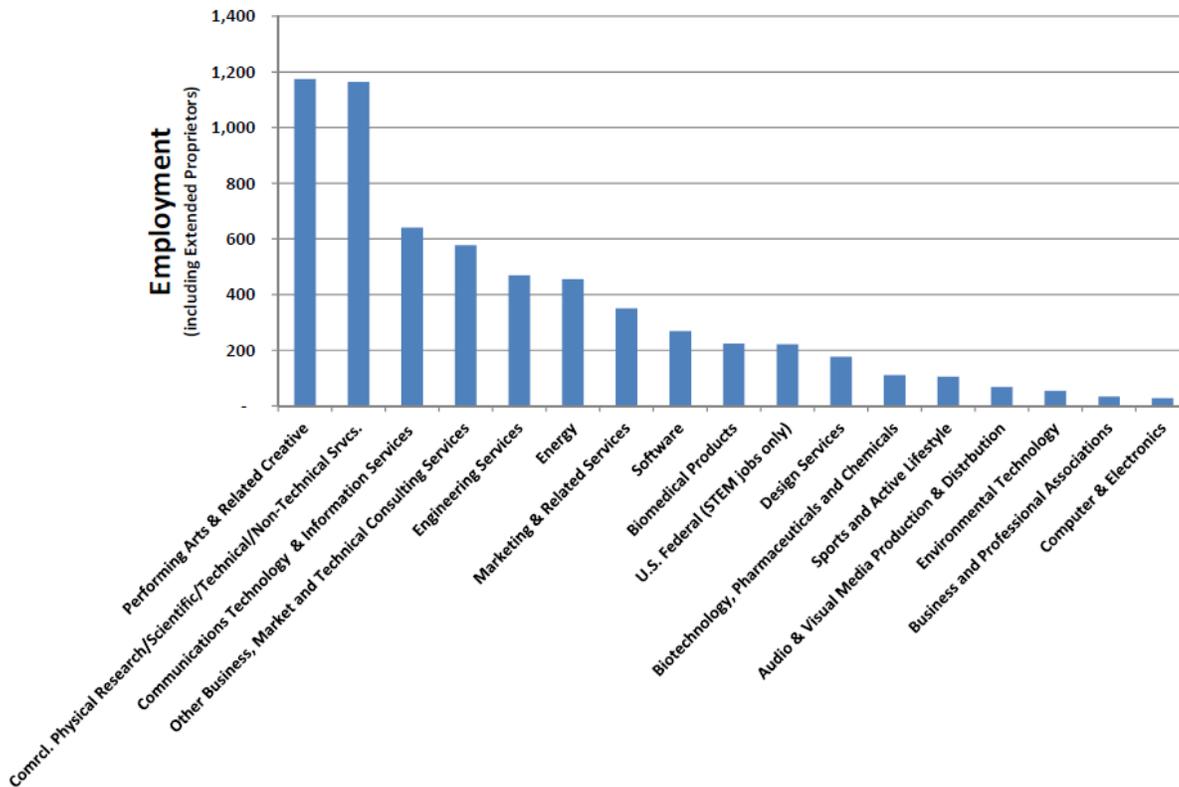


Hawai'i County

HAWAII COUNTY				
	Number of Jobs (incl. Extended Proprietors)	Number of Jobs as Percent of Total Innovation Economy Jobs	Number of Establishments	Number of Extended Proprietors
CORE TECHNOLOGY	2,488	4.0%	160	922
PERIPHERAL/FACILITATOR TECHNOLOGY	1,397	2.2%	126	269
CREATIVE SECTOR	2,237	3.6%	119	1,387
Total	6,122	9.8%	405	2,578

Hawai'i County accounts for almost 10 percent of the state's innovation economy jobs, and performing arts and related creative sectors ranked as the largest employers of related innovation economy jobs in the county. Commercial research and scientific technical services was the second largest sector in terms of innovation jobs, nearly equal to the performing arts sector. Communications and information services jobs made up the third largest innovation sector in the county. Hawai'i County has several hundred engineering, energy, marketing services, software, and biomedical sector jobs as well. Over one hundred biotech/pharma/chemical sector jobs are found in the county as well as a similar number of sports and active lifestyle sector jobs.

HAWAII COUNTY JOBS BY INDUSTRY SECTOR

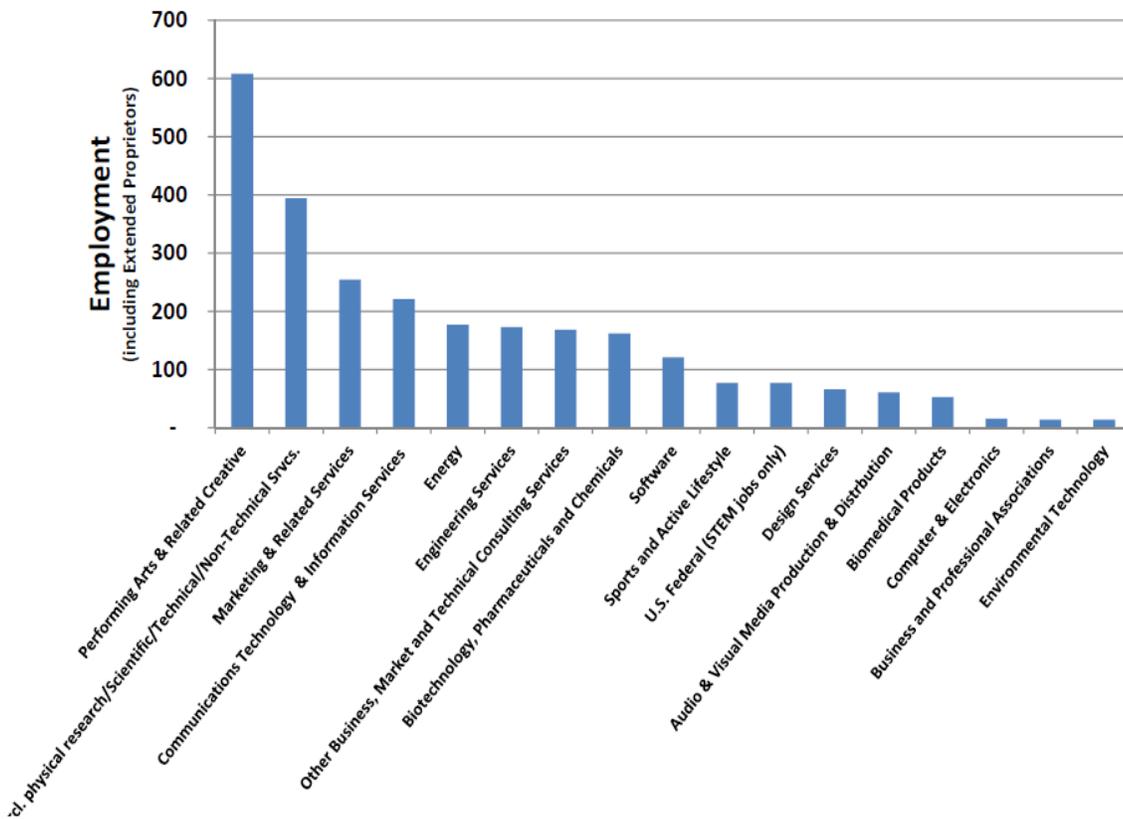


Kaua'i County

KAUAI COUNTY				
	Number of Jobs (incl. Extended Proprietors)	Number of Jobs as Percent of Total Innovation Economy Jobs	Number of Establishments	Number of Extended Proprietors
CORE TECHNOLOGY	1,051	1.7%	66	327
PERIPHERAL/FACILITATOR TECHNOLOGY	463	0.7%	60	109
CREATIVE SECTOR	1,142	1.8%	62	574
Total	2,656	4.2%	188	1,010

Kaua'i County accounts for more than four percent of the state's innovation economy jobs. Again, performing arts and related creative sectors ranked as the largest employers of related innovation economy jobs in the county. Commercial research and scientific technical services was the second largest sector in terms of innovation jobs, nearly equal to the performing arts sector. Marketing related services jobs ranked third and communications and information services jobs made up the fourth largest innovation sector in the county. Kaua'i County had just under 200 energy, engineering, business and technical consulting and biotechnology sector jobs each. Over one hundred software sector jobs are found in the county as well.

KAUAI COUNTY JOBS BY INDUSTRY SECTOR



CORE TECH SECTORS

Industry Sector Grouping	CORE TECH							
	Number of Jobs excluding Extended Proprietors	Jobs as a Percent of Total Innovation Economy Jobs	Number of Extended Proprietors	Extended Proprietors as a Percent of Total Innovation Economy EPs	Number of Jobs including Extended Proprietors	Jobs incl. EPs as a Percent of Total Innovation Economy Jobs incl. EPs	Number of Establishments	Number of Establishments as Percent of Total Innovation Economy Establishments
Commercial physical research/Scientific & Technical & Non-Technical Services	2,412	5.5%	4,428	21.6%	6,840	10.6%	196	4.9%
U.S. Federal (STEM jobs only)	5,841	13.3%	-	0.0%	5,841	9.1%	-	0.0%
Software	4,049	9.2%	726	3.5%	4,775	7.4%	763	19.1%
Energy	2,311	5.3%	105	0.5%	2,416	3.7%	35	0.9%
Biotechnology, Pharmaceuticals and Chemicals	1,994	4.5%	14	0.1%	2,008	3.1%	53	1.3%
Other Business, Market and Technical Consulting Services	812	1.8%	594	2.9%	1,406	2.2%	148	3.7%
Sports and Active Lifestyle	1,071	2.4%	279	1.4%	1,350	2.1%	80	2.0%
Environmental Technology	503	1.1%	279	1.4%	782	1.2%	71	1.8%
Computer & Electronics	495	1.1%	195	0.9%	690	1.1%	89	2.2%
Engineering Services	552	1.3%	28	0.1%	580	0.9%	63	1.6%
Biomedical Products	340	0.8%	13	0.1%	353	0.5%	38	1.0%
Defense and Aerospace	164	0.4%	29	0.1%	193	0.3%	9	0.2%
Communications Technology & Information Services	13	0.0%	13	0.1%	26	0.0%	7	0.2%
Total Innovative Economy	20,557	46.8%	6,703	32.6%	27,260	42.3%	1,552	39%

PERIPHERAL/FACILITATOR TECH SECTORS

Industry Sector Grouping	PERIPHERAL TECH							
	Number of Jobs excluding Extended Proprietors	Jobs as a Percent of Total Innovation Economy Jobs	Number of Extended Proprietors	Extended Proprietors as a Percent of Total Innovation Economy EPs	Number of Jobs including Extended Proprietors	Jobs incl. EPs as a Percent of Total Innovation Economy Jobs incl. EPs	Number of Establishments	Number of Establishments as Percent of Total Innovation Economy Establishments
Communications Technology & Information Services	6,127	13.9%	1,094	5.3%	7,221	11.2%	245	6.1%
Engineering Services	5,381	12.2%	637	3.1%	6,018	9.3%	655	16.4%
Biomedical Products	1,653	3.8%	16	0.1%	1,669	2.6%	40	1.0%
Business and Professional Associations	359	0.8%	47	0.2%	406	0.6%	91	2.3%
Commercial physical research/Scientific & Technical & Non-Technical Services	374	0.9%	7	0.0%	381	0.6%	31	0.8%
Total Innovative Economy	14,039	31.9%	1,987	9.7%	16,026	24.9%	1,156	29.0%

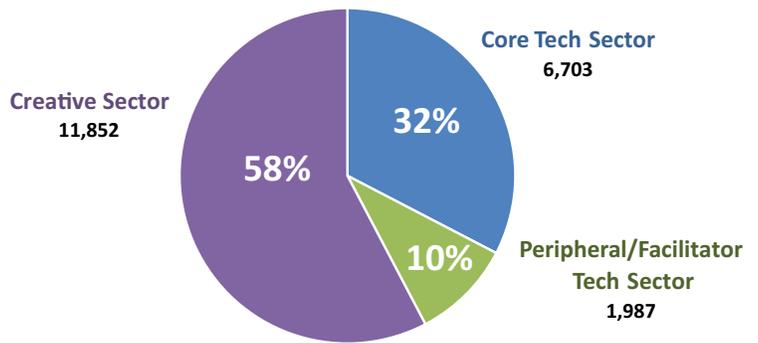
CREATIVE SECTORS

Industry Sector Grouping	CREATIVE							
	Number of Jobs excluding Extended Proprietors	Jobs as a Percent of Total Innovation Economy Jobs	Number of Extended Proprietors	Extended Proprietors as a Percent of Total Innovation Economy EPs	Number of Jobs including Extended Proprietors	Jobs incl. EPs as a Percent of Total Innovation Economy Jobs incl. EPs	Number of Establishments	Number of Establishments as Percent of Total Innovation Economy Establishments
Performing Arts & Related Creative	3,342	7.6%	6,003	29.2%	9,345	14.5%	247	6.2%
Marketing & Related Services	2,163	4.9%	1,906	9.3%	4,069	6.3%	322	8.1%
Other Business, Market and Technical Consulting Services	1,649	3.8%	2,343	11.4%	3,992	6.2%	410	10.3%
Design Services	508	1.2%	1,077	5.2%	1,585	2.5%	122	3.1%
Audio & Visual Media Production & Distribution	1,522	3.5%	18	0.1%	1,540	2.4%	168	4.2%
Sports and Active Lifestyle	166	0.4%	505	2.5%	671	1.0%	15	0.4%
Total Innovative Economy	9,350	21.3%	11,852	57.7%	21,202	32.9%	1,284	32.2%

As one might expect the creative sector accounts for the largest number of extended proprietors. This is likely due to the inclusion of independent performing artists as one of the sub-sectors. The creative sector accounts more than half of the extended proprietor jobs in the innovation economy.

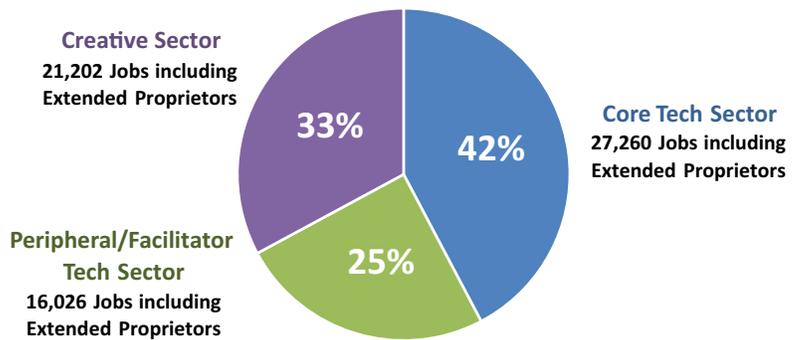
HAWAI'I INNOVATION ECONOMY – EXTENDED PROPRIETORS (20,542 JOBS)

The creative sector accounts for more than one-third of the state's innovation economy, when extended proprietors are included. The peripheral/facilitator tech sector has a significantly smaller number of extended proprietors than both the core tech and creative sectors, and accounts for 25 percent of the overall innovation economy in Hawai'i.



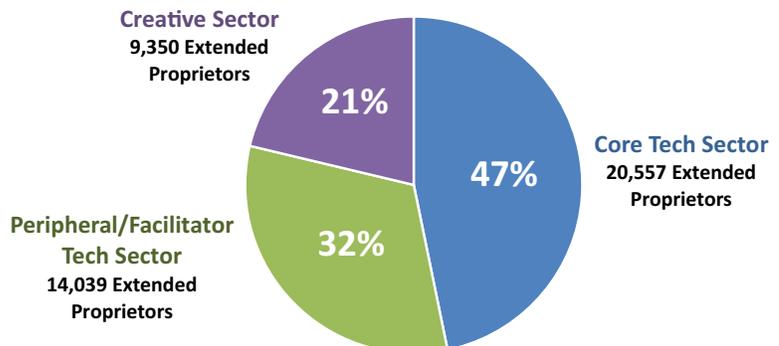
HAWAI'I INNOVATIVE ECONOMY – TOTAL JOBS INCLUDING EXTENDED PROPRIETORS (64,488 JOBS)

If extended proprietors are not included, the core technology sectors comprise the majority of the innovation economy.



HAWAI'I INNOVATION ECONOMY – TOTAL JOBS EXCLUDING EXTENDED PROPRIETORS (43,946 JOBS)

If extended proprietors are not included, the core technology sectors comprise the majority of the innovation economy.



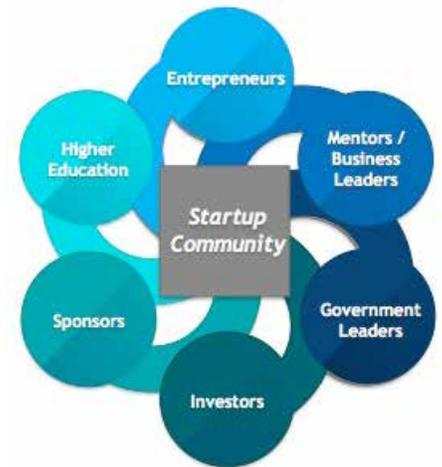
Start-Up Activity in Hawai‘i



Entrepreneurial Development Programs

New company creation, or start-up activity, is an important part of a region's economic growth engine. These are companies that can nimbly innovate and commercialize new technologies. They tend to have around two employees at their start, but with sufficient capital infusion and a skillful management team can scale their businesses quickly. This creates both essential job growth as well as increasing the state's tax base. In the innovation economy, establishing a robust pipeline of these companies is important to a regions' competitiveness.

As is noted throughout this report a thriving entrepreneurial ecosystem requires the collaborative interaction among a number of different parts and constituents. Higher education can provide skilled workers and emerging entrepreneurs. These entrepreneurs can benefit greatly from mentoring by local business leaders. Government leaders need to be made aware of the importance and interdependence of the elements of a successful innovation economy, and provide support to grow new companies. Investors are a key element to help startups cross the "Valley of Death" as they seek to prove their business models in the marketplace. Sponsors may include organizations that support groups that focus on assisting startups and early stage companies such as incubators, accelerators and industry trade organizations.



ENTREPRENEURIAL ECOSYSTEM

INITIATIVES AND INVESTMENT FUNDS

Hawai'i Angels

Hawai'i Angels was founded by Robert Robinson PhD, a former Harvard Business School professor and nationally recognized expert on angel investing. Through his leadership, the Hawai'i Angels network has become highly successful and well recognized in the Honolulu business community and beyond. Since its founding in February 2002, the member angels have invested more than \$30 million in over 60 companies.

The organization provides a forum for its members to review investment presentations and share opinions about these opportunities. This forum also allows for networking with professionals of various backgrounds and exploring new opportunities in Hawai'i. The group has attracted high net worth individuals from a variety of professions including chief executives, attorneys, physicians, and scientists, who share an enthusiasm for entrepreneurship. The number of members has grown to approximately 80.

Hawai'i Venture Capital Association

Since its founding in 1988, the Hawai'i Venture Capital Association (HVCA) has stood as a nexus for Hawai'i entrepreneurship, capital foundation, and networking opportunities. Fostering entrepreneurial development through education, exposure to excellent speakers and introductions to key members of the business community continues to be the association's goal as it moves forward in growing a vibrant and successful venture community.

HVCA hosts a monthly luncheon at the Plaza Club that provides guests with a host of excellent speakers discussing the latest trends and developments in Hawai'i's growing venture capital industry. HVCA also hosts Hawai'i's annual Entrepreneur of the Year Award ceremony and the Venture Capital Deal of the Year Award ceremony where both entrepreneurs and companies are honored for their achievements in Hawai'i's venture community.

HI Growth Initiative

The HI Growth Initiative is a comprehensive investment program that represents a new approach to re-invigorate state efforts to fuel an innovation economy. The HI Growth Initiative, overseen by the Hawai'i Strategic Development Corporation, engages with the private sector to startup and to grow creative and innovative businesses that can create high-wage jobs for Hawai'i.

The objective of the HI Growth Initiative is to develop investment capacity in Hawai'i along the continuum of financing for startups: commercialization, business formation, and early stage growth. This effort will allow Hawai'i to leverage the research funds invested in Hawai'i and the respective Hawai'i Targeted Investment Programs (HiTIP) established by Hawai'i's key institutional investors, the Employees Retirement System and Kamehameha Schools.

HSDC was allocated \$13.2 million from the U.S. Department of the Treasury's Small Business Credit Initiative (SSBCI). The State Legislature appropriated \$2 million for the Launch Akamai Venture Accelerator Program (LAVA) and \$6 million for the HI Growth Initiative. HSDC has combined these funding sources under the HI Growth Initiative to

implement a comprehensive investment program that generates a critical mass of startup activity that will attract private capital to invest in Hawai'i. Earlier this year, Hawai'i committed to giving \$4.5 million to a startup venture, called Startup Capital Ventures II, between the state and California that will provide investment capital to help Isle technology companies grow in size.

The HI Growth Initiative has already invested in Honolulu-based venture accelerator, Blue Startups, which provides pre-seed capital to startups, and Maui-based mbloom Fund I, which provides expansion capital. These funds, together with the University of Hawai'i research commercialization fund, UPSIDE Fund II, create a pipeline of companies for prospective investments by Startup Capital Ventures.

The increase in activity in the innovation ecosystem, spurred by HI Growth Initiative investments, has led to the community's adoption of "Startup Paradise" to brand Hawai'i as an innovation hub. Grass roots efforts have resulted in Startup Weekend events, pitch events, co-working spaces, and other efforts to increase entrepreneurial capacity.

mbloom

mbloom is Hawai'i's first dedicated early stage technology investment fund. mbloom was created to fill the gap between seed and follow on financing without leaving the state. It seeks to identify and nurture Hawai'i based entrepreneurs, thereby helping to develop and grow Hawai'i's technology infrastructure. mbloom's first fund, mbloom1, is a \$10 million fund that closed at the beginning of 2014.

The Maui-based mbloom will target early-stage Hawai'i technology companies, including those that are supported by the state's HI Growth Initiative programs such as Blue Startups, Hawai'i's first technology venture accelerator. The fund is being managed by Maui entrepreneur Arben Kryeziu and his partner, Nick Bicanic, in California.

Typical mbloom investments range in value from \$50,000 to \$250,000. mbloom1 funds are supported by participation by the Hawai'i Technology Development Corporation (HTDC) and private investor capital. Working with a unique network of specialized business consultants and professional services providers, mbloom helps entrepreneurs secure investment, build their products, create customer acquisition and go-to-market strategies, and achieve milestones in their professional journeys.

MEDB Ke Alahele Education Fund

In 2006, the Maui Economic Development Board (MEDB) created the MEDB Ke Alahele Education Fund as a grant-making vehicle which channels community investment that enhance STEM education and broaden career pathways in the Maui County. Educators, students, schools and other organizations may apply for funds to support innovations in STEM education. Eligible grant areas include developing new curriculum, integrating culture and science, internships, apprenticeships, professional development, and equipment to enhance preparation in STEM fields. As of 2014, the Fund has touched over 30,300 students and teachers in Maui County.

UPSIDE Fund I and II

The UPSIDE Fund provides seed venture capital to support the University of Hawai'i's strategy to diversify the state's economy through the aggressive commercialization of its innovative technology to a third economic engine along with tourism and military spending. The fund is managed by the UH Foundation in conjunction with the Hawai'i Strategic Development Corporation and the Research Corporation of the University of Hawai'i (RCUH).

BUSINESS ACCELERATORS, INCUBATORS AND CO-WORKING SPACES

Blue Startups

Blue Startups is a venture accelerator founded by Hawai'i-based entrepreneur Henk Rogers that aims to stimulate economic growth in Hawai'i and create new business opportunities in the Asia-Pacific Region. The company, which provides investment capital and mentorship to startup companies in Hawai'i, accepts up to 10 companies for each cohort, in the areas of Internet, software, mobile, gaming and e-commerce technology. Each participant receives up to \$70,000 in investment capital and access to more than \$500,000 in mentorship and direct services. Workspace for each founding team of up to three people is provided at Blue Startups' office. In exchange for the capital and in-kind services provided, Blue Startups takes an equity stake in each company. Blue Startups has a network of more than 70 mentors who help the startups in the program and obtain funding from the state and private investors.

Box Jelly

BoxJelly is Hawai'i's first co-working space, bringing together a community of entrepreneurs, creatives, freelancers and independents, and giving them a better place to work. The shared workspace facilitates collaboration, knowledge-sharing, and built-in networking opportunities. Many of the casual office conversations lead to new and better projects. BoxJelly hosts gatherings of up to 60 people, from workshops to conferences, Startup Weekend Honolulu to gathering showcases. BoxJelly has HI Capacity as an anchor tenant, a hackerspace that provides a space for the Honolulu community to gather, create and build.

Cellular Bioengineering Inc.

Cellular Bioengineering Inc. (CBI) is a sister company to SKAI Ventures and is a Hawai'i-based accelerator of disruptive technologies with biomedical applications. CBI searches for innovative and ingenious ideas which it can nurture and grow into mature products that will change the way the world operates. Cellular Bioengineering Inc. is home to EYE-GENIX Artificial Cornea. There are currently 10 million people worldwide with corneal blindness due to the lack of adequate organ donors. CBI has the worldwide license for the development of a bio-integrating poly-

mer corneal substitute which aims to return the gift of sight to these people. Currently in pilot clinical trials, the initial cohort of patients shows promising results at preliminary follow up.

Creative Lab

Creative Lab is a gathering place in Hawai'i where film, music and technology come together to offer local and visiting filmmakers, composers and innovators from around the world, the chance to learn and collaborate on new and exciting creative content. It runs the Hawai'i International Film Festival Creative Lab Writers Accelerator and the Broadband Accelerator, which identifies diverse creative professionals to provide opportunities to deepen their relationship with their craft, the ground/real life coaching on the business of creating content, producing it, marketing and monetizing it on the internet, and create a plan to assist them in taking their next steps in their professional careers.

Designer-in-Residence Program

Hawai'i's DIR program is organized by DBEDT's HI Growth Initiative that targets high-growth and high-potential entrepreneurs. The goal is to institute a "boot camp", with brainstorming and discussion sessions, mentoring and access to capital programs for fashion related companies to grow the next Tommy Bahama, Pink Martini or Diesel – but from Hawai'i.

Energy Excelerator

The Energy Excelerator is a startup program born in January 2013, dedicated to helping solve the world's energy challenges, starting in Hawai'i. They help innovative companies succeed in Hawai'i and the Asia Pacific with funding, strategic relationships, and a vibrant ecosystem. The \$30M program is funded by the U.S. Department of Energy and the U.S. Office of Naval Research and operates as a project of the Pacific International Center for High Technology Research (PICHTR).

Founder Institute (Honolulu)

The Founder Institute is the world's largest entrepreneur training and startup launch program, helping aspiring founders across the globe build enduring technology companies. Based in Silicon Valley and with chapters across 33 countries including Hawai'i, the Founder Institute has helped

launch over 1,129 companies in five years. The company's mission is to "Globalize Silicon Valley" and build sustainable startup ecosystems that will create one million new jobs worldwide. Entrepreneurs go through a four-month, part-time program, where they launch a company through structured training course, practical business-building assignments, and expert feedback.

GVS Transmedia Accelerator

The GVS Transmedia Accelerator is a new accelerator program for businesses across multiple creative media platforms in the entertainment sector. Based at Honua Studios on the Big Island, the accelerator will accept six entrepreneurs each year into the intensive, hands-on program and provide them with the seed capital needed to develop an investable business. The program's goal is to successfully raise the necessary follow-on financing for each business. A key aspect of the program is the ability to work with other entrepreneurs in a shared production workspace in Kailua-Kona and to work with leading entertainment industry executives and experts as coaches and mentors. Entrepreneurs that qualify can have ideas from films, to direct-to-web series, to interactive eBooks. An investment of \$50,000 will be provided to each entrepreneur selected in exchange for 10 percent equity in the business.

The accelerator is funded by a \$1.2 million commitment from the state through the HSDC's HI Growth Initiative and will be used to match monies provided by the County of Hawai'i in support of the program. An addition, a private investor group will co-invest in a \$1 million investment program with HSDC to provide seed capital to companies accepted into the GVS Transmedia Accelerator.

Hawai'i Innovation Center at Hilo

Managed by HTDC, HICH is a general purpose business incubator. HICH assists clients in their business development by providing a wide range of business incubation facilities and services. The Center's strategic location also provides clients with immediate access to banking facilities, printers, federal offices, including a major post office facility, restaurants and shops. HICH is also located within minutes of Hilo International Airport, state and county agencies, the UH Hilo campus and the University Park of Science and Technology, which houses an array of multinational tenants.

Hawai'i Investment Ready

A project of the Kamehameha Schools and Social-Impact International, the Hawai'i Investment Ready program connects 14 Hawaiian social enterprises to combine with Hawai'ian worldview with best enterprise practices to create an impactful island enterprise. The social enterprises share their future vision, serve local, regional and global customers, and pioneer an emerging island impact ecosystem. Sectors include media/communication, food systems/ food security, community services, and land stewardship/renewal.

Hawai'i TechWorks

Hawai'i TechWorks is a co-working space to build a community of design and tech professionals to gather, create, and collaborate. The company organizes tech meetups regularly to watch emerging companies demo new ideas, discuss leading-edge technology topics, and build their networks to develop their businesses and ideas.

HiBEAM

HiBEAM, a not-for-profit organization, was created in 2000 to help launch and build high growth Hawai'i technology, biotechnology and life sciences companies by providing them expert professional advice and access to funding sources. Since then, the HiBEAM portfolio companies have raised over \$100 million in equity funding. Programs include a formal mentoring program, informal mentoring through forums, office hours and workshops, and a technology showcase to present the newest innovations from the technology and life science fields.

INNOVATE Hawai'i

INNOVATE Hawai'i is a program of the National Institute of Standards and Technology Manufacturing Extension Partnership (NIST MEP) administered by the High Technology Development Corporation (HTDC). INNOVATE Hawai'i acts as a general practitioner, and provides knowledge and helps local manufacturing companies meet various industry-specific needs. Assistance includes food processing, agribusiness, construction materials, management consulting, SBIR/ STTR grant assistance, electronics, metals, secondary wood, textile, biotech and many other industries.

Mānoa Innovation Center

The Mānoa Innovation Center (MIC) brings together the best of Hawai'i's intellectual and physical resources. MIC's primary role is

to serve as an incubator for new and early-stage technology companies. Tenants enjoy advanced 100Mb/s symmetric internet connectivity, state-of-the-art facilities and shared support services. MIC began its 20th year of operations in 2012, accelerating the growth of technology companies by providing business development services, synergistic and strategic partnerships, networking activities and professional marketing opportunities.

Maui Research & Technology Center

The Maui Research & Technology Center (MRTC) is a technology center and business incubator strategically located in Kihei, Maui, within the 415-acre Maui Research & Technology Park. Dedicated to supporting technology-oriented businesses, MRTC brings together a diversity of enterprises from industry niches as varied as astronomy and biotechnology. MRTC is home to startups, technology companies phasing in Maui operations, and compelling federal technology projects.

Pacific Asian Center for Entrepreneurship

Since its inception in 2000, the Pacific Asian Center for Entrepreneurship (PACE) at UH Mānoa's Shidler College of Business has grown to encompass over 15 programs to cultivate new entrepreneurs, encourage entrepreneurial thinking and spawn new businesses. Its programs have seamlessly integrated itself into a number of successful collaborative commercialization efforts between leading University entities, including the John A. Burns School of Medicine, University of Hawai'i Cancer Center, College of Tropical Agriculture and Human Resources and the College of Engineering.

At the same time, PACE has also evolved in to an effective training ground for future entrepreneurs and business leaders, and in the process, has developed into an invaluable link between the "town and gown" worlds of business and academia. Because of this link, PACE will play a key role in the University of Hawai'i's recent partnership with the local business community on the Hawai'i Innovation Initiative—an ambitious effort to help revitalize the state's economy through the successful commercialization of UH research.

The Center provides entrepreneurial/ commercialization education to faculty and student researchers accepted into XLR8UH, the University of Hawai'i's new proof of

concept center venture accelerator launched this past September. Business models, business plans and other entrepreneurial tools for success is offered by PACE.

Earlier this year, PACE launched a five-year initiative to raise \$2.5 million for new programs and a larger location within the college. The new facility will enable PACE to create a vibrant co-working space for entrepreneurial activity at UH, double the number of entrepreneurial programs it offers, introduce an entrepreneurial curriculum to other UH Mānoa colleges, train key faculty on current entrepreneurial pedagogy and establish a presence in Asia as a leader in entrepreneurial education.

SKAI Ventures

SKAI Ventures is a Hawai'i-based venture accelerator of disruptive technologies with biomedical and biodefense applications. SKAI Ventures, a hybrid of venture capital and technology accelerator, is focused on transforming novel and ingenious ideas into disruptive innovations and high growth companies with global impact. SKAI Ventures actively mentors and nurtures entrepreneurs and innovators from around the world. SKAI Ventures searches for innovative and ingenious ideas which it can nurture and grow into mature products that will change the way the world operates. It has brought forward suites of technology at varying stages of development which have favorably impacted health care and homeland security in our country.

Sultan Ventures

Sultan Ventures (SV) is a consulting firm offering services to entrepreneurs and investors. The company serves as a startup catalyst that provides pivotal resources via a network of experts and investors. Sultan Ventures works closely with innovative startups, providing the hands-on expertise and access to capital needed to accelerate growth, as well as with investors, performing the diligence necessary to make strategic investment decisions. Since 2009, SV has helped startups raise millions of dollars, providing the strategic direction, business development, and connections needed to succeed.

XLR8UH

The University of Hawai'i has achieved numerous accolades in research: from the cloning of green mice to the recent launch of a student-designed and built small satellite.

Building upon these achievements, UH now aims to transform its world-class research and talent into an equally viable commercial success.

XLR8UH is UH's first proof-of-concept venture accelerator. In a collaborative effort along with the Pacific Asian Center for Entrepreneurship (PACE) and the Office of Vice President for Research and Innovation, the mission of XLR8UH is to identify, fund, mentor and empower University of Hawai'i entrepreneurs with the skills, connections and expertise needed to drive startup success. XLR8UH will harvest promising UH research, develop talented UH entrepreneurs and connect them to a diverse network of investors and businesses. Successful technologies may then lead to further funding from the Upside Fund, a UH-focused seed stage venture fund based out of the University of Hawai'i Foundation.

All faculty and student cohorts accepted to XLR8UH must successfully complete an entrepreneurial/commercialization education program conducted in conjunction with PACE located in the Shidler College of Business at UH Mānoa. PACE, which has been instrumental in encouraging and promoting entrepreneurial activity to UH students and faculty through a multitude of programs, will provide cohorts with the necessary education, guidance and resources to nurture the development of UH's entrepreneurship ecosystem.

With XLR8UH, UH joins a growing movement of universities around the country in creating POCs focused on investing in innovative ideas, providing a launch pad for commercialization. By creating a thriving entrepreneurial sector based on the successful commercialization of its research, UH has embarked on a proactive and aggressive approach to help with the diversification of Hawai'i's economy.

INDUSTRY AND GOVERNMENT RESOURCES

County of Hawai'i Department of Research and Development

The mission of the department is to provide pro-active leadership, enhancing the quality of life, and sustainability of Hawai'i Island communities through programs related to: agriculture, energy, tourism, economic development, community development, and film.

County of Honolulu Office of Economic Development

The Mayor's Office of Economic Development (OED) works in partnership with Oahu's businesses, non-profit groups and communities to support economic growth and enhance the quality of life in the City and County of Honolulu.

County of Kaua'i Office of Economic Development

The Office of Economic Development (OED) works, in partnership with the community, to create economic opportunities towards the development of a healthy, stable and balanced economy for the residents of the County of Kauai. OED interfaces with business and community leaders as well as other government programs to enhance Kauai's economic development activities. OED is responsible to provide technical and financial support, as feasible, for both large and small business establishments, or existing and emerging new industries which offer full employment for Kauai's residents.

County of Maui Office of Economic Development

The OED works in partnership with the community, business and government sectors to strengthen and diversify the economy by supporting existing businesses, assisting in the attraction, development and expansion of new businesses and events that will in turn provide new jobs for our community.

Hawai'i Island Economic Development Board

HIEDB provides and promotes private sector support and expertise for balanced growth in Hawai'i County in partnership with federal, state, county and private resources. They nurture sustainable growth and development of its place, people, and products of Hawai'i Island in balance with the diverse and unique resources of its island home and always respectful of its native culture.

Kaua'i Economic Development Board

KEDB is a non-profit that develops innovative, effective partnerships with public, private, non-profit, and other community sectors to accomplish shared goals for a strong economy. It nurtures key economic clusters and initiates efforts to educate local youth so that they can succeed in the global marketplace.

Maui Economic Development Board

The MEDB is a nonprofit organization dedicated to achieving a balanced economy and more rewarding choices for its residents, working with an extensive network of public, private and nonprofit partners to build homegrown solutions to countywide problems, including transforming education, preparing a workforce for the Information Age, and building community dialogue and consensus about its future.

Enterprise Honolulu - Oahu Economic Development Board

Enterprise Honolulu is an organization that envisions a prosperous Hawai'i through partnerships, collaboration, and community input. Its grounding values are Aloha and Pono and they believe that with these values they are able to connect all sectors of Hawai'i's residents and visitors to a full and healthy future.

Creative Industries Division of DBEDT

The Creative Industries Division (CID) is the state's lead agency focused on strengthening, advocating and accelerating the growth of Hawai'i's creative clusters. CID acts as a business advocate for Hawai'i's culture, arts, music, film, publishing, digital and new media industries, supporting initiatives, and policy and infrastructure development to expand the capacity of Hawai'i's creative entrepreneurs. Comprised of the Hawai'i Film Office (HFO) and the Arts and Culture Development Branch (ACDB), CID's programmatic priorities provide the basis for positioning the state as a leader in the global creative economy movement.

Pacific International Center for High Technology Development

The Pacific International Center for High Technology Research (PICHTR) mission is to accelerate technology commercialization to increase security, safety, and economic opportunities in Hawaii and the Asia-Pacific region. Its focus is on renewable energy; natural disaster management; agriculture; and ocean, educational and dual-use technology.

PICHTR has extensive success providing specialized administrative support services for grant and contract management, business consulting and capacity building support services, education & technical training, co-funding and technical project support for renewable energy systems including village

hybrid power systems, climate change systems & technologies, environmental science & technologies, biopower systems, health information systems and telecommunications, and applications in healthcare, disaster mitigation, and is uniquely positioned to provide technical assistance for technology transfer and commercialization (dual use) of such technologies.

Pacific International Space Center for Exploration Systems

Pacific International Space Center for Exploration Systems (PISCES) is a Hawai'i State Government Aerospace Agency located in Hilo, Hawai'i. As a part of DBEDT, PISCES conducts environmentally-safe field tests on Hawai'i's volcanic terrain to experiment and validate advanced space technologies, operating under the jurisdiction of the Hawai'i State Department of Land and Natural Resources (DLNR).

Hawai'i Center for Advanced Transportation Technologies

The Hawai'i Center for Advanced Transportation Technologies (HCATT), managed by the High Tech Development Corporation (HTDC), has organized public/private partnerships between the federal government and private industry to develop advanced low emission and zero emission vehicles centered on electric drive technologies. Over the years, HCATT has been awarded more than \$40 million in federal funds, which was matched by another \$23 million from private partners.

Hawai'i Small Business Development Center

The Hawai'i Small Business Development Center established in 1990, provides professional business consulting, research and training to business owners and new entrepreneurs in order to promote growth, innovation, productivity and management improvement. To accomplish these objectives, it links federal, state and local resources, the educational community and the private sector to meet the needs of Hawai'i's businesses.

Hawai'i Strategic Development Corporation

The Hawai'i Strategic Development Corporation (HSDC) is an agency of the state of Hawai'i established in 1990 to promote economic development and economic diversification in Hawai'i through a return driven investment program in partnership with private capital.

High Tech Development Corporation

The High Tech Development Corporation (HTDC) provides key resources to help develop and retain high tech in Hawai'i. Its core initiatives are: to develop and manage a statewide network of incubation services and facilities; to expand existing business development services for new start-ups, as well as existing businesses in the technology sector; to secure and administer federal and private grants and contracts in support of technology research and to provide technical assistance to small technology businesses; and to support skilled workforce development for the technology sector through outreach programs, partnerships, and web-based communications activities.

Hawai'i Crop Improvement Association

The Hawai'i Crop Improvement Association (HCIA) is a nonprofit trade association representing the agricultural seed industry in Hawai'i, whose members include Dow AgroScience, Monsanto, Pioneer Hi-Bred International, Syngenta and BASF. HCIA member companies contribute to the economic diversity of the islands by providing living wage jobs in rural communities, keeping important agricultural lands in agricultural use, and serving as responsible stewards of Hawai'i's natural resources.

Hawai'i Farm Bureau

The Hawai'i Farm Bureau Federation (HFBB) is a non-profit organization of farming families united for the purpose of analyzing problems and formulating action to ensure the future of agriculture thereby promoting the well-being of farming and the state's economy. HFBB is very active in government and one of its legislative goals is to increase awareness of the economic and social contributions that agriculture makes to the state.

Marine Technology Society

The Marine Technology Society (MTS) was incorporated in June 1963 to give members of academia, government and industry a common forum for the exchange of information and ideas. Today, MTS is a growing organization, boasting a membership of businesses, institutions, individual professionals and students who are ocean engineers, technologists, policy makers and educators.

NEW STARTUPS

CONNECT analyzed new company formation data sourced from Dun and Bradstreet for the NAICS categories used in this study to define Hawai'i's innovation economy. These companies were established within the last several years. The numbers of companies established between 2011 through 2013 are shown in the chart below.

There were more than 2,500 startups created in the innovation economy during that past four years. These companies created more than 5,100 jobs and reported combined sales revenue of more than \$340 million.

Services industry startups accounted for the 70 percent of Hawai'i's innovation sector during the period 2010 through 2013. The two largest industry groups are commercial physical research/scientific & technical and non-technical services and other business, marketing and technical consulting services. These groups represented almost 50 percent of the state's innovation startups and jobs during the four year period.

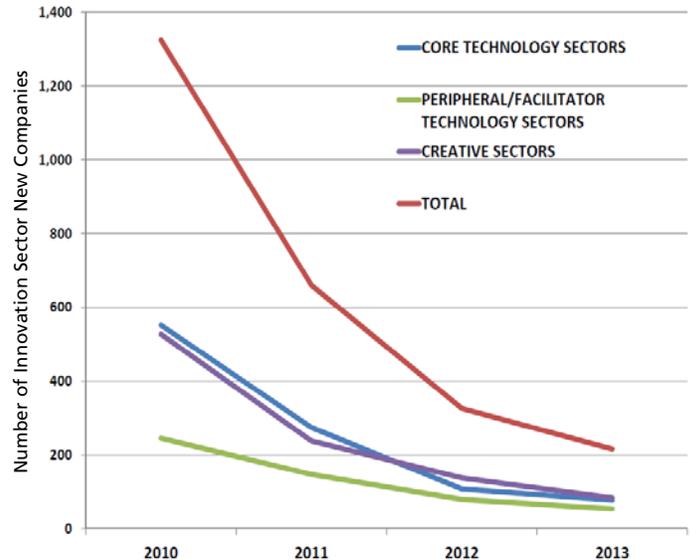
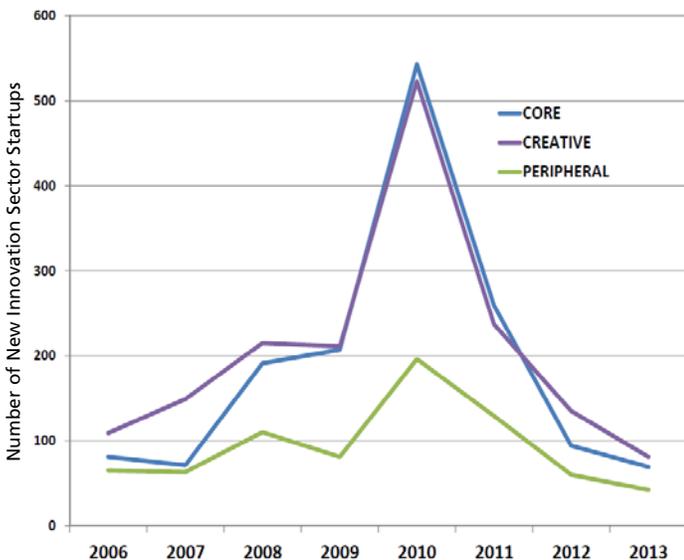
Data from Dun & Bradstreet shows that there was a sharp increase in new company creation in 2010 followed by a decline to pre-2010 startup levels. The core technology and creative sectors saw the biggest increase in startups in 2010.

State of Hawai'i Startups	2010 - 2013		
	Number of Startups	Revenues	Jobs
Commercial physical research/Scientific & Technical & Non-Technical Services	719	\$74,939,584	1,307
Other Business, Market and Technical Consulting Services	513	\$66,521,672	1,121
Engineering Services	222	\$37,619,674	522
Communications Technology & Information Services	162	\$21,023,755	326
Marketing & Related Services	161	\$12,548,000	211
Performing Arts & Related Creative	152	\$10,187,676	256
Software	135	\$44,812,500	345
Audio & Visual Media Production & Distribution	128	\$14,407,334	263
Sport and Active Lifestyle	72	\$7,004,304	144
Energy	61	\$6,338,500	98
Design Services	60	\$5,975,000	88
Business and Professional Associations	52	\$7,397,250	140
Biomedical Products	32	\$5,911,269	97
Environmental Technology	21	\$3,348,376	46
Computer & Electronics	19	\$5,175,525	39
Biotechnology, Pharmaceuticals and Chemicals	12	\$16,787,636	119
Aquaculture	5	\$521,000	13
Defense and Aerospace	1	\$96,000	1
Total	2,527	\$340,615,055	5,136

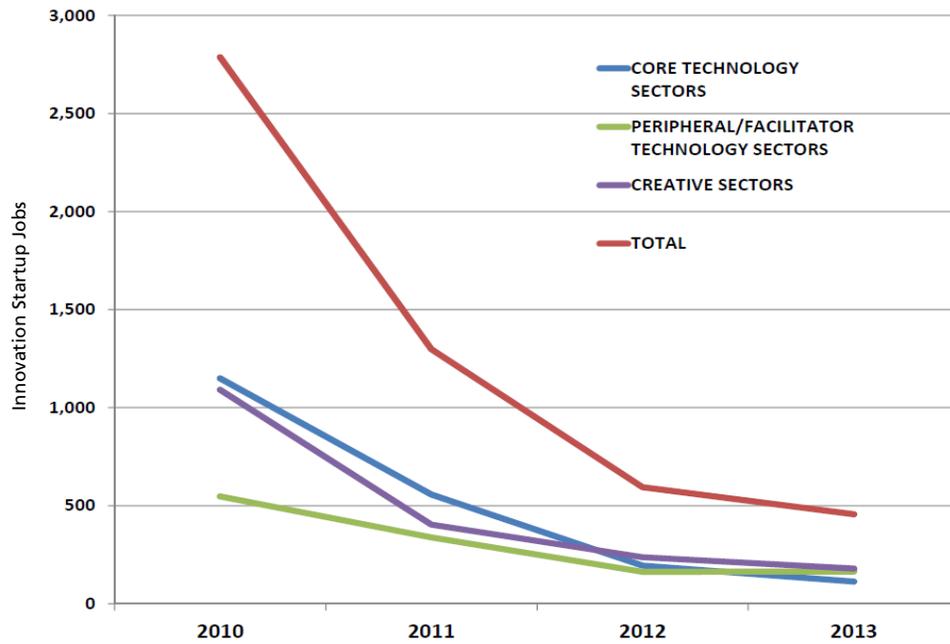
Source: Dun and Bradstreet; CONNECT

Startups

	2010	2011	2012	2013
CORE TECHNOLOGY SECTORS	552	275	108	78
PERIPHERAL/FACILITATOR TECHNOLOGY SECTORS	245	147	80	54
CREATIVE SECTORS	527	238	138	84
TOTAL	1,324	660	326	216



INNOVATION STARTUP JOBS



Jobs

	2010	2011	2012	2013
CORE TECHNOLOGY SECTORS	1149	557	194	113
PERIPHERAL/FACILITATOR TECHNOLOGY SECTORS	547	338	163	164
CREATIVE SECTORS	1091	403	237	179
TOTAL	2,787	1,298	594	456

Hawai'i Innovative Technology & Creative Start-ups

NEW COMPANY FORMATION 2010-2013: CORE TECHNOLOGY, PERIPHERAL TECHNOLOGY, CREATIVE SECTOR

The following tables show a breakdown of the number of innovation startups, jobs and reported sales revenues on each major island, for the period 2010 through 2013. Industry sectors with approximately 100 or more jobs created are highlighted in orange.

OAHU INNOVATION TECHNOLOGY & CREATIVE START-UPS NEW COMPANY FORMATION 2010-2013: CORE TECHNOLOGY, PERIPHERAL/FACILITATOR TECHNOLOGY AND CREATIVE SECTOR COMPANIES

Honolulu County Startups Industry Group	2010 - 2013		
	Number of Startups	Revenues	Jobs
Commercial physical research/Scientific & Technical & Non-Technical Services	492	\$ 55,499,799	824
Other Business, Market and Technical Consulting Services	390	\$ 55,006,672	909
Engineering Services	138	\$ 28,305,097	367
Performing Arts & Related Creative	121	\$ 8,327,676	212
Communications Technology & Information Services	120	\$ 15,229,755	217
Marketing & Related Services	116	\$ 9,646,000	158
Software	96	\$ 15,003,500	210
Audio & Visual Media Production & Distribution	89	\$ 10,627,334	188
Energy	53	\$ 5,100,500	84
Sport and Active Lifestyle	51	\$ 5,004,304	100
Design Services	38	\$ 3,591,000	56
Business and Professional Associations	34	\$ 4,918,508	88
Biomedical Products	24	\$ 4,813,269	78
Environmental Technology	14	\$ 2,334,000	32
Computer & Electronics	12	\$ 3,885,525	21
Biotechnology, Pharmaceuticals and Chemicals	10	\$ 16,451,000	114
Aquaculture	3	\$ 201,000	6
Defense and Aerospace	1	\$ 96,000	1
Hydroelectric Power Generation	1	\$ 87,000	2
Total	1,802	\$ 244,040,939	3,665

MAUI, MOLOKA'I AND LANA'I INNOVATION TECHNOLOGY & CREATIVE START-UPS NEW COMPANY FORMATION 2010-2013: CORE TECHNOLOGY, PERIPHERAL/FACILITATOR TECHNOLOGY AND CREATIVE SECTOR COMPANIES

Maui County Startups Industry Group	2010 - 2013		
	Number of Startups	Revenues	Jobs
Commercial physical research/Scientific & Technical & Non-Technical Services	129	\$10,837,838	297
Other Business, Market and Technical Consulting Services	60	\$5,688,000	97
Engineering Services	44	\$4,126,000	79
Communications Technology & Information Services	29	\$1,940,000	39
Software	28	\$28,413,000	112
Marketing & Related Services	23	\$1,582,000	27
Audio & Visual Media Production & Distribution	21	\$2,013,000	38
Performing Arts & Related Creative	19	\$1,053,000	25
Design Services	13	\$811,000	16
Sport and Active Lifestyle	11	\$993,000	20
Business and Professional Associations	7	\$623,592	15
Computer & Electronics	6	\$352,000	9
Biomedical Products	4	\$398,000	7
Environmental Technology	3	\$728,376	6
Total	397	\$59,558,806	787

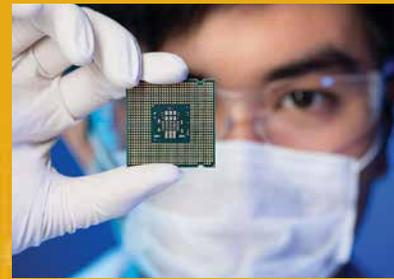
**ISLAND OF HAWAI'I INNOVATION TECHNOLOGY & CREATIVE START-UPS
NEW COMPANY FORMATION 2010-2013: CORE TECHNOLOGY,
PERIPHERAL/FACILITATOR TECHNOLOGY AND CREATIVE SECTOR COMPANIES**

Hawai'i County Startups		2010 - 2013		
Industry Group	Number of Startups	Number of		
		Revenues	Jobs	
Commercial physical research/Scientific & Technical & Non-Technical Services	66	\$6,453,947	138	
Other Business, Market and Technical Consulting Services	45	\$4,047,000	79	
Engineering Services	25	\$3,319,577	45	
Business and Professional Associations	11	\$1,855,150	37	
Audio & Visual Media Production & Distribution	10	\$963,000	19	
Marketing & Related Services	9	\$574,000	11	
Performing Arts & Related Creative	9	\$692,000	16	
Software	9	\$1,262,000	21	
Sport and Active Lifestyle	7	\$615,000	13	
Communications Technology & Information Services	6	\$651,000	11	
Design Services	4	\$1,228,000	9	
Biomedical Products	3	\$600,000	10	
Energy	3	\$570,000	7	
Environmental Technology	3	\$194,000	6	
Aquaculture	2	\$320,000	7	
Biotechnology, Pharmaceuticals and Chemicals	2	\$336,636	5	
Computer & Electronics	1	\$950,000	10	
Total	215	\$24,631,310	444	

**KAUA'I INNOVATION TECHNOLOGY & CREATIVE START-UPS
NEW COMPANY FORMATION 2010-2013: CORE TECHNOLOGY,
PERIPHERAL/FACILITATOR TECHNOLOGY AND CREATIVE SECTOR COMPANIES**

Kauai County Startups		2010 - 2013		
Industry Group	Number of Startups	Number of		
		Revenues	Jobs	
Commercial physical research/Scientific & Technical & Non-Technical Services	34	\$2,219,000	50	
Other Business, Market and Technical Consulting Services	23	\$2,168,000	43	
Engineering Services	15	\$1,869,000	31	
Marketing & Related Services	13	\$746,000	15	
Audio & Visual Media Production & Distribution	7	\$718,000	16	
Communications Technology & Information Services	7	\$3,203,000	59	
Design Services	5	\$345,000	7	
Energy	5	\$668,000	7	
Performing Arts & Related Creative	3	\$115,000	3	
Software	3	\$201,000	3	
Biomedical Products	1	\$100,000	2	
Computer & Electronics	1	\$51,000	1	
Environmental Technology	1	\$92,000	2	
Sport and Active Lifestyle	3	\$392,000	11	
Total	121	\$12,887,000	250	

Featured Innovative Companies



AEROSPACE AND SPACE SCIENCE

Maui Space Surveillance Site



The Maui Space Surveillance Site (MSSS) includes the Air Force Maui Optical Station (AMOS), an asset of the U.S. Air Force Materiel Command's Phillips Laboratory, the Maui Optical Tracking and Identification Facility (MOTIF), and a Ground-based Electro-Optical Deep Space Surveillance (GEODSS) site operated by U.S. Air Force Space Command.

Situated on top of the dormant Haleakal volcano, MSSS is part of the Ground-based Electro-Optical Deep-Space Surveillance network (GEODSS) responsible for keeping tabs on errant space debris, comprised of anything from lost satellites to spent rocket capsules. Capable of tracking basketball-size objects from over 20,000 miles away in space, MSSS makes sure the objects don't stray too far and crash into each other, which could have disastrous consequences.

Combined with two other locations in New Mexico and in the Indian Ocean, the debris-monitoring sites have the ability to account for almost 80 percent of Earth's geosynchronous orbital belt, making it an indispensable resource to the Air Force. The technology used in each of the complex's telescopes relies on the refraction of sunlight, so it can only be used on sunny days — making Haleakalā, as it is situated above light-absorbing clouds, an excellent location.

Oceanit Laboratories, Inc.



Oceanit Laboratories, Inc. operates as a science and engineering company serving engineering, aerospace, information technology, and life sciences businesses. It offers INSPECTA, a Web-based system to offer inspection management tools; LG1

medical devices to collect patients' vital signs; 3D Ship-to-Ship Modeling systems to model how two ships interact and how they interact within harbors; and Fluid Level Alarm Gauge (FLAG), a wireless sewer spill prevention system.

The company provides High Accuracy Network Determination System, a network of optical ground stations for space object characterization and tracking; LIDAR and 3D-Ceilometer Systems for the SST3D and the SST40 Ceilometers to respond to the needs of the aviation and weather service industry; On-Demand Fluid Sampling and Reporting systems to stream sampling for TMDL studies; and Cigua-Check, a fish poison test kit to detect ciguatera toxin in reef fish.

Oceanit offers a Construction Dust Monitoring System to alert crews about dust outbreaks that cause health hazards and complaints from adjacent neighborhoods; Hostile Fire Detection System, a camera system to detect a bullet being fired and locate the point of origination; Sense Through The Wall, a system designed to detect individuals in a building through heartrate and respiration; and cathodic protection systems.

The company provides services, such as Maui optical systems and imaging, custom iPhone application development, and desalination plant design. It serves the U.S. Army Corps of Engineers and Missile Defense Agency, the National Science Foundation, NASA, the State of Hawai'i, the City and County of Honolulu, and private homeowners.

AGRICULTURAL BIOTECHNOLOGY AND AGRIBUSINESS

DeKalb Genetics Corporation



DeKalb Genetics Corporation was a seed business purchased by Monsanto in 1998, who now manages and owns the company.

Historically, DeKalb researched and sold hybrid corn seeds since the Great Depression, and today remains to be a top research and development branch for agronomics.

The DEKALB® brand has since introduced corn and soybean products with herbicide and insect resistant characteristics. Phone apps offered under the DEKALB® brand were one of the first in Canada for agricultural producers. For 2012, the DEKALB® brand brought another innovation to market with Genuity® RIB Complete™ corn products.

Hawai'i Commercial and Sugar Company



Hawai'i Commercial and Sugar Company (HC&S) is the state's largest farm, with 36,000 acres under cultivation, and is Hawai'i's sole producer of raw and specialty sugar. HC&S also generates enough electricity, primarily from renewable sources, to be 100 percent energy self-sufficient, and provide the local utility with six percent of its total annual power supply for the island. As one of Maui's largest private employers, HC&S provides full-time jobs for 800 men and women.

Monsanto Hawai'i



Monsanto is an agriculture biotechnology company and is the leading producer of genetically engineered seed and herbicide. Among the first to genetically modify the plant cell, Monsanto still pioneers the agricultural biotechnology sector and conducts the top field trials of genetically modified organisms.

Since 90 percent of all U.S. corn has been engineered in Hawai'i, it is no surprise that Monsanto owns farms on Maui on which they conduct their research for desirable plant traits like insect and drought resistance.

Monsanto Hawai'i is part of the state's seed industry, established in the 1960s as small scale winter nurseries for corn breed-

ing. More than 90 percent of Monsanto Hawai'i's crops are corn. Corn cannot pollinate any of Hawai'i's native or endangered species. More than 40 years later, corn still dominates Hawai'i's seed industry, which has grown to become the state's largest agricultural commodity. Hawai'i is a great fit for seed operations.

For agriculture companies like Monsanto, Hawai'i offers an attractive year-round growing climate for corn, an established agricultural industry and a skilled workforce. In exchange, Hawai'i's seed industry:

- makes \$240 million in direct contributions to Hawai'i's economy, including more than \$76 million in labor income for local employees;
- creates 1,400 jobs in Hawai'i with average earnings higher than the statewide average;
- generates over \$550 million in total direct and indirect economic impact to Hawai'i;
- pays nearly \$30 million in tax revenue to the State of Hawai'i;
- provides economic diversification—especially important on the neighbor islands;
- creates good jobs in a green industry;
- offers high-tech jobs for local residents; and
- helps put fallow agricultural land back into productive agricultural use.

Mycogen



Mycogen Corporation offers agricultural biotechnology research services. It researches, develops, and markets seeds for improved crop varieties. The company has provided crop protection products and services for more than 30 years, including high-yielding grain corn, soybeans, high-premium sunflowers and canola, alfalfa, and tough-standing sorghum. Mycogen Corporation operates as a subsidiary of Rofan Services Inc.

BIOTECHNOLOGY AND BIOMEDICAL TECHNOLOGY

Cardax Pharmaceuticals



Cardax is focusing first on developing products utilizing astaxanthin, a naturally occurring compound demonstrated to reduce inflammation, at its source, without the harmful side effects of current anti-inflammatory treatments (e.g. steroids and NSAIDs).

Astaxanthin use is supported by hundreds of peer-reviewed papers published in leading medical research journals. More than 40 human clinical trials supporting the safety and efficacy of astaxanthin have been conducted to date. As the broader scientific community has discovered the health benefits of astaxanthin, awareness and demand for astaxanthin has grown dramatically.

In 2006, Cardax and BASF entered into a Joint Development and Supply Agreement related to the development of a proprietary and scalable process to cost-effectively manufacture a competitively differentiated, pharmaceutical-grade, nature-identical, astaxanthin with a defined molecular structure (ASTX-1), which will provide an efficient and economical path to mass markets not available to low volume agricultural astaxanthin producers.

BASF has exclusively licensed rights from Cardax to develop and commercialize ASTX-1 as an intermediate/ingredient in nutraceutical products ("BASF Astaxanthin Products"), and will pay Cardax royalties on future nutraceutical sales of BASF Astaxanthin Products. Human clinical trials are not required for nutraceutical product approvals. Cardax retains the exclusive rights to use ASTX-1 as an intermediate/ingredient in pharmaceutical products ("Cardax Astaxanthin").

Cardax plans to develop Cardax Astaxanthin for pharmaceutical use as an over-the-counter and/or prescription drug, targeting

conditions where inflammation and oxidative stress are strongly implicated. The company's patents protect compositions of matter, pharmaceutical compositions, and pharmaceutical uses of astaxanthin and related products in key disease areas.

CBI Polymers, Inc.



Cellular Bioengineering LLC. (CBI) is a sister company to SKAI Ventures and is a Hawai'i-based accelerator of disruptive technologies with biomedical applications.

CBI Polymers LLC also manufactures a family of DeconGel™ products for the cost effective and environmentally sustainable decontamination of radioactive, nuclear, and chemical spills, and with additional applications in industrial cleaning and environmental remediation.

In early 2010, CBI Polymers was recognized and honored by the U.S. Department of Energy receiving the annual Environment, Security, Safety and Health Achievement Award for the agency's effective use of this premier product. DeconGel™ was used after the Fukushima nuclear disaster in Japan to remove high levels of radiation from the Asahimachi Baptist School, after the March 11, 2011 earthquake and subsequent tsunami compromised reactors and cooling baths at TEPCO's Fukushima Daiichi Nuclear Power Station. The product has been tested by numerous agencies and organizations in Japan including first responders, nuclear power plant operators, and private companies.

Eyegenix, Inc.



Eyegenix™ has created a biosynthetic artificial corneal material for transplantation, which holds the potential promise to cure the estimated 10 million people who suffer from corneal blindness, but have no access to a transplant due to a global shortage of donors.

Invented at the University of Ottawa by Drs. May Griffith, David Carlsson and their colleagues, the class of polymers which is

being developed by Cellular Bioengineering Inc./Eyegenix™, has also been used in a physician sponsored first-in-human clinical trial conducted at a Swedish university.

Eyegenix is a wholly-owned subsidiary of Cellular Bioengineering Inc. CBI is currently making preparations for expanded trials of the bio engineered cornea and completing certified manufacturing facilities for large scale clinical production, both for use in the next set of clinical trials and for eventual global patient use.

Hawai'i Biotech, Inc.



Hawai'i Biotech, Inc. (HBI) is a privately held biotechnology company focused on the research and development of vaccines for established and emerging infectious diseases. The company has developed proprietary expertise in the production of recombinant proteins applicable to the development of safe and effective vaccines. Lead vaccine candidates in clinical development target the West Nile virus and Dengue virus. Additional recombinant protein subunits vaccine candidates produced from this protein production platform are currently under development. In August of 2010, Merck Sharp and Dohme purchased certain assets from including all rights to the dengue virus vaccine developed by the company.

Hawai'i Biotech utilizes its internal research pipeline, supported primarily by grant revenues and supplemented by a strategic in-licensing program, to produce additional proprietary clinical development vaccine candidates.

HBI has a strong track record of securing research funds from the National Institute of Health and the Department of Defense to support its research programs and is currently engaged in pre-clinical development of a tick borne encephalitis virus vaccine funded by a grant from the NIAID.

The company's progress has been financed by private equity funding, as well as over \$50 million in federal funding.

Pono Pharma



Pono Pharma is working on developing technologies for the treatment of drug resistant bacteria and cancer. The company is developing a new antibiotic technology that integrates traditional beta-lactams and ionic silver. Pono Pharma's antibiotic uses the drug resistant bacteria's strength against itself. The results to date have shown that Pono Pharma's antibiotic is broad spectrum, with efficacy both on gram positive and gram negative.

Pono Pharmaceuticals is an example of technology commercialization from the university to the commercial market. Three technologies developed by the University of Hawai'i were licensed to Pono Pharma in 2012, including a proteasome inhibitor drug, humanized cobra venom factor, and a hybrid nanocarrier drug delivery system. Pono is working to develop the technologies under the agreement with a focus on moving them through the regulatory approval process.

The proteasome inhibitors are a new class of compounds potentially useful for anti-cancer and other therapeutic uses, and improved cancer treatment through targeted, tumor-specific delivery of chemotherapeutic drugs is the aim of the proprietary nanocarrier system developed by Drs. André S. Bachmann and Mahavir Chougule at UH Hilo's Daniel K. Inouye College of Pharmacy.

At the University of Hawai'i Cancer Center, Dr. Carl-Wilhelm Vogel and Dr. David Fritzing developed the cobra venom factor proteins which are modified for treatment of diseases such as reperfusion injury and autoimmune diseases.

INFORMATION AND COMMUNICATIONS TECHNOLOGY AND CYBERSECURITY

2c4 Technologies



2c4 Technologies is a high-tech startup company that was founded to create information technology solutions for the federal, state, and commercial markets. While 2c4 is based in the Maui Research & Technology Park, it has already established an office with five employees in Frederick, Maryland supporting the Defense Health Information Management System (DHIMS). The company's work involves the development and sustainment of AHLTA-Theater, the clinical documentation and management application that serves as the military's electronic health record (EHR) for the Theater and Operational environment.

Much of 2c4's work ranges from mobile applications development, data architecture and database design and development. Lawson said the future of his company looks promising, in part because of the U.S. military's commitment to investing in health care technology globally and their local commitment to Maui through the Pacific Joint Information Technology Center (JITC) contracts.

On the island, 2c4 has been networking through Maui Economic Development Board as it recruits and hires employees.

Akimeka



Akimeka, a subsidiary of VSE Corporation since 2010, was founded in 1997, and provides technology-driven services and solutions worldwide. Whether it's helping transform the future of military medicine, providing timely, trusted access to vital classified information, or saving lives by enhancing 911 services, delivers innovative

IT solutions to help accomplish important missions.

By blending domain knowledge, advanced technologies, disciplined project management, and proven best practices, Akimeka is able to deliver high-impact IT solutions that meet high-priority challenges. Akimeka's proven solutions for government include: medical logistics, medical command and control, e-health, information assurance and public safety.

The company draws on its proven information technology capabilities to develop extremely flexible solutions that help its government customers make critical decisions and achieve new levels of performance and productivity. Akimeka's core technology capabilities include: enterprise architecture, web-based technologies, database management, software engineering, security and Geographic Information Systems (GIS).

Ardent Management Consulting



Ardent Management Consulting's Maui Geospatial Software Development Center (GSDC) at the Ke Alahele Center in the Maui Research & Technology Park is involved in competitively awarded software development work related to U.S. Department of Homeland Security geospatial mapping initiatives. The software developed in Maui provides Homeland Security leadership with geospatial situational awareness regarding natural and man-made disasters. The Maui GSDC also supports U.S. Department of Justice software development, enabling geospatial visualization and criminal activity analysis.

Integrity Applications Incorporated/ Pacific Defense Solutions, LLC



Integrity Applications Incorporated (IAI) is an engineering and software services and solutions company with a nationwide

presence primarily supporting the intelligence community and other civil, defense and intelligence customers with a focus on Government space and intelligence surveillance reconnaissance systems activities. Headquartered in Chantilly, Virginia, IAI also has offices in California, Colorado, Hawai'i, Massachusetts, Maryland, Michigan, New Mexico, Ohio and Pennsylvania.

IAI provides specialized subject matter expertise in system engineering, system integration, system acquisition, software integration, visualization and modeling and simulation expertise to system program offices, enterprise system engineering activities, operational elements, and other organizations across the intelligence community and Department of Defense. IAI has specific domain expertise in intelligence, surveillance and reconnaissance systems including radar, electro-optical, infrared and MASINT payloads, product quality analysis, ground systems, imagery-based geo-positioning and targeting, photogrammetric analysis, service oriented architectures, unmanned systems, cyber security, operations and special communications systems. IAI also creates innovative software applications focused primarily on web-based intelligence data visualization, exploitation tools and capabilities using the Open Source, GOTS and COTS software models.

Pacific Disaster Center



The Pacific Disaster Center (PDC) works with decision makers, disaster managers, planners, and the public to develop solutions to some of the most challenging disaster management problems. Their suite of tools, services, and products supports all phases of disaster management.

PDC's public applications and tools provide information that is easy to use — delivering useful information as hazards occur, or as disasters unfold. Building on nearly two decades of experience these public resources have been developed to offer multi-hazard early warning and decision support tools worldwide.

PDC provides easy access to hazard and risk information and analytical products for executive decision-makers, disaster manag-

ers, and community planners. The company's comprehensive multi-hazard monitoring, early warning, and decision support capabilities to provide critical information to enable sound decision making throughout the disaster management cycle.

Referentia Systems Incorporated



Responding to current and evolving cybersecurity challenges in the Asia Pacific Region and the Western U.S., Referentia Systems opened its Cyber Collaboration Center (CCC) in Honolulu in 2011. The 25,000-square foot facility was established to enable security experts from government, academia and industry to collaborate on critical cybersecurity concerns threatening our nation's networks and IT modernization.

The CCC serves as an operational test bed for the Department of Defense, alternative energy, the smart grid and utilities. The Center's initiatives include developing effective solutions for cybersecurity, interoperability operations and critical infrastructure and innovations based on critical gaps from the operational community. Staffed by cybersecurity experts, computer scientists, programmers and network engineers, the CCC offers a dynamic open-space work environment that encourages collaborative research across disciplines. Teams work on building block technologies used to construct highly adaptive architectures and advanced cybersecurity solutions for seamless and secure interoperability, secure agile virtual enclaves and network infrastructure command and control.

In the community, the CCC serves as a gathering place for educators, students and industry mentors to advance interest in science, technology, engineering and math (STEM) in our schools and help ensure a well-trained and economically competitive workforce in Hawai'i and foster the next generation of national security professionals.

OCEAN SCIENCE AND TECHNOLOGY

Hawai'i Oceanic Technology, Inc.

Hawai'i Oceanic Technology, Inc. offers a new generation deep ocean fish farming (mariculture) technology that can help meet growing demand for seafood in an environmentally responsible manner. Aquaculture is a \$100 billion industry that now provides half of all seafood consumed in the world. Almost one third of wild caught ocean species are being depleted beyond sustainability according to the UN Food Agriculture Association. A substantial amount aquaculture production globally is done on land and requires fresh water, quickly becoming scarce and costly. It is time to turn to the ocean to farm seafood in a sustainable manner if we are to meet the world's growing demand for seafood. Hawai'i Oceanic Technology, Inc. has created the Oceansphere™. A revolution in open ocean aquaculture technology, the Oceansphere™ makes farming fish in the open ocean a practical reality. Self-sustaining and untethered to the ocean floor, the Oceansphere™ is designed to produce large harvests in a very small footprint. For example, twelve Oceanspheres in less than half of a square mile can yield as much as 24,000 tons of seafood.

Hawai'i Oceanic Technology's patented design includes innovations that pertain to robotics, geostatic positioning, inertial navigation telemetry and environmentally responsible fish rearing. By leveraging such breadth of expertise and intellectual property, the Oceansphere™ is able to support a self-sustaining deep water environment nearly twice as large as any contemporary tethered cage. The massive scale and deep water operation of this technology affords many benefits, all of which combine to provide an economically viable and environmentally sustainable method to meet society's ever-growing demand for seafood.

Makai Ocean Engineering



Makai Ocean Engineering was founded in 1973 as a diversified ocean engineering company focused on providing design engineering and development services to a broad range of clientele both foreign and domestic. Practice areas include engineering for ocean based renewable energy (OTEC [ocean thermal energy conversion] and SWAC [sea-water air conditioning]), large underwater pipelines, software for planning, simulation, installation and recovery of submarine cables and arrays, and software for visualizing scientific 4D/5D data. Makai Ocean Engineering has an extensive record of success in achieving innovative solutions to difficult problems for its partners and clients and continues to serve leading industrial and commercial firms as well as federal, state and local governments worldwide.

In 2013, Makai received a \$3.6 million contract from the Hawai'i Natural Energy Institute and the Office of Naval Research for the research and design on the marine renewable energy known as ocean thermal energy conversion. The Waimanalo-based ocean technology and engineering firm performs this work at its Ocean Energy Research Center in Kailua-Kona on the Big Island, which is the largest OTEC research facility in the world. Makai will work on two initiatives toward the ultimate goal of making commercial OTEC a reality, including designing, manufacturing and testing and improved heat exchanger for OTEC and connecting power from its OTEC plant to the electric grid on the Big Island.

In 2014, Makai installed a 100-kilowatt turbine at the Ocean Energy Research Center to generate OTEC power onto the local grid and is the world's only operational OTEC plant.

International Underwater Explorations



International Underwater Explorations (IUE) is a commercial business in Hawai'i and part of the growing geospatial information industry (GIS) both in the region and internationally. IUE provides GIS solutions and tools to companies in the renewable energy, defense, commercial, and marine sectors. IUE creates information management tools that bring data online to provide a rich visualization environment that leverages cloud services to provide a rich set of desktop, server, and mobile applications.

IUE technology can be applied to renewable energy monitoring, survey, planning, and engineering. In addition IUE provides solutions and tools for wind, wave, and solar energy to aid in site selection for wind mills, solar farms, transmission lines, and infrastructure both commercial and residential. IUE technology is optimized for the dual-use of large data sets retrieved in real time from a wide range of sources, and provides tools to help people and organizations move from data warehousing to information management.

PHOTONICS AND SENSOR TECHNOLOGIES

HNu-Photonics



HNU-PHOTONICS
LIGHT SOLUTIONS

Incorporated in 2006 and based on Maui, Hawai'i, HNu Photonics is a science and technology company focused on renewable energy, defense photonics, specialized optics, and medical imaging technologies. HNu has made breakthroughs in solar energy generation with advances in both efficiency and practical applications. In medical technology, HNu develops instrumentation and optical sensor packages, and is introducing a

new form of microscopy with broad clinical, scientific and even forensic applications.

HNu Photonics has a long-standing relationship with the military, having placed in service a number of successful technologies. Current projects include multi-dimensional sensor technology including 3D imaging, spectrometer design and development, laser beam control interfacing and the development of beam projectors and receivers. In addition to advances in optics technologies, HNu is expanding techniques for shaping and polishing specialized materials, metals, sapphire for transparent armor and ceramics such as silicon carbide for and space applications. Activities with broad application across various domains of investigation, design and fabrication are its successes in the areas of miniaturization and light-weighting.

Spectrum Photonics



Spectrum Photonics, Inc. develops standoff and remote sensors systems to detect and identify chemical compounds for military and commercial interests. Their compact, lightweight systems use advanced hyperspectral imaging (HSI) and optical sensing technologies to provide trace level detection and analysis.

For the military and first responders, detecting and identifying a potentially hazardous material requires proximal sensors. This means the user must get up close and personal with something that may turn out to be highly dangerous. Since proximal sensors were first used, people have sought a way to enable detection and identification from greater, and safer, distances. By its inherent nature, hyperspectral imaging makes remote and standoff detection and analysis possible.

Hyperspectral imaging provides a greater depth of information about a single pixel than is possible with other analysis techniques. In consequence, hyperspectral imaging is able to differentiate specific materials from a similar background.

Since their founding in 2008, Spectrum Photonics has been awarded more than twenty SBIR Phase I, II, and III contracts as well as other DoD sponsored awards. Under

these contracts, Spectrum Photonics has developed custom hyperspectral imaging and optical sensors for use in handheld, terrestrial, aerial, and underwater detection and identification operations. Each system's size, weight, and power (SWaP) trade-offs are optimized for the specific application.

Spectrum Photonics owns the exclusive rights to the Sagnac-based hyperspectral imaging technology and ancillary detection algorithms invented and patented at the University of Hawai'i.

TruTag Technologies, Inc.



TruTag Technologies provides product authentication and brand protection solutions for multiple industries, including pharmaceutical and nutritional, food and food packaging, electronics, industrial and general consumer goods. The company uses customized and proprietary nanotechnology solutions using spectrally coded silica microtags to address the trillion dollar global problem of counterfeiting.

The TruTag solution represents a breakthrough in the industry because these microtags are made of the highest purity silica, rendering it biologically inert, edible, and virtually invisible.

TruTag was incorporated in 2011 and is a privately-held company headquartered in Kapolei, Hawai'i, with offices in California and Texas. The company is backed by Angel investors, investment firms and strategic partners in the Asia-Pacific region.

RENEWABLE TECHNOLOGIES

Cellana



Cellana's Kona Demonstration Facility (KDF) on Hawai'i's Big Island. Photo credit: Cellana

Cellana, a leading developer of algae-based feedstocks for biofuels, animal feed, and

Omega-3 nutritional oils, entered into a multi-year off-take agreement with Neste Oil, the world's leading supplier of renewable diesel, for commercial-scale quantities of Cellana's ReNew™ Fuel algae oil feedstocks for biofuel applications.

Under the agreement, Neste Oil has committed to purchase crude algal oil produced by commercial-scale algae biorefineries that Cellana is developing worldwide. The agreement is contingent on Cellana's future production capacity and on compliance with future biofuel legislation in the EU and US, among other factors. The agreement between Cellana and Neste Oil is non-exclusive and allows each company to enter into additional agreements with other parties.

Whole algae biomass consists of natural oils, proteins, sugars, minerals, and other micronutrients that can make valuable feedstocks or supplements for human nutrition, animal feed, and biofuel applications. Cellana's patented ALDUO™ process has produced over 20 metric tons (dry weight) of whole algae biomass to date, branded ReNew Algae™, from a diverse variety of carefully selected, non-GMO microalgae strains. These industrial-scale quantities of ReNew Algae™, and their valuable components, have been tested by Cellana and potential customers in all three of the key application areas of fuel, Omega-3, and feed.

Cellana signed a letter of intent in June 2014 with Israel-based Galil Algae Cooperative Agriculture Society Ltd. to produce high-value algae products for aquaculture uses. The main goal of the program is to identify, cultivate, develop and scale up algae strains with immediate commercial value, emphasizing the high-value components for existing aquaculture, mariculture, nutraceuticals, pharmaceutical and/or cosmetic applications.

Additionally, the letter of intent includes Cellana and Galil Algae to explore the establishment of a new algae research and development center in northern Israel, which together with the research and development activities to be undertaken at Cellana's facility in Hawai'i, would be a focal point for the development and testing of new or optimized strains of high-value algae biomass.

Cyanotech



Cyanotech Corporation is engaged in the cultivation, production, and sale of natural products derived from microalgae world-wide. The company's products include Hawaiian Spirulina Pacifica, a nutrient-rich dietary supplement that is used for extra energy, a strengthened immune system, cardiovascular benefits, and as a source of antioxidant carotenoids; and Hawaiian BioAstin natural astaxanthin, a dietary antioxidant, which is used as a human nutraceutical and functional food ingredient to support and maintain the body's natural inflammatory response, enhance skin, and support eye and joint health.

Cyanotech Corporation sells its products in bulk quantities to manufacturers, formulators, and distributors in the health foods and nutritional supplements markets; and as packaged consumer products to distributors, retailers, and direct consumers. The company sells its products online and through resellers. Cyanotech Corporation was founded in 1983 and is headquartered in Kailua-Kona, Hawai'i.

Hitachi



Hitachi, Ltd., a multinational engineering and electronics conglomerate headquartered in Tokyo, has a vision for the future of "smart cities" that are harmonious with the natural environment of the Earth. Hitachi is spearheading collaboration with the Maui Electric Company to test and demonstrate the power of smart grids on the Hawaiian Islands.

On-site demonstrations will use wind power generation systems and power systems installed on the island of Maui, which generate a total of 72,000 kW of power. These power systems leverage information technologies to demonstrate controls for the power distribution systems and the load on the consumer side, as well as systems for controlling EV operations and charging, including various types of rapid charging devices. Operations at the demonstration site are scheduled to continue until March 2015, and following this period, subsequent studies and discussions will be conducted for implementing new business models based on the results of these demonstrations and evaluations.

HNu Energy



HNu Energy, a Maui-based complete energy solution provider and engineering firm, offers renewable energy generation, energy storage, and high-efficiency lighting products for all types of residential and commercial customers. The HNu Energy team deploys state-of-the-art solar power generating systems and energy storage. HNu's solar division is currently prototyping solar modules that have increased efficiency and a lower manufacturing cost than traditional solar products.

Research and Education

Hawai'i's universities, schools, research centers and institutes produce cutting-edge research and train the state's future skilled workforce, researchers and entrepreneurs





UNIVERSITY
of HAWAII®
SYSTEM

The University of Hawai'i System, the state's public higher education system, is comprised of 10 campuses — the University of Hawai'i at Mānoa, University of Hawai'i at Hilo, University of Hawai'i Maui College, University of Hawai'i at West Oahu, six community colleges and dozens of educational, training and research centers across the island chain. Ideally located in the middle of the Pacific, the University of Hawai'i (UH) is a recognized leader in Asia/Pacific leadership, collaboration and influence; and is the state's leading engine for economic growth and diversification — providing stimulus to the local economy with jobs, research and workforce development.

The UH System offers 676 academic programs, including bachelor's degrees in 143 fields of study, master's degrees in 93 fields of study, doctoral degrees in 54 fields of study, and associate degrees in 129 fields of study. In 2013, total enrollment across the 10-campus system was 58,941.

University of Hawai'i at Mānoa

The University of Hawai'i's flagship campus, the University of Hawai'i at Mānoa (UH Mānoa), is classified by The Carnegie Foundation as a research university producing "very high" research activity. It is also ranked by the National Science Foundation as one of the top 30 public universities for federal research funding in science and engineering—averaging \$333 million over the past five years. Recently, UH Mānoa was ranked among the top world universities by the National Taiwan University Ranking (NTU Ranking) for its scientific publications, placing 203rd overall and 80th in the United States out of the top 500 worldwide. With programs in ocean and earth sciences, astronomy, medicine, international business and information sciences being ranked among the nation's best, UH Mānoa was elected to membership in the Association of Pacific Rim Universities, a leading consortium of 45 premier research universities in the region.

University of Hawai'i at Hilo

The University of Hawai'i at Hilo (UH Hilo) offers a variety of degrees—37 undergraduate, seven master's and two doctorate—ranging from the only master's degree in an indigenous language in the nation to the only undergraduate degree in astronomy in the state. The Hilo campus also serves as home to the Daniel K. Inouye College of Pharmacy (DKICP), ranked in 2012 by U.S. News & World Report as one of the top five new pharmacy schools. Additionally, the DKICP is the first school of pharmacy in the state and the Pacific region to be accredited by the Accreditation Council for Pharmacy Education. Recently, the Office of the Governor released \$33 million for the construction of a permanent building for the DKICP.

University of Hawai'i Maui College

University of Hawai'i Maui College (UH Maui College) offers three four-year baccalaureate degrees—applied science in applied business and information technology, engineering technology, and sustainable science management—and 49 programs in the fields of accounting, nursing, art, business, culinary arts, dentistry, electronic and computer engineering, hospitality and tourism, and language.

The engineering technology and electronic & computing engineering technology programs were developed and is co-taught through collaborations between the UH Institute for Astronomy Maui Division and the Akamai Workforce Initiative (AWI). Both programs prepare students for careers in telescope operations, high performance computing, sustainable energy production and other related sectors that are based on the island.

ENROLLMENT

Total Enrollment	58,941
Undergraduate	52,849
Graduate	6,092

RESIDENCY

Hawai'i	84.5%
U.S. Mainland	9.5%
U.S. Affiliated	1.0%
Foreign	3.7%
Unknown	1.2%

GENDER (FULL-TIME STUDENTS)

Men	44.4%
Women	55.6%

AGE

Average	25.5
Under 18	4.1%
18-24	59.6%
25 and older	36.3%

CURRICULA OFFERED

Total	676
Bachelor's	143
Master's	93
Doctorate	54
1st Professional	7
Post Baccalaureate	3
Third Year Certificate	3
Associate	129
Certificate of Achievement	82
Certificate of Completion	68
Undergraduate Certificate	60
Graduate Certificate	34

University of Hawai'i West O'ahu

University of Hawai'i West O'ahu (UH West O'ahu) targets the educational needs of both recent high school graduates and non-traditional students, through its innovative alternative learning opportunities such as instruction via computer and telecommunications, certificate programs and individualized degree programs. The West O'ahu campus offers 12 baccalaureate and certificate programs, including a bachelor of arts (BA) with 18 different areas of concentration, a bachelor of education (BEEd) in elementary education, and a bachelor of applied science with three possible majors. Five BA degrees and three certificate programs are offered through UH West O'ahu's distance learning program.

Hawai'i Community College

Hawai'i Community College (Hawai'i CC) offers more than 50 associate degree, certificate and non-credit programs, including applied technical education, business education and technology, hospitality, liberal arts and nursing.

Kaua'i Community College

Kaua'i Community College (Kaua'i CC) offers 32 associate degree and certificate programs in the fields of business, technology, hospitality, health, early childhood education and liberal arts, and also administers the UH Center on Kaua'i, which provides students an opportunity to obtain baccalaureate and graduate degrees and certificates from other institutions within the UH System

Honolulu Community College

Honolulu Community College (Honolulu CC) offers a two-year Associate in Arts degree and certificate programs in more than twenty Career and Technical Education areas. In total, Honolulu CC offers 49 associate degree and certificate programs including aeronautics maintenance, automotive maintenance and marine education.

Kapi'olani Community College

Kapi'olani Community College (Kapi'olani CC) offers 47 degree and certificate programs, including nationally recognized programs in culinary studies, health sciences, emergency medical services and legal assistance.

Leeward Community College

Leeward Community College (Leeward CC) offers 26 degree and certificate programs, including a strong liberal arts program and technical programs that provide opportunities for employment or transfer. The Digital Media and Television Production programs in particular are viewed by some as the best in the state.

Windward Community College

Windward Community College (Windward CC) offers six associate degree and certificate programs in the fields of Hawaiian studies, natural sciences, fine arts, veterinary technology, and vocational training.

Research, Innovation and Entrepreneurship

One of only a handful of universities nationwide to hold the distinction of being a land-, sea-, and space-grant institution, UH Mānoa is ranked in the top 50 public universities in research funding by the National Science Foundation. UH Mānoa received \$333 million per annum in extramural awards averaged over the last five years. Seven of UH Mānoa’s faculty are currently members of the National Academy of Sciences, the National Academy of Engineering, and the National Institute of Medicine.

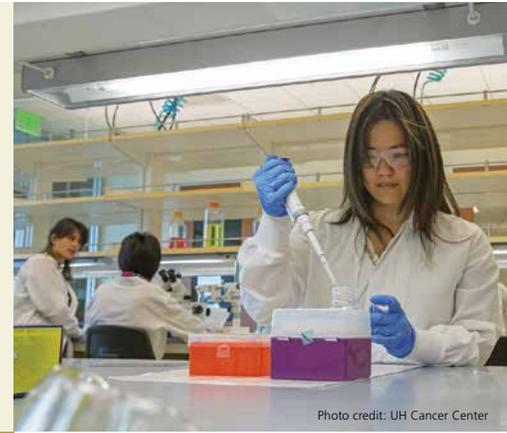


Photo credit: UH Cancer Center

RESEARCH AWARDS BY SOURCE, 2010-14 (\$ MILLIONS)

UH System	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Federal	327	362	323	264	264
Non-Federal	125	127	113	146	128
Total	452	489	436	410	392

Note: Includes both research and training
Source: UH Office of Research Services

THE HAWAI‘I INNOVATION INITIATIVE

The economy of Hawai‘i is currently highly dependent on the tourism sector and military spending. Working with the business community, research and innovation has been identified as a third sector to be developed. As the largest research enterprise in the state, UH is essential to achieving this. The University of Hawai‘i also has the most critical role in educating and training Hawai‘i citizens to lead and participate in this sector.

Recently, UH has taken on a greater role to help diversity the state’s economy through the Hawai‘i Innovation Initiative. The University of Hawai‘i has partnered with the local business community to help leverage its research to create and attract new companies, cultivate talent for a knowledge based economy and encourage the development of future technologies. The common goal is to build a thriving research enterprise that will be driven by the growth of new industries including a robust advanced manufacturing community in Hawai‘i, fueled by UH’s plans to aggressively commercialize its research and to employ and develop to researchers in several focus areas over the next decade.

A key strategy is to emphasize the creation of innovation clusters or hubs capable of linking fundamental scientific discovery with the applied research and development as well as training necessary for technological innovation and economic development. Consistent with work over many years to identify areas of established and/or emerging excellence, the Hawai‘i Innovation Initiative will focus on the following hubs: astronomy, ocean sciences, health sciences and wellness, data intensive sciences and engineering, agriculture and sustainability sciences—including energy.

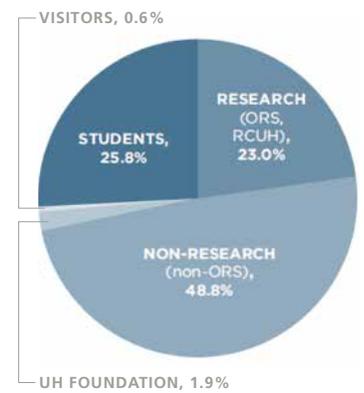


Figure 1 - Total UH Expenditures

Figure 1, above, shows a breakdown of how that \$2.32 billion in direct total expenditures is divided among the different UH entities. Non-research spending (mostly instructional expenditures) represents nearly half of all UH-related spending (48.8 percent). Spending on research activities and student expenditures were at a close second 23.0 percent and 25.8 percent, respectively. All other categories combined comprised less than three percent of the total. Table 1, below, details these expenditures. These numbers can also be used to illustrate \$376 million in State General Fund expenditures into \$1.47 (=1.84 billion – \$376 million) billion dollars of related research and educational expenditures.

ECONOMIC IMPACT OF THE UNIVERSITY OF HAWAI'I

The University of Hawai'i generates economic activity through its purchases from local businesses, its w to its employees, and spending by students and visitors.

- Total UH related expenditures (including visitor spending) were \$2.32 billion in FY 2012, \$1.84 billion of which was spent locally.
- Together with additional indirect and induced benefits from these activities, UH had a total impact of \$3.61 billion on Hawai'i's economy.

- Each UH-related dollar spent generates \$1.96 of total business sales, \$0.59 of employee earnings, and \$0.11 of state revenues in Hawai'i in FY 2012; and each million dollars of spending generates 15 jobs in Hawai'i.
- The \$2.32 billion of education-related expenditures attributable to UH generated \$3.61 billion in local business sales, \$1.10 billion in employee earnings, \$194 million in state tax revenues, and over 28,500 jobs in Hawai'i in FY 2012.

- Each dollar of State General Fund spending on UH translates into \$9.61 of total business sales, \$2.91 of employee earnings, and \$0.52 of state taxes in Hawai'i. For every dollar of state funds spent on UH, the University was able to leverage an additional \$4.90 of spending in the state.²²

CREATING JOBS AND GENERATING INCOME

One can think of the University of Hawai'i as if it were one of many businesses or industries in Hawai'i. It produces education and research services as its primary outputs. It produces entertainment and sports services, consulting services, health care, housing, and food services. Its customers include students, visitors, private businesses, governments, and the general public. It attracts customers worldwide, many of whom stay for four or more years, as well as serves the local community.

An important difference between the University of Hawai'i and a private business is that UH gets a substantial part of its funding from taxpayers. In FY 2012, the University of Hawai'i and the supporting RCUH (Research Corporation of the University of Hawai'i) spent a total of \$1.7 billion in support of its educational mission; the State General Fund paid \$376 million of the total. The difference between what the State General Fund paid for and the total amount spent by UH (\$1.7 billion - \$376 million = \$ 1.3 billion) was paid for by government research and training

grants, revolving funds (e.g., bookstore revenues), special funds (e.g., tuition and fees), and federal matching grants (e.g., U.S. Department of Agriculture Hatch and Smith-Lever funds).

Adding money spent by the privately funded University of Hawai'i Foundation, spending by students on items other than tuition, fees, dorm fees, and books, out-of-town visitor spending related to UH sponsored professional meetings and conferences brings total UH-related expenditures to \$2.32 billion locally.

Table 1. UH Expenditure Breakdown (000\$)

	Non research (non-ORS)	Research (ORS, RCUH)	UH Foundation	Students and Visitors	TOTAL UH
Total local purchases of goods and services	\$711,312	\$361,338	\$31,336	\$611,911	\$1,715,896
Total labor income	\$302,903	\$114,258	\$7,140	-	\$424,302
Imports	\$120,051	\$58,897	\$5,228	-	\$184,176
Total expenditures	\$1,134,266	\$534,493	\$43,704	\$611,911	\$2,324,373

For the complete UHERO report, go to: <http://uhero.hawaii.edu/29/Project-UH>

22) UHERO, The Economic Impact of the University of Hawai'i System FY2012 (April 16, 2013); accessed August 6, 2014.

Other Education Institutions

The growth of Hawai'i's innovation economy depends on the development of a skilled workforce, especially in the science, technology, engineering and math fields and entrepreneurial training programs. The following institutions train thousands of undergraduate and undergraduate students, as well as primary and secondary students.

Hawai'i Pacific University



Founded in 1965, Hawai'i Pacific University (HPU) has grown to become the state's leading private, non-profit university with a student population of nearly 7,000 undergraduate and graduate students. HPU is one of the most culturally diverse universities in America with students from all 50 U.S. states and nearly 80 countries. HPU prides itself on maintaining strong academic programs, small class sizes, individual attention to students, and a diverse faculty and student population. The university offers more than 50 acclaimed undergraduate programs and 14 distinguished graduate programs to students.

Hawai'i Pacific University is an international learning community set in the rich cultural context of Hawai'i. Students from around the world join enroll at HPU for an American education built on a liberal arts foundation. Our innovative undergraduate and graduate programs anticipate the changing needs of the community and prepare our graduates to live, work, and learn as active members of a global society.

Chaminade University



Chaminade University, the only Catholic university in Hawai'i, offers 23 undergraduate degree programs on the main Honolulu campus, seven graduate degree programs and 14 degree opportunities for working adults, through evening and weekend courses in satellite locations and online.

Chaminade University offers the distinct advantage of size: small. Students can work closely with excellent faculty, peers, and business mentors, in a highly collaborative environment. The Hogan Entrepreneurial program is another opportunity for those pursuing business knowledge, a close-up look at how to get a new idea off the ground. Alumni have described these programs as "intimate, yet professional."

Brigham Young University – Hawai'i



Brigham Young University—Hawai'i is the preeminent international center of learning in the Pacific. Its small campus is a unique laboratory of intercultural leadership development, where a diverse population of 2,500 students representing over 70 countries live, study, and work together. Small classes taught by expert faculty empower students to master challenging and relevant curriculum, while affordable tuition, financial aid, and online study options make this valuable education more accessible than ever. Operated by The Church of Jesus Christ of Latter-day Saints, a total BYU–Hawai'i education involves not only intellectual learning and career preparation, but also moral, ethical, and spiritual enrichment.

Hawai'i State Department of Education

The Hawai'i State Department of Education (DOE) is the ninth-largest U.S. school district and the only statewide educational system in the country. It is comprised of 255 schools and serves more than 183,000 students.

Hawai'i Association of Independent Schools

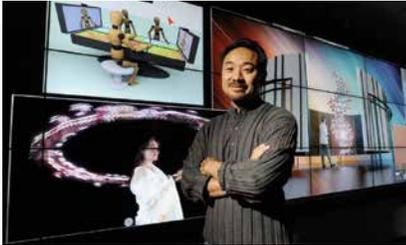
Established in 1969, the Hawai'i Association of Independent Schools (HAIS) is comprised of over 100 private and/or independent schools with a combined enrollment of over 40,000 students statewide. Member schools include several of the largest independent schools in the nation to some of the smallest.

Featured Research and Innovation Assets



Scalable Adaptive Graphics Environment (SAGE)

Next generation collaboration and visualization software infrastructure



Jason Leigh,
Laboratory of
Advanced Visualization
and Applications

Photo credit:
Jason Leigh, UH/UIC

“A picture is worth a thousand words” is an old adage. But with the

help of technologies developed by visualization experts like University of Hawai‘i at Mānoa Information and Computer Sciences Professor Jason Leigh, pictures are now worth a whole lot more.

As researchers around the world begin to work more closely with each other to solve complex problems, collaborative scientific visualization environments comprised of ultra-resolution tiled display walls interconnected by optical networks, are becoming vital for data sharing and analysis.

This virtual environment is provided by SAGE (Scalable Adaptive Graphics Environment), a software system developed by Leigh, then director of the prestigious Electronic Visualization Lab and Software Technologies Research Center at the University of Illinois at Chicago. It enables users to access, display and share a variety of data-intensive information, in a variety of resolutions and formats, from multiple sources, on tiled display walls. Information displayed can be digital-cinema animations, high-resolution images, high-definition video conferences, presentation slides, documents and spreadsheets. The SAGE software is the National Science Foundation’s de facto standard for driving ultra-high resolution display walls and is currently in use by over 100 top research and industrial organizations worldwide, including Monsanto and Japan’s NTT.

Building on the highly successful CAVE (Computer Assisted Virtual Environment), Leigh’s recent CAVE2 is the next generation, large-scale, virtual-reality system that allows researchers to completely immerse themselves in a seamless 2D/3D environment of visual information.

“The CAVE2 technology helps to bring science to the big screen,” said Leigh. “It allows the study of worlds too small, too large, too dangerous or too complex to be viewed otherwise, like the hostile surface of a distant planet or the intricate system of arteries in the human body.”

Leigh’s technologies are already being utilized by UH researchers including Karen Meech at the Institute for Astronomy and by world-renowned oceanographer David Karl at the Center for Microbial Oceanography: Research and Education (C-MORE).

“Jason Leigh is a terrific addition to the UH ohana,” said Karl, the director of C-MORE. “We already have plans for a meaningful collaboration between his new visualization team and C-MORE scientists, who will soon be able to display our marine microbial genomics and biogeochemical datasets in vivid 3-D.”

To further assist researchers in applying cyber infrastructure and visualization technologies to improve research and scholarship, construction is underway for the Laboratory for Advanced

Visualization and Applications (LAVA). LAVA will research, develop and commercialize visual analysis technologies and train current and future generations of students, faculty and companies in the skill of big data visualization.

According to Leigh, the future goal of LAVA is to attract funding to research and develop the next generation of CAVE2 technology for Hawai‘i, called CANOE (Collaborative, Analytics, Navigation and Observation Environment).

Source: Eric R. Matsunaga, University of Hawai‘i Office of the Vice President for Research and Innovation - May 7, 2014

C-MORE: Center for Microbial Oceanography: Research and Education

At less than a hundredth of the thickness of a strand of human hair, marine microorganisms are small in stature—but their impact on life is enormous in comparison.



C-MORE Hale

Photo credit: UH

“Marine microorganisms sustain planetary survival. They produce most of the oxygen we breathe,” said David M. Karl, director for the Center for Microbial

Oceanography: Research and Education (C-MORE) at the University of Hawai‘i at Mānoa (UH Mānoa). “They capture solar energy, produce food and sequester carbon dioxide, yet we are largely ignorant about how they live and interact.”

It is this ignorance on the part of science that has led Karl to delve deeper into one of the ocean’s last remaining mysteries. Invisible to the naked eye, marine microbes produce nearly half of the Earth’s oxygen supply. They consume many pollutants of human activities and serve as the base of the marine food chain. Unlocking the secrets of these infinitesimal sea creatures and their roles in nature, will have a tremendous impact on the environment, marine industries and medicine.

A microbial biologist and oceanographer in UH Mānoa’s School of Ocean and Earth Science and Technology, Karl was instrumental in the establishment of an open ocean time-series station, known as HOT Station ALOHA, in the subtropical North Pacific as a sentinel for observing the effects of climate on the structure and function of microbial communities. He has participated in more than 100 major oceanographic cruises and submersible dives around the world to identify new microbes that live in harsh environments.

Since joining UH Mānoa in 1978, Karl has been principal investigator on more than 80 grants bringing over \$70 million in federal and foundation funds to the University. Additionally, he has brought in over \$50 million to support various research vessels and submersibles used in his own research.

In 2006, Karl was awarded a 10-year \$36.8 million National Science Foundation (NSF) grant that led to the establishment of C-MORE, one of only 17 NSF Science and Technology Centers in the nation. C-MORE is an interdisciplinary partnership led by UH Mānoa that includes the Massachusetts Institute of Technology (MIT), University

of California at Santa Cruz, Woods Hole Oceanographic Institution, Oregon State University, Columbia University and the Monterey Bay Aquarium Research Institute.

In 2010, the center moved into its 27,000-square-foot permanent home located in UH Mānoa's newest research facility, the Daniel K. Inouye C-MORE Hale, named after the late U.S. senator from Hawai'i.

"Senator Inouye was a champion of C-MORE because he was impressed by UH's world-class expertise in microbial oceanography," said Vassilis L. Syrmos, vice president for Research and Innovation at the University of Hawai'i. "He also understood the importance of this research, its significance to the environment and its future potential in healthcare and other industries."

C-MORE investigators are recognized leaders in the field and their research has appeared in over 600 scientific papers and published in many leading journals. It is also home to four elected members of the National Academy of Sciences (NAS), including Karl, C-MORE Co-Director Edward DeLong, and MIT's Sallie Chisholm and Ed Boyle. Karl, Chisholm and Woods Hole's John Waterbury are also recipients of NAS medals of distinction. In 2013, President Barack Obama presented Chisholm with the National Medal of Science, the nation's highest honor in science and engineering, for her research on the ocean phytoplankton *Prochlorococcus* — the world's smallest, yet most abundant, photosynthetic organism.

In addition to its primary research function, C-MORE has taken an active role in increasing scientific literacy about microbial oceanography among the general population, as well as training microbial oceanographers. It offers undergraduate internships, a summer graduate training course, a Native Hawaiian outreach program and provides resources for K-12 educators, including training workshops, science kits, and a teacher-at-sea program.

"C-MORE was created to explore the enormous and mostly uncharted biodiversity in the sea," added Karl. "But it is the dedicated efforts and accomplishments of our investigators and staff that garnered us international attention and helped us to establish the University of Hawai'i as the world's leading institution in microbial oceanography."

In June of last year, the Simons Foundation awarded Drs. Edward DeLong and David Karl, \$40 million to lead the Simons Collaboration on Ocean Processes and Ecology (SCOPE), making it the largest private foundation gift UH has ever received. SCOPE is one of the programs of the Simons Foundation's division of Life Sciences, which aims to advance basic research in life sciences.

"We are incredibly grateful to the Simons Foundation for this remarkable investment in Ed's and Dave's work," said David Lassner, president of the University of Hawai'i. "Private funding is increasingly essential to our ability to recruit, retain and support our world-class faculty so that UH can advance research and innovation in Hawai'i."

Source: Eric R. Matsunaga, University of Hawai'i
Office of the Vice President for Research and
Innovation - May 9, 2014



The Daniel K. Inouye College of Pharmacy

Encouraging better health care throughout the Pacific



Sketch of the Daniel K. Inouye College of Pharmacy, which is currently under construction.

Photo credit: UH

"Build it and they will come" is often attributed to the

famous baseball film *Field of Dreams*, but it also fittingly describes the remarkable story of the Daniel K. Inouye College of Pharmacy (DKICP) at the University of Hawai'i at Hilo.

In the movie, its main character set out to build a baseball field in an Iowa cornfield. For UH Hilo, its protagonist was the late U.S. senator from Hawai'i and his dream to establish a pharmacy school in Hilo.

"Building a high-quality college of pharmacy on Hawai'i island was part of Senator Inouye's vision to encourage better health care throughout the Pacific region and throughout the neighbor islands of Hawai'i," said Donald Straney, UH Hilo chancellor. "His vision was that each neighbor island would harbor a center of excellence, that every island should have its own specialty. The specialty for Hawai'i island envisioned by Senator Inouye was our own college of pharmacy."

Opening doors to its first cohort of 90 students in August 2007, DKICP's humble beginnings were literally and figuratively true. Spread across over five different locations, the administration was housed in a county building a few miles away that was built in 1920, research labs were located seven miles out of town in buildings constructed in the 1960s and temporary classrooms were located on the campus outskirts.

Despite these less than ideal arrangements, DKICP flourished to become one of the fastest growing programs in the UH System with enrollment reaching 360 students in its first five years of existence. In 2012, a year after graduating its inaugural class and in its first year of eligibility, the college was ranked as one of the top five new schools of pharmacy by U.S. News & World Report. Much of this success can be attributed to the leadership of John Pezzuto, founding dean of DKICP, who was recently presented with the 2014 Volwiler Research Achievement Award for his outstanding research and contributions to the field of natural product drug discovery. It is the American Association of Colleges of Pharmacy's top research award.

"Despite the many challenges and hurdles that Dean Pezzuto and his staff have had to overcome in establishing a college of pharmacy from the ground up, they have successfully met every benchmark set," said Matthew Platz, vice chancellor for Academic Affairs at UH Hilo. "His knowledge, leadership and vision make it very viable for us to set our sights on becoming one of the top 25 pharmacy schools in the nation."

DKICP has added to its doctor of pharmacy program with a bachelor of arts in pharmacy studies, a master of science in clinical psychopharmacology and a doctor of philosophy in pharmaceutical sciences. Plans are in the works offer a doctorate in physical therapy as well.

As the only college of pharmacy in the Pacific region accredited by the Accreditation Council for Pharmacy Education, DKICP has brought in more than \$50 million of economic activity per year in the state, according to an independent study by UH Hilo Economic Professor David Hammes. Also contributing to economic development is the work being done by faculty researchers to expand the state's research capacity. UH Hilo's researchers are working on drug development to fight malaria; ways to reverse the progression of cancerous tumors; understanding diseases of the central nervous system; the cellular process implicated in many diseases; disease tolerance in native Hawaiian bird populations; antitumor drug development; and drugs for use in tuberculosis and malaria. These projects, funded by the National Institutes of Health, allow UH Hilo to collaborate with UH Mānoa on biomedical research, strengthening research capacity not only for the DKICP but for the entire state.

DKICP is also working to save millions of dollars in Hawai'i health care costs. One its most successful programs is Pharm2Pharm, a pharmacist-care system established in 2012. The \$14.3 million federally funded program is designed to reduce medication-related hospitalizations and emergency room visits by establishing teamwork between hospital and community pharmacists in rural counties of Hawai'i Island, Maui and Kauai. The program, developed by Professor Karen Pellegrin, founding director of the Center for Rural Health Sciences, is expected to save over \$27 million across the state.

For UH Hilo, the holidays arrived early this year courtesy of the state legislature. This past April, lawmakers approved \$33 million in funding for the University to proceed with the construction of a permanent building to house the Daniel K. Inouye College Pharmacy. The funds were released by the lieutenant governor's office in October.

Build it and they will come.

Source: Eric R. Matsunaga, University of Hawai'i Office of the Vice President for Research and Innovation - May 23, 2014

Prospective Motion Correction Technology for MRI

Advanced technology allows MRI scans in children and patients who move



Magnetic Resonance Imaging (MRI) has revolutionized the practice of medicine by giving physicians the unparalleled capability to evaluate the structure, physiology and function of the living human brain. Despite continuing advances in image quality and acquisition speeds, current MRI examinations can easily be compromised by a patient's movement.

It is estimated that one in five MRI scans are repeated due to patient movement, costing the global healthcare industry over \$2 billion annually.

However, a new prospective motion correction technology for MRI developed by Thomas Ernst, a professor and physicist at the University of Hawai'i at Mānoa's John A. Burns School of Medicine (JABSOM),

may soon eliminate these staggering industry losses and give physicians razor-sharp images for more accurate diagnoses.

This state-of-the-art technology involves a marker that is placed on the patient's head and allows the imaging to continuously track and adjust to the patient's movements in real-time, yielding brain images that are unaffected by motion. Its application is extremely useful for patients who are unable to control their movement during a scan, particularly children and the elderly, and those suffering from head trauma, dementia, and Parkinson's disease and brain tumors. Ernst's technology will also help reduce the need to sedate patients agitated by anxiety or pain, further decreasing costs and increased risks.

"The corrections are very fast and they are highly accurate," said Ernst. "You can actually see people breathe when they are in the scanner."

Ernst and the JABSOM Neuroscience and Magnetic Research team developed the motion-correction technology in collaboration with investigators at the University of Wisconsin-Milwaukee, the Medical College of Wisconsin, the University of Freiburg and the University of Magdeburg. The project was made possible with the support of a \$3.6 million multi-year grant from the National Institute of Health.

To help commercialize the technology, a startup company called KinetiCor, Inc. was created in 2012 through funding from the University of Hawai'i Upside Venture Fund, the Hawai'i Medical Service Association and the Queen's Development Foundation.

"Blurring caused by patient motion remains one of the last unsolved problems in MR imaging and the largest challenge for obtaining quality images," said Jeffrey Yu, president and CEO of KinetiCor, Inc. "We are excited to be the University of Hawai'i's commercialization partner to bring this compelling technology to market."

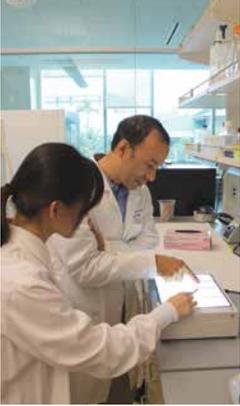
KinetiCor currently has its advanced prospective motion correction prototypes installed at a number of leading national and international magnetic resonance research centers, including the University of Minnesota's Center for Magnetic Resonance Imaging and Washington University in St. Louis. It has several world-renowned MR research centers are in its pipeline and has garnered the interests of MRI systems manufacturers looking to incorporate KinetiCor's technology into their MR scanners. It is ultimately aiming to receive clearance of the technology by the Food and Drug Administration for routine clinical MRI use.

"Prospective motion correction will have a huge impact for clinical MRI," added Ernst. "With potential cost savings on the order of \$2 billion per year, MRI scans may eventually become less expensive and therefore more affordable, which means more people can benefit from an MRI."

Source: Eric R. Matsunaga, University of Hawai'i Office of the Vice President for Research and Innovation - May 1, 2014

University of Hawai'i Cancer Center

Hawai'i becomes focal point between Asia and the U.S. in the fight against cancer



Dr. Charles Rosser

Photo credit: UH Cancer Center

The University of Hawai'i Cancer Center, in partnership with The Queen's Medical Center via the Hawai'i Cancer Consortium, is launching a new national clinical drug trial looking at the effectiveness of a promising new drug against non-muscle invasive bladder cancer, the most common type of bladder cancer with very high recurrence rates.

Unlike other national drug trials based on the mainland, this clinical trial is based in Hawai'i and is among the first to highlight

Hawai'i as a growing healthcare center and focal point between Asia and the U.S. in the fight against cancer. The project also highlights the specialty inpatient unit at Queen's, where these early clinical trials can be safely performed.

"The medical community does not yet have an effective means of preventing bladder cancer from recurring with currently available treatments," said Professor Charles Rosser, a UH Cancer Center urologist and principal investigator of the trial. "Finding an effective treatment would go a long way toward preventing more people from suffering from this disease."

The trial will examine the efficacy of ALT-803, a drug created by Florida-based Altor BioScience Corp. In early studies, the drug showed strong potential to stimulate the body's immune system and create a protective and long-lasting effect against tumors. Altor BioScience has received a \$1.2 million Small Business Innovation Research grant from the National Cancer Institute to test ALT-803 against non-muscle invasive bladder cancer for this Phase I/II trial.

Patients will be treated at Queen's, in a six-bed unit located on the oncology floor. Queen's has the only inpatient clinical trials unit focusing on translational research in Hawai'i, in particular Phase I/II trials. "This is the beginning of many future endeavors partnering with the UH Cancer Center to bring new cancer treatments/trials to Hawai'i," said Darlena Chadwick, vice president of patient care at Queen's. "Thanks to the establishment of the Hawai'i Cancer Consortium, we are able to attract and recruit innovative researchers like Dr. Rosser, who will engage and work with our local physicians in order to bring their new treatments to the people of Hawai'i."

Source: University of Hawai'i System News - August 20, 2014

Hawai'i Statewide Research and Education Partnership

JABSOM awarded \$18.4 million grant to foster biomedical careers

The University of Hawai'i at Mānoa John A. Burns School of Medicine (JABSOM) has been awarded \$18.4 million over five years for a "Hawai'i Statewide Research and Education Partnership" (HISREP) under the IDeA Networks for Biomedical Research Excellence (INBRE) program at the National Institute of General Medical Sciences.

The Hawai'i INBRE program has been supported for over 10 years by the National Institutes of Health and has recently received an additional five years of support. The current grant will be devoted to fostering biomedical careers among students at our partner institutions. The partner institutions include the University of Hawai'i at Hilo's Daniel K. Inouye College of Pharmacy, UH Maui College, Chaminade University, Hawai'i Pacific University, and the UH community colleges (Kapi'olani CC, Windward CC, Leeward CC, Hawai'i CC and Kaua'i CC).

In the previous round of INBRE funding, development of state-of-the-art facilities and support for entry-level junior investigators were provided at our primarily undergraduate-based partner institutions in order to help create a foundation where students can participate in cutting-edge biomedical research. A major emphasis for the research among our partners will be to bank on the unique resources in Hawai'i with regard to marine and plant life for discovery of natural products with potential application as biomedicines. A second emphasis will be to investigate health disparities arising in our unique and highly diverse population.

According to Dr. Robert Nichols, principal investigator, "Students in our program, who may, in fact, be the first in their family to attend college, now have the exciting opportunity to pursue biomedical research as a career.

In conjunction with activities in the basic and clinical sciences including our other IDeA program Centers of Biomedical Research Excellence (COBREs) in Cardiovascular Research, Infectious Disease and Reproductive Biology, our Research Center for Minority Institutions (RCMI), our RCMI Clinical Translational Research Center (RCTR RMATRIX) and our Center for Native and Pacific Health Disparities Research (CNPHDR), INBRE III-HISREP will help nurture the next generation of biomedical scientists across our islands," Dr. Nichols said.

Source: Tina Shelton in UHMedNow News - October 6, 2013

Hawai'i Natural Energy Institute

Innovating the future of clean energy maintenance and regulations



Hawai'i benefits from abundant sunshine, consistent winds, and reliable currents and tides. Despite these features making it a prime energy source, Hawai'i is one of the most oil-dependent states in the country, and this is partly due to inherent fluctuation in weather patterns that could leave one section of Hawai'i underpowered. Smart grids can address these issues by making sure power can be automatically regulated and redistributed. This capability would not only allow for more efficient maintenance, but it could also allow energy to redistribute itself to other locations, eliminating the wasted energy that is lost during storage. Smart grids are a nascent technology, however, and require much more research to optimize its capabilities and minimize adverse effects.

The Hawai'i Natural Energy Institute (HNEI) is focusing on this smart grid solution by leveraging their interdisciplinary access to the best minds in energy solutions, as well as their collaborations with several major electric companies on the Hawaiian Islands. Energy companies and research institutes expect to see a 300 percent rise in renewable energy generation over the next 15 years, and HNEI is working hard to develop an infrastructure to maintain and accommodate Hawai'i's increasing energy independence.

One of the projects HNEI is developing is the Smart Grid Inverter to mitigate adverse impacts of high penetrations of photovoltaic (PV) systems onto electric grids. This project is funded by the U.S. Department of Energy (DOE) and the SEGIS-AC Program Office. The development and demonstration of the new inverter technology developed under this project will help to significantly reduce the integration and interconnection costs of future distributed PV systems, improve grid reliability for high-penetration PV, and aid commercialization of smart inverters.

In collaboration with the Maui Electric Company (MECO), the Maui Smart Grid Project seeks to demonstrate the application of smart technology for helping greater renewable energy utilization and providing a variety of benefits for the MECO grid and its customers. MECO will achieve reduced costs, increased system reliability, improvements in power quality, and distribution and transmission system benefits. MECO customers will also have reduced costs and a more reliable utility. Successes in this project will yield similar benefits for utilities on the mainland facing problems with increased levels of renewable sources online.

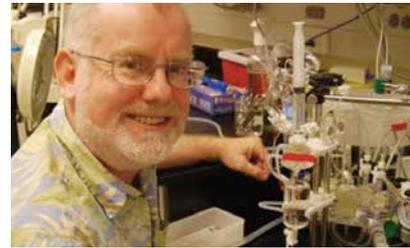
The Hawai'i Natural Energy Institute, located on the campus of the University of Hawai'i at Mānoa, was established by the Legislature in 1974, in the aftermath of the world's first oil crisis, to seek new forms of energy that would supplant the nation's tremendous dependence

on fossil fuels. HNEI has become an acknowledged international leader in the energy field, and has broadened its expertise to encompass the development of technologies that will enable us to tap our oceans for energy, food, minerals, and other resources.

Source: Hawai'i Natural Energy Institute's Smart Grid Project - June 20, 2014

Center for Cardiovascular Research

JABSOM becomes the focal point for cardiovascular investigation in Hawai'i



Ralph Shohet, MD
Photo credit: JABSOM CCR

The John A. Burns School of Medicine's (JABSOM) Center for Cardiovascular Research (CCR) has become the focal point for cardiovascular research in the

state of Hawai'i. Under the direction of Ralph V. Shohet, MD, the CCR has grown to become an interdisciplinary research and education institution, employing over 30 faculty, fellows, technicians, and graduate and medical students with a focus on the following:

Investigating heart and blood vessel diseases. Understanding how the heart and blood vessels respond to stress is the Center's central goal. Five principal investigators lead research in different aspects of cardiac function. These include the genetic response to low oxygen levels, how inflammation affects the heart and blood vessels, how diabetes damages the cardiovascular system, and how different kinds of cells in the heart "choose their fate."

Developing new therapies. Researchers are investigating ways to improve gene therapy to treat diseases. For example, they are developing a new technology that directs genes to the heart and other organs, using microbubbles as a delivery system. The surface of the bubbles is loaded with DNA that will express a therapeutic gene and these bubbles are popped as they pass through the heart using low frequency sound waves.

Training students, new investigators, and clinicians. The Center trains graduate students, postdoctoral fellows and young investigators to develop the skills required to become independent investigators. They have also developed an innovative program to teach high school biology teachers about modern techniques in molecular biology. The CCR also provides research training for the new cardiology fellows at Queen's Medical Center, who represent the next generation of cardiologists in Hawai'i.

Since Shohet's arrival in 2005, the National Institutes of Health (NIH) has recognized the CCR's excellence with awards of more than \$20 million to support recruitment of new faculty, training of young investigators, core equipment and technologies required for molecular medicine, and ongoing research. Last year, Shohet was awarded an NIH training grant, the first at the JABSOM, to support graduate students and postdoctoral fellows in the CCR.

Exciting research is underway and more advances are on the horizon, as CCR researchers are collaborating with an international network of investigators looking for greater understanding and improved prevention and treatment of heart disease.

"Every day we improve our understanding of how our heart works, how it goes wrong, and how to prevent and cure problems," said Shohet. "These discoveries, involving what are the leading cause of death and disability in our community, are really what drive us and keeps us tap-dancing into work each morning."

Source: John A. Burns School of Medicine Center for Cardiovascular Research

New Heart Failure Prevention Compounds

JABSOM researcher develops new therapy that allows heart to maintain its function to prevent failing



Alexander Stokes, PhD
Photo credit: JABSOM

Biotech startup Makai Biotechnology LLC is licensing technology from the University of Hawai'i to develop new cardiovascular drugs aimed at treating and

preventing heart failure. Alexander Stokes, an assistant professor of cell and molecular biology at the John A. Burns School of Medicine (JABSOM), developed the science for the drugs.

Stokes worked on identifying a new target and set of effective therapeutic compounds for the treatment and prevention of cardiac hypertrophy, heart failure, and associated pathologies. Makai Biotechnology LLC was recently formed by Stokes and David G. Watumull, who serves as senior advisor and is also the CEO of Cardax, Inc., a publicly held life sciences company. Patent rights are pending.

Many types of diseases ultimately affect the heart by making it work harder. The heart muscle compensates by getting bigger (cardiac hypertrophy). The heart becomes stiffer and less functional, and eventually starts to fail.

"We have a way of protecting the heart with a completely new therapeutic approach," Stokes said. "This new therapy will allow the heart to compensate for the extra work it needs to perform, without losing function and failing."

The new treatment method focuses on the regulation of the ion channel TRPV1. This ion channel is best known for being activated by capsaicin, the hot component of chili peppers. Stokes' lab at JABSOM recently published data that reveals that in pre-clinical trials, inhibition of TRPV1 with a small molecule compound can protect the heart from the pathological and functional changes associated with cardiac hypertrophy, heart failure and associated pathologies.

Makai Biotechnology LLC is licensing intellectual property from the University of Hawai'i's Office of Technology Transfer & Economic Development (OTTED). Makai Biotechnology LLC plans to establish alliances with major pharmaceutical companies to develop and test compounds from pre-clinical through phase II human clinical trials.

Funding for the pre-clinical studies was provided through grants awarded by the National Institutes of Health (NIH) and the Hawai'i Community Foundation, totaling approximately \$1 million over five years, ending 2015. One of the NIH grants was part of the Research Multidisciplinary and Translational Research Infrastructure Expansion (RMATRIX) program designed to aid translational research at JABSOM.

"It is a science researcher's dream to translate their work from the laboratory bench to the patient's bedside," said JABSOM Dean Jerris Hedges. "The research underway by Dr. Stokes exemplifies this opportunity and advances our most important goal—which is to provide results that will make life better for patients in Hawai'i."

"The collaboration between Dr. Stokes and Makai Biotechnology in developing and commercializing research that started at the University of Hawai'i could ultimately end up saving many lives," said UH Vice President for Research and Innovation Vassilis L. Symros. "This kind of partnership is an example of UH's commitment to building the state's research industry and diversifying our local economy via the Hawai'i Innovation Initiative."

Source: Tina Shelton in UHMedNow News - May 11, 2014

UH Mānoa Satellite Lab

Student-designed and -built satellite in orbit puts UH in rarified air



Professor Wayne Shiroma and students of the UH Mānoa College of Engineering watch the launch of the Air Force rocket carrying the satellite they helped build.

Photo credit: University of Hawai'i

On November 19, 2013, a U.S. Air Force Minotaur 1 rocket blasted off into orbit carrying a little bit of Aloha and a lot of history with it. In the payload bay was a nanosatellite call Ho'oponopono 2, or H2, constructed entirely by graduate and undergraduate engineering students at the UH Mānoa Satellite Lab.

When it safely reached orbit, H2 became the first UH-built satellite to circle the Earth and joined an elite group of student-designed orbiters to reach space. It was also the culmination of over three years of design and construction by over 30 students in the cutting-edge program established at UH Mānoa by Electrical Engineering Professor Wayne Shiroma in 2001.

With dimensions comparable to a loaf of bread, H2's experimental mission is to perform radar calibration and performance monitoring for U.S. Department of Defense radar stations that track various objects in space. That task was previously carried out for the past 20 years by RADCAL, a satellite that is 20 times larger and whose mission was 40 times more expensive than the \$220,000 cost of H2.

Source: Eric R. Matsunaga, University of Hawai'i Office of the Vice President for Research and Innovation – March 2014

Hawai'i Space Flight Laboratory

A multidisciplinary space mission center



Successful test firing of the LEONIDAS rocket motor

Photo credit: HSFL

The Hawai'i Space Flight Laboratory (HSFL) was established in May 2007 within the School of Ocean and Earth Science and Technology (SOEST) and the College of Engineering (CoE) at the University of Hawai'i at Mānoa. As a multidisciplinary research and education center, HSFL brings together individuals from diverse areas to work on the exploration and understanding of the space environment. HSFL aims to:

- Promote innovative engineering and science research for terrestrial and planetary space missions
- Develop, launch, and operate small spacecraft from the Hawaiian Islands to accelerate the validation of new space technologies
- Provide workforce training in all aspects of unmanned space missions
- Build synergistic collaborations among educational, governmental, and corporate institutions interested in space exploration

Source: HSFL

University of Hawai'i to Conduct Cyberinfrastructure Research

Partners with Clemson University on a \$5.3 million initiative to study advanced computing resources



The new high-performance computing cluster is the first to leverage the capabilities of the Information Technology Center at UH Mānoa.

Photo Credit: Kaunana: The Research Publication of the University of Hawai'i

The University of Hawai'i is one of the founding partners of a new initiative led by Clemson University to enable a national network of Advanced Cyberinfrastructure Research and Education Facilitators (ACI-REFs) that will broaden research and education impacts of advanced computing resources at campuses across the country.

Advanced cyberinfrastructure refers to high-performance computing systems, massive data storage systems and visualization environments, all linked together by software and high-performance networks to enable human collaborations that improve education and research productivity and enable breakthroughs not otherwise possible.

The National Science Foundation awarded the group \$5.3 million over two years to broaden cyberinfrastructure education and outreach through this network. In addition to Clemson and UH, the other collaborating institutions are the University of Southern California, the University of Utah, the University of Wisconsin and Harvard University.

"Data-intensive science and engineering is a major thrust for the Hawai'i Innovation Initiative, and the advanced cyberinfrastructure facilitator capability that will be supported is exactly what we need to help many of our gifted faculty and students take their scholarship to the next level by leveraging local and national cyberinfrastructure and collaborations," said UH President David Lassner.

Source: University of Hawai'i System News - March 6, 2014

Intelligent Energy Management Technician Training Program

Preparing the Nation's Workforce for the New Energy Technology Ecosystem



Smartphones, smart buildings and other intelligent technologies are quickly shaping today's world and will play a substantial role in future technologies and related industries. Maintaining a highly skilled and trained workforce to maintain these complex systems is crucial, especially in the intelligent or "smart-grid" power utilities sector.

Responding to this challenge, the Pacific Center for Advanced Technology Training (PCATT) established the Intelligent Energy Management Technician Training Program, the first national curriculum developed to prepare technicians for careers in smart-grid technology. PCATT, headquartered at Honolulu Community College, is a consortium of the University of Hawai'i Community Colleges that provides leadership and training in advanced technologies to enhance economic and workforce development programs and initiatives in the state of Hawai'i.

Development of PCATT's smart-grid curriculum was made possible by an \$833,000 U.S. Department of Energy (DOE) Smart Grid Workforce Development grant awarded to the consortium in 2010. The program was one of 33 projects selected by DOE to receive \$41.6 million in American Recovery and Reinvestment Act funds for the development of new training programs, strategies and curricula related to the electric power and smart grid sectors.

These select programs chosen to receive funding included projects at universities, community colleges and technical schools that served as models for training or retraining workers across the U.S. The awards also included support for Strategic Training and Education in Power Systems (STEPS) initiatives to develop cross-disciplinary electric power system programs at the university and college level.

Creation of the program required the mobilization of utility and power systems experts, program managers, educational specialists and administrators to map out the education and training requirements to develop this innovative curriculum. This huge undertaking involved the development and/or modification of 21 undergraduate courses to address foundations in power engineering technology and the emerging fields in distribution automation. As a result, PCATT offers two associate degrees and three certificates in intelligent energy systems.

“This program has positioned us to direct the training trajectory for the next generation workforce in Hawai'i and abroad,” said Scott Murakami, director of Workforce Development at UH Community Colleges and former director of PCATT. “It has also contributed significantly to our ability to prepare the local workforce to embrace the future of intelligent energy systems.”

To further enhance program training, an intelligent grid management laboratory was established at Leeward Community College's Office of Continuing Education and Workforce Development. It provides students with experience in managing a distributed power generation system in a realistic, real-time environment to help develop critical problem solving skills and solutions in time-sensitive situations involving brown and black outs.

“Our analysis indicates that the existing smart grid curriculum developed by University of Hawai'i represents content identified by both smart grid experts and broader energy workforce experts,” said Joselito Lualhati and Christopher Anderson, grant commissioned evaluators from Global Skills X-change. “In particular, the results indicate that UH Community College system's smart grid curricula address the skill gaps expressed by smart grid workforce experts across the country.”

Options that are being evaluated for next phase of the Intelligent Energy Management Technician Training Program grant include an expanded curriculum in areas of cyber and physical security, alternate power sources (wave, geothermal, nuclear), interoperability of micro grids; and the development of a national repository for smart grid instructional materials.

Source: Eric R. Matsunaga, University of Hawai'i Office of the Vice President for Research and Innovation – June 9, 2014

Applied Research Laboratory at the University of Hawai'i

Conducting vital national research today to meet tomorrow's critical security challenges

The Applied Research Laboratory at the University of Hawai'i (ARL/UH) serves as a research center of excellence for critical Navy and national defense science, technology and engineering with a focus on naval missions and related areas. As a designated Navy-sponsored research laboratory administered by the University of Hawai'i System, ARL/UH conducts strategic research for the Navy, the Department of Defense and other government agencies in the areas of astronomy, ocean science, remote sensing, electro optics, and engineering support to sensors, communications and information technology. It is one of 13 University Affiliated Research Centers (UARC) within the Department of Defense and one of five centers contracted with the Navy.

In September, the Office of Naval Research contracted with ARL/UH on \$2.5 million energy research project to develop a power grid modernization strategy and action plan to meet the future needs of the Navy in Hawai'i, with a special focus on the reliability and power quality demands of electrical service to Joint Base Pearl Harbor-Hickam. The project will be conducted by the Hawai'i Natural Energy Institute's (HNEI) Grid System Technologies Advanced Research Team (GridSTART), which is focused on the integration and analysis of energy technologies and power systems, including smart grid and micro grid applications. Earlier this year, ARL/UH and HNEI received \$9 million from the Naval Facilities Engineering Command to support industry testing of wave energy conversion devices at the Wave Energy Test Site located

off Marine Corp Base Hawai'i (MCBH). When cabled to shore and connected to MCBH's power grid, the site will become the first grid-connected wave energy test site in the United States.

Source: ARL/UH

Daniel K. Inouye Solar Telescope

World's largest solar telescope will provide new answers in solar physics

When completed in 2019, Hawai'i will be home to the largest and most powerful solar telescope in the world, with unprecedented abilities to view details of the Sun. The Daniel K. Inouye Solar Telescope (DKIST*) aptly reflects the late senator's forward-thinking commitment to science and technology.



Using adaptive optics technology, DKIST will be able to provide the sharpest views ever taken of the solar surface, which will allow scientists to learn even more about the Sun and solar-terrestrial interactions. Astronomers will also be able to discover new information for understanding how our nearest star works, and for protecting the nation's vital space-based assets, the power grid and communication and weather satellites.

One of the many barriers of astrophysics is that solar physicists have to cope with “atmospheric seeing.” Looking through Earth's atmosphere is similar to looking from the bottom of a swimming pool. Without corrective measures, current ground-based solar telescopes can reveal structures no smaller than a few hundred kilometers across the surface of the Sun. Orbiting telescopes have perfect “seeing” environments but are expensive and have limited lives.

A larger telescope, like the DKIST, would solve this optical resolution problem and is anticipated to be a powerful tool for U.S. and international solar physics communities as their main ground-based facilities for several decades. Additionally, a ground-based telescope would mean that upgrades are easily and inexpensively installable as technology updates and progresses in the upcoming years.

“Funding for the construction of the DKIST is being provided by the National Science Foundation. Approximately half of the construction funding was received from the American Recovery and Reinvestment Act. Development of the DKIST on Haleakalā will employ local construction firms and personnel in the erection of its structure and offer local high tech jobs during construction and the multi-decade operations phase of the facility,” says Dr. Joseph McMullin, DKIST program director.

The DKIST also represents a collaboration of 22 institutions.

*The DKIST will also be known as the Advanced Technology Star Telescope (ATST), and is located at the Haleakalā High Altitude Observatory.

Source: DKIST/ATST (NSO) - June 20, 2014

Pacific Missile Range Facility Barking Sands

*World's largest instrumented,
multi-environment testing range*



The Pacific Missile Range Facility (PMRF) Barking Sands is the world's largest instrumented multi-environment range capable of supporting surface, subsurface, air, and space operations simultaneously. There are more than 1,100 square miles of instrumented underwater range and more than 42,000 square miles of controlled airspace. This makes PMRF a premier facility for supporting operations which vary from small, single-unit exercises up to large scale, multiple-unit battle group scenarios.

The mission of PMRF is to facilitate training, tactics development, and test and evaluations for air, surface, and sub-surface weapons systems and advanced technology systems. PMRF provides the full spectrum of instrument range support, including; radar, underwater instrumentation, telemetry, electronic warfare, target remote command and control, communications, target launching facilities, data display, data processing and target/weapon launching and recovery facilities.

The headquarters and primary operation center of PMRF occupies approximately 1800 acres and is located on the western shore of the island of Kaua'i. PMRF features a state-of-the-art instrumentation suite and communication network.

The PMRF range includes broad ocean areas to the north, south, and west with varying water depths from 400 to 2,500 fathoms. PMRF's relative isolation, ideal year-round tropical climate, and encroachment-free environment are significant factors in PMRF's excellent record for operation completions. PMRF's proximity to major Department of Defense installations and organizations, and to University of Hawai'i's ocean research facilities on Oahu, presents major cost and operational benefits to the range user. Transportation of project personnel, equipment, and materials is easily accommodated via commercial or military systems.

Source: PMRF

The Natural Energy Laboratory of Hawai'i Authority

*Economic development through renewable and
ocean-based resources*



The mission of the Natural Energy Laboratory (NELHA) is to develop and diversify the Hawai'i economy by providing resources and facilities for energy and ocean-related research, education, and commercial activities in an environmentally sound and culturally sensitive manner.

The state of Hawai'i has invested over \$100 million since 1974 to create HOST Park, a unique outdoor demonstration site for emerging renewable and ocean-based technologies. Three sets of pipelines deliver deep sea water from a depth of 3,000 feet, as well as pristine sea surface water. Solar insolation is among the highest for coastal areas in the United States. The innovative green economic development park is administered by NELHA, a state of Hawai'i agency administratively attached to DBEDT. After three decades, NELHA is well on track to fulfilling its mission as an engine for economic development.

NELHA tenants employ over 300 people. Among them, 36 percent (or 117 employees) work for tenants who are either in research or education-related fields. Over a quarter of NELHA's tenants are involved in research activities. For example, larger research-oriented entities at NELHA are Cellana Inc.—a developer of algae-based biofuels and bio-products; Moana Technologies LLC focuses on research and development in biotechnology; and the University of Hawai'i's Infrasound Laboratory, which provides and develops technical expertise in the field of low frequency acoustics and conducts research into acoustic source processes.

The estimated impact of NELHA's in-state expenditures in 2010 on the state's output (sales), earnings, and tax revenues was estimated to be \$87.7, \$24.7, and \$4.5 million, respectively. Furthermore, not only do NELHA tenants employ hundreds of people, but their expenditures also contribute to hundreds of other jobs in the larger Hawai'i economy (583 total, including NELHA employees). Finally, NELHA receives on average about \$2 million per year from the state. One way to look at the state's return on these expenditures is to consider what the state's investment has provided in terms of the net impact from NELHA. Every dollar the state spends on NELHA generates \$42.8 of output in the Hawai'i economy.

"NELHA holds a unique place in the Pacific for energy and distributed energy applied research, demonstration, test and evaluation, and deployment of clean energy technologies. NELHA possesses an extraordinary combination of physical infrastructure and access to natural energy resource. (...) This strategic location makes NELHA the ideal clean energy R&D through deployment test bed on Hawai'i Island." (Pacific International Center for High Technology Research, March 2013, NELHA Distributed Energy Strategy Update)

Source: NELHA and OTEC International

Maui High Performance Computing Center

A national resource for high performance computing



The Maui High Performance Computing Center (MHPCC) Department of Defense Supercomputing Resource Center (MHPCC DSRC), established in 1993, is an Air Force research laboratory (AFRL) center managed by the University of Hawai'i under contract to the Air Force Research Laboratory's Directed Energy Directorate at Kirtland Air Force Base, New Mexico. The MHPCC DSRC operates as one of the five Supercomputing Resource Centers in the Department of Defense's (DoD) High Performance Computing Modernization Program (HPCMP). The MHPCC DSRC allocates more than 70,000,000 computational hours annually to the HPCMP Research, Development, Test, and Evaluation community.

The MHPCC DSRC provides computational resources for the DoD's scientific computational needs through their support of "Challenge Projects" and other government users. The Center also supports the Directed Energy Directorate's Maui Space Surveillance System. Located atop 10,000-foot Mt. Haleakala, the Space Surveillance System is used for imaging and tracking of space objects.

The MHPCC DSRC is a national resource at the forefront of high performance computing and has established itself as a leader in DoD research and development community. Chartered to support a diverse base of DoD and other government users, the MHPCC DSRC is facilitating the collaborations needed to solve tomorrow's complex computational problems today.

Source: MHPCC, Maui Now

The Oceanic Institute

Hawai'i Pacific University Completes Merger to Bring the Oceanic Institute Formally Into the University



The Oceanic Institute (OI) focuses on aquaculture, biotechnology, shrimp husbandry, and coastal resource management. The institute is reputable for its work in feed development. This Waimanalo-based nonprofit research and development organization merged with Hawai'i Pacific University in 2014, making it a major player in the research arm of the state's largest private university.

"This is a merger that makes great sense for both OI and HPU," said HPU President Geoffrey Bannister. "Oceanic Institute's successes in integrating and leveraging the research of various departments within the institute will help to inspire additional multi-disciplinary research within the university. HPU will benefit through the ability of faculty and students throughout the university to study and conduct research at OI."

Appendix

Selection of Innovation Industries

UHERO created an initial cut of innovation industries for use in the Hawai'i Innovation Assets Report using the following definitions:

Definitions:

Innovation industries are industries that have a high concentration of either high-tech or creative workers.

The definition of high-tech occupations borrows from the list of "technology-oriented workers" defined by Daniel Hecker (2005). His definition includes the following occupations and occupation groups:

- Computer and Mathematical Occupations (SOC 15-000)
- Engineers (SOC 17-2000)
- Drafters, Engineering, and Mapping Technicians (SOC 17-3000)
- Life Scientists (SOC 19-1000)
- Physical Scientists (SOC 19-2000)
- Life, Physical, and Social Science Technicians (SOC 19-4000)
- Computer and Information Systems Managers (SOC 11-3020)
- Architectural and Engineering Managers (SOC 11-9040)
- Natural Science Managers (SOC 11-9120)

The definition of creative workers borrows from the definition of the "super creative core" in Florida et. al (2008). Specifically, we include art, design, entertainment, sports, and media occupations (SOC 27-0000). In contrast to Florida, we exclude education, training and library occupations.

Data:

EMSI "Inverse Staffing Patterns" Occupation-Industry crosswalk. Dataset used is QCEW + Non-QCEW + Self-Employed.

Selection Criteria:

Nationally, high-tech jobs account for ~5.1% of total jobs. Creative jobs account for ~1.7% of total jobs.

Using data for the U.S. as whole, an industry is identified as an innovation industry if either of the following is true:

- The share of high-tech workers in the industry as a proportion of total industry employment is more than three times the national average (~15.3%).
- The share of creative workers in the industry as a proportion of total industry employment is more than three times the national average (~5.1%).

The three times threshold used above is the one applied in the HiSciTech Institute 2008 report on Hawai'i's Technology workforce.

Initial Results:

127 industries meet the criteria for high-tech occupational concentration, 92 industries meet the criteria for creative occupational concentration, and six industries meet both. In total 213 unique industries are selected as innovative.

	INDUSTRIES	HAWAI'I JOBS	HAWAI'I ESTABLISHMENTS
High-Tech	127	33,734	3,222
Creative	92	34,279	3,709
Total	213	67,578	6,877

Modifications:

Following the HiSci Tech report, UHERO suggested including seed corn research and excluding civil engineering firms. In addition, UHERO suggested keeping fossil fuel electric power generation in the list of technology industries and excluding all federal, state, and local government agencies from selection.^{23,24}

This list was compared to a list of innovation industries used by San Diego CONNECT in their study of the San Diego innovation economy. CONNECT worked closely with UHERO to compile a list of industries defined by the North American Industry Classification System (NAICS). Previous reports and studies by DBEDT and other organizations were

reviewed in consideration of industries classified as technology or creative sectors. CONNECT's experience measuring and the innovation economy in San Diego and other regions was the primary subjective determinant in designating industry sectors as "core tech" or "peripheral tech."

What CONNECT defines as "core" are those industries that are primarily engaged in technology research and development of manufactured products as well as professional and technical services. Examples include industries such as biotechnology, pharmaceuticals and biomedical product development, communications technology and information services, commercial physical research/scientific, technical services, computer and electronics manufacturing, software development, aerospace and defense, and energy.

A broader sector includes those industries that utilize technologies and facilitate their application to providing goods and services in the economy but whose focus is not developing new or next generation technologically innovative products. Examples here include medical laboratories, diagnostic imaging centers, wireless communications carriers, broadcasting and publishing, and engineering services.

In their 2012 study Hawai'i's Technology Workforce Occupations and Projections, DBEDT reported that while the core of the technology sector may be technical occupations, the technology sector is also highly dependent on administrative and managerial support occupations.

The creative sector industries included in this report were selected from the list of creative industries identified by both DBEDT and UHERO.

The CONNECT team and HBR's Research and Innovation Task Force discussed both lists and agreed upon the following list of 135 industries as being representative of both the technology and creative sectors of Hawai'i's innovation economy. The CONNECT team then grouped the 135 industries into 18 broader industry groups:

NAICS Code	Category	Industry Name	Industry Sector
512190	CREATIVE	Postproduction Services and Other Motion Picture and Video Industries	Audio & Visual Media Production & Distribution
512240	CREATIVE	Sound Recording Studios	Audio & Visual Media Production & Distribution
334612	CREATIVE	Prerecorded Compact Disc (except Software), Tape, and Record Reproducing	Audio & Visual Media Production & Distribution
512110	CREATIVE	Motion picture and video production	Audio & Visual Media Production & Distribution
512120	CREATIVE	Motion Picture and Video Distribution	Audio & Visual Media Production & Distribution
512210	CREATIVE	Record Production	Audio & Visual Media Production & Distribution
512220	CREATIVE	Integrated Record Production/Distribution	Audio & Visual Media Production & Distribution
512230	CREATIVE	Music Publishers	Audio & Visual Media Production & Distribution
512290	CREATIVE	Other Sound Recording Industries	Audio & Visual Media Production & Distribution

23 Hecker, Daniel. 2005. "High-technology employment: a NAICS-based update", BLS Monthly Labor Review, (July), 57-72.

24 Florida, R, C Mellander, and K Stolarick. 2008. "Inside the Black Box of Regional Development--Human Capital, the Creative Class and Tolerance." Journal of Economic Geography 8 (5) (July 21): 615-649.

NAICS Code	Category	Industry Name	Industry Sector
333314	CORE	Optical Instrument and Lens Manufacturing	Biomedical Products
334510	CORE	Electromedical and Electrotherapeutic Apparatus Manufacturing	Biomedical Products
334516	CORE	Analytical Laboratory Instrument Manufacturing	Biomedical Products
334517	CORE	Irradiation Apparatus Manufacturing	Biomedical Products
337127	CORE	Institutional Furniture Manufacturing (e.g., hospital operating rooms; labs furniture)	Biomedical Products
339112	CORE	Surgical and Medical Instrument Manufacturing	Biomedical Products
339113	CORE	Surgical Appliance and Supplies Manufacturing	Biomedical Products
339114	CORE	Dental equipment and supplies manufacturing	Biomedical Products
339115	CORE	Ophthalmic goods manufacturing	Biomedical Products
339116	CORE	Dental laboratories (manufacturing)	Biomedical Products
621511	PERIPHERAL	Medical Laboratories	Biomedical Products
621512	PERIPHERAL	Diagnostic Imaging Centers	Biomedical Products

NAICS Code	Category	Industry Name	Industry Sector
111150	CORE	Corn farming	Biotechnology, Pharmaceuticals and Chemicals
311223	CORE	Other oilseed processing	Biotechnology, Pharmaceuticals and Chemicals
325199	CORE	All Other Basic Organic Chemical Manufacturing	Biotechnology, Pharmaceuticals and Chemicals
325211	CORE	Plastics material and resin manufacturing	Biotechnology, Pharmaceuticals and Chemicals
325221	CORE	Cellulose organic fiber manufacturing	Biotechnology, Pharmaceuticals and Chemicals
325314	CORE	Fertilizer, mixing only, manufacturing	Biotechnology, Pharmaceuticals and Chemicals
325320	CORE	Pesticide and other agricultural manufacturing	Biotechnology, Pharmaceuticals and Chemicals
325411	CORE	Medicinal and Botanical Manufacturing	Biotechnology, Pharmaceuticals and Chemicals
325412	CORE	Pharmaceutical Preparation Manufacturing	Biotechnology, Pharmaceuticals and Chemicals
325413	CORE	In-Vitro Diagnostic Substance Manufacturing	Biotechnology, Pharmaceuticals and Chemicals
325414	CORE	Biological Product (except Diagnostic) Manufacturing	Biotechnology, Pharmaceuticals and Chemicals
541711	CORE	Research and Development in Biotechnology	Biotechnology, Pharmaceuticals and Chemicals

NAICS Code	Category	Industry Name	Industry Sector
813910	PERIPHERAL	Business Associations	Business and Professional Associations
813920	PERIPHERAL	Professional Organizations	Business and Professional Associations

NAICS Code	Category	Industry Name	Industry Sector
541712	CORE	Commrc'l Phys Rsrch	Commercial physical research/Scientific & Technical & Non-Technical Services
541990	CORE	All Other Professional, Scientific, and Technical Services	Commercial physical research/Scientific & Technical & Non-Technical Services
541720	PERIPHERAL	Research and Development in the Social Sciences and Humanities	Commercial physical research/Scientific & Technical & Non-Technical Services

Appendix

NAICS Code	Category	Industry Name	Industry Sector
334210	CORE	Telephone Apparatus Manufacturing	Communications Technology & Information Services
334220	CORE	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	Communications Technology & Information Services
334290	CORE	Other Communications Equipment Manufacturing	Communications Technology & Information Services
517400	CORE	Satellite Telecommunications	Communications Technology & Information Services
511110	PERIPHERAL	Newspaper Publishers	Communications Technology & Information Services
511120	PERIPHERAL	Periodical Publishers	Communications Technology & Information Services
511130	PERIPHERAL	Book Publishers	Communications Technology & Information Services
511140	PERIPHERAL	Directory and Mailing List Publishers	Communications Technology & Information Services
511191	PERIPHERAL	Greeting Card Publishers	Communications Technology & Information Services
511199	PERIPHERAL	All Other Publishers	Communications Technology & Information Services
515111	PERIPHERAL	Radio Networks	Communications Technology & Information Services
515112	PERIPHERAL	Radio Stations	Communications Technology & Information Services
515120	PERIPHERAL	Television Broadcasting	Communications Technology & Information Services
515210	PERIPHERAL	Cable and Other Subscription Programming	Communications Technology & Information Services
517110	PERIPHERAL	Wired Telecommunications Carriers	Communications Technology & Information Services
517200	PERIPHERAL	Wireless Telecommunications Carriers (except Satellite)	Communications Technology & Information Services
517919	PERIPHERAL	All Other Telecommunications	Communications Technology & Information Services
519110	PERIPHERAL	News Syndicates	Communications Technology & Information Services
519190	PERIPHERAL	All Other Information Services	Communications Technology & Information Services

NAICS Code	Category	Industry Name	Industry Sector
518200	CORE	Data Processing, Hosting, and Related Services	Computer & Electronics
334111	CORE	Electronic Computer Manufacturing	Computer & Electronics
334112	CORE	Computer Storage Device Manufacturing	Computer & Electronics
334119	CORE	Other Computer Peripheral Equipment Manufacturing	Computer & Electronics
334310	CORE	Audio and Video Equipment Manufacturing	Computer & Electronics
334413	CORE	Semiconductor and Related Device Manufacturing	Computer & Electronics
334416	CORE	Electronic Coil, Transformer, and Other Inductor Manufacturing	Computer & Electronics
334418	CORE	Printed Circuit Assembly (Electronic Assembly) Manufacturing	Computer & Electronics
334419	CORE	Other Electronic Component Manufacturing	Computer & Electronics
334515	CORE	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	Computer & Electronics

NAICS Code	Category	Industry Name	Industry Sector
334511	CORE	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	Defense and Aerospace
336411	CORE	Aircraft Manufacturing	Defense and Aerospace
336412	CORE	Aircraft Engine and Engine Parts Manufacturing	Defense and Aerospace
336413	CORE	Other Aircraft Part and Auxiliary Equipment Manufacturing	Defense and Aerospace
336414	CORE	Guided missile and space vehicle mfg.	Defense and Aerospace
336415	CORE	Space vehicle propulsion units and parts mfg.	Defense and Aerospace
336419	CORE	Other guided missile and space vehicle parts	Defense and Aerospace

NAICS Code	Category	Industry Name	Industry Sector
541410	CREATIVE	Interior Design Services	Design Services
541420	CREATIVE	Industrial Design Services	Design Services
541430	CREATIVE	Graphic Design Services	Design Services
541490	CREATIVE	Other specialized design services	Design Services

NAICS Code	Category	Industry Name	Industry Sector
221111	CORE	Hydroelectric Power Generation	Energy
221112	CORE	Fossil Fuel Electric Power Generation	Energy
221114	CORE	Solar Electric Power Generation	Energy
221115	CORE	Wind Electric Power Generation	Energy
221116	CORE	Geothermal Electric Power Generation	Energy
221117	CORE	Biomass Electric Power Generation	Energy
221118	CORE	Other Electric Power Generation	Energy
221119	CORE	Other Electric Power Generation *	Energy

*the 2012 NAICS code changes involved some conversions to new NAICS and some data cannot be compared. For example a firm classified previously as NAICS code 221119, Other Electric Power Generation may now be classified under NAICS 221114, Solar Electric Power Generation; 221115, Wind Electric Power Generation; 221116, Geothermal Electric Power Generation; 221117, Biomass Electric Power Generation; or 221118, Other Electric Power Generation.

NAICS Code	Category	Industry Name	Industry Sector
541330	CORE & PERIPHERAL	Engineering Services (allocated 15% to core and 85% to peripheral)	Engineering Services
541310	PERIPHERAL	Architectural services	Engineering Services
541320	PERIPHERAL	Landscape architectural services	Engineering Services
541340	PERIPHERAL	Drafting Services	Engineering Services
541360	PERIPHERAL	Geophysical surveying and mapping services	Engineering Services
541370	PERIPHERAL	Surveying and Mapping (except Geophysical) Services	Engineering Services
541380	PERIPHERAL	Testing laboratories	Engineering Services

*Engineering services firms include a broad range of companies. Fifteen percent of the engineering firms were involved with more research and technology development activities and the remaining 85 percent were more utilizers of existing technologies in their business activities.

NAICS Code	Category	Industry Name	Industry Sector
112500	CORE	Agribusiness (aquaculture production)	Environmental Technology
334512	CORE	Automatic Environmental Control Manufacturing for Regulating Residential, Commercial, and Appliance Use	Environmental Technology
334513	CORE	Instruments and Related Product Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	Environmental Technology
541620	CORE	Environmental Consulting Services	Environmental Technology

NAICS Code	Category	Industry Name	Industry Sector
541810	CREATIVE	Advertising Agencies	Marketing & Related Services
541820	CREATIVE	Public Relations Agencies	Marketing & Related Services
541830	CREATIVE	Media Buying Agencies	Marketing & Related Services
541840	CREATIVE	Media Representatives	Marketing & Related Services
541850	CREATIVE	Display Advertising	Marketing & Related Services
541860	CREATIVE	Direct Mail Advertising	Marketing & Related Services
541870	CREATIVE	Advertising Material Distribution Services	Marketing & Related Services
541890	CREATIVE	Other Services Related to Advertising	Marketing & Related Services
541921	CREATIVE	Photography Studios, Portrait	Marketing & Related Services
541922	CREATIVE	Commercial Photography	Marketing & Related Services

NAICS Code	Category	Industry Name	Industry Sector
541614	PERIPHERAL	Process, Physical Distribution, and Logistics Consulting Services	Other Business, Market and Technical Consulting Services
541690	PERIPHERAL	Other Scientific and Technical Consulting Services	Other Business, Market and Technical Consulting Services
541910	PERIPHERAL	Marketing Research and Public Opinion Polling	Other Business, Market and Technical Consulting Services
541611	CREATIVE	Administrative Management Consulting Services	Other Business, Market and Technical Consulting Services
541612	CREATIVE	Human Resources Consulting Services	Other Business, Market and Technical Consulting Services
541613	CREATIVE	Marketing Consulting Services	Other Business, Market and Technical Consulting Services
541618	CREATIVE	Other Management Consulting Services	Other Business, Market and Technical Consulting Services

NAICS Code	Category	Industry Name	Industry Sector
611610	CREATIVE	Fine Arts Schools (Private)	Performing Arts & Related Creative
711110	CREATIVE	Theater Companies and Dinner Theaters	Performing Arts & Related Creative
711120	CREATIVE	Dance Companies	Performing Arts & Related Creative
711130	CREATIVE	Musical Groups and Artists	Performing Arts & Related Creative
711190	CREATIVE	Other Performing Arts Companies	Performing Arts & Related Creative
711310	CREATIVE	Promoters of Performing Arts, Sports, and Similar Events with Facilities	Performing Arts & Related Creative
711320	CREATIVE	Promoters of Performing Arts, Sports, and Similar Events without Facilities	Performing Arts & Related Creative
711410	CREATIVE	Agents and Managers for Artists, Athletes, Entertainers, and Other Public Figures	Performing Arts & Related Creative
711510	CREATIVE	Independent Artists, Writers, and Performers	Performing Arts & Related Creative

NAICS Code	Category	Industry Name	Industry Sector
511210	CORE	Software Publishers	Software
541511	CORE	Custom Computer Programming Services	Software
541512	CORE	Computer Systems Design and Related Services	Software
519130	PERIPHERAL	Internet Publishing and Broadcasting and Web Search Portals	Software
611420	PERIPHERAL	Computer Training (Private)	Software

NAICS Code	Category	Industry Name	Industry Sector
315200	CORE	Apparel manufacturing (to be allocated at 65%)	Sport and Active Lifestyle
316210	CORE	Athletic shoes manufacturing	Sport and Active Lifestyle
336991	CORE	Motorcycle, bicycle, parts manufacturing	Sport and Active Lifestyle
339920	CORE	Sporting and Athletic Goods Manufacturing	Sport and Active Lifestyle
711211	CREATIVE	Sports Teams and Clubs	Sport and Active Lifestyle
711219	CREATIVE	Other Spectator Sports	Sport and Active Lifestyle

NAICS Code	Category	Industry Name	Industry Sector
911000	CORE	US Federal (science, tech, engineering & math occupations only)	US Federal (science, tech, engineering & math occupations only)

Note: U.S. federal STEM jobs in Hawai'i numbered 5,840 in 2013.

According to the 2013 EMSI data, several of the industries included the list above did not have any establishments or employees, and these were thus excluded from the report. Industries with less than 10 employees were also excluded.

New Company Formation

In order to determine the number of new companies established in the innovation section, Dun & Bradstreet data were analyzed using the NAICS codes selected in the list above for the years 2006 through 2013. The companies were assigned to one of the 15 industry groups and designated as "core tech", "peripheral tech" or "creative sector."

In addition, the D&B data included street address and city/county location information. These data were used to determine the number of new companies created in Hawai'i by county.

Featured Research and Innovation Companies

The research projects that are featured in the Hawai'i Innovation Assets Report were chosen by HBR's Research and Innovation Task Force and CONNECT to provide an overview of prominent examples of the research excellence and impact in Hawai'i.

Similarly, the companies featured in the report were selected to provide several examples of commercial innovation across a range of key emerging and more established technology industry sectors in the state.

Entrepreneurial Programs

The programs included in this section of the report were selected by CONNECT and reviewed by HBR's Research and Innovation Task Force to provide examples of new initiatives being pursued by the state and the private sector to provide both funding and other types of support to entrepreneurs in Hawai'i.

Industry and Government Associations

The industry and government associations included in this report provide support and other services to startups, small to medium sized businesses and larger business establishments across a wide range of industry sectors. UHERO provided the initial list of organizations and this list was reviewed and finalized by HBR's Research and Innovation Task Force.

EMSI Employee Data Presented in the Innovation Assets Report²⁵

Explanation of Employees & Proprietors

Two important distinctions that will help better understand the data. EMSI datasets are primarily concerned with those workers who are classified as either "employees" or "proprietors."

- **EMPLOYEES** – Employees are often referred to as simply "wage and salary workers." This includes workers receiving wages and salaries, as well as those working for commission, tips, pay-in-kind, and other similar forms of payment. These workers can be employed by any public or private organization. Government workers, regardless of the industry or agency (federal, state and local) are also considered employees. People who work for all incorporated private organizations (for-profit and non-profit) are also considered employees.
- **PROPRIETORS** – Broadly speaking, any worker who does not fall into the "employee" category will be considered a proprietor. In technical

25 <http://www.economicmodeling.com/2012/07/09/emsi-data-update-four-new-categories/>; accessed November 5, 2014.

terms, anyone who files Schedule C (Profit or Loss from Business), Schedule F (Profit or Loss from Farm), or Form 1065 (U.S. Return of Partnership Income) is considered a proprietor. These are people who work for their own unincorporated business, practice, or farm. It is important to note that people who work for their own incorporated businesses are considered wage and salary workers for their own companies, and are thus not considered proprietors. In addition, all partners in a business partnership are considered proprietors and counted individually.

New Categories

These are four new categories that create a better way to present the data. Deacon James, VP of Data Products at EMSI, said of the changes, "The four classes provide clearer distinctions between types of workers, allowing our customers to find exactly what they need. I have been looking forward to releasing these additional worker breakouts for some time now."

1. QCEW

This is simply unsuppressed QCEW²⁶.

2. NON-QCEW EMPLOYEES

This set is other groups who are not captured by QCEW, but who still count as employees. This includes railroad, military, some non-QCEW federal government workers, UI-exempt non-profits, and a few other miscellaneous categories. This is particularly helpful for evaluating those military and government sectors that can dominate regional economies.

Advantages of this set: When paired with QCEW, this shows complete picture of employment in the region.

3. SELF-EMPLOYED

These are self-employed workers who count their self-employed work as their primary source of income.

Advantages of this set: A growing number of industries (see below) are composed of the self-employed. If you are just using QCEW to evaluate the industries, you might be missing a lot of jobs.

4. EXTENDED PROPRIETORS

These are workers who are counted as proprietors, but classify the income as peripheral to their primary employment. Many industries include people who are considered sole proprietors or part of a partnership, yet have little or no involvement or income in the venture. And an increasing number of people fall into this category (e.g., those who do freelance work on the side, like writers or musicians) and now you will be able to see who they are more clearly.

Advantages of this set: This set is most useful when combined with the other three categories to get a complete picture of all proprietor and employee income.

Supplemental Tables and Charts

Hawai'i Innovation Start-ups: Core, Peripheral/Facilitator, Creative Sectors: 2010-2013

	2010			
	Number of Startups	Startups as Percent of Total	Number of Jobs	Jobs as Percent of Total
CORE TECHNOLOGY SECTORS	552	42%	1,149	41%
PERIPHERAL/FACILITATOR TECHNOLOGY SECTORS	245	19%	547	20%
CREATIVE SECTORS	527	40%	1,091	39%
Total	1,324	100%	2,787	100%

	2011			
	Number of Startups	Startups as Percent of Total	Number of Jobs	Jobs as Percent of Total
CORE TECHNOLOGY SECTORS	275	42%	557	43%
PERIPHERAL/FACILITATOR TECHNOLOGY SECTORS	147	22%	338	26%
CREATIVE SECTORS	238	36%	403	31%
Total	660	100%	1,298	100%

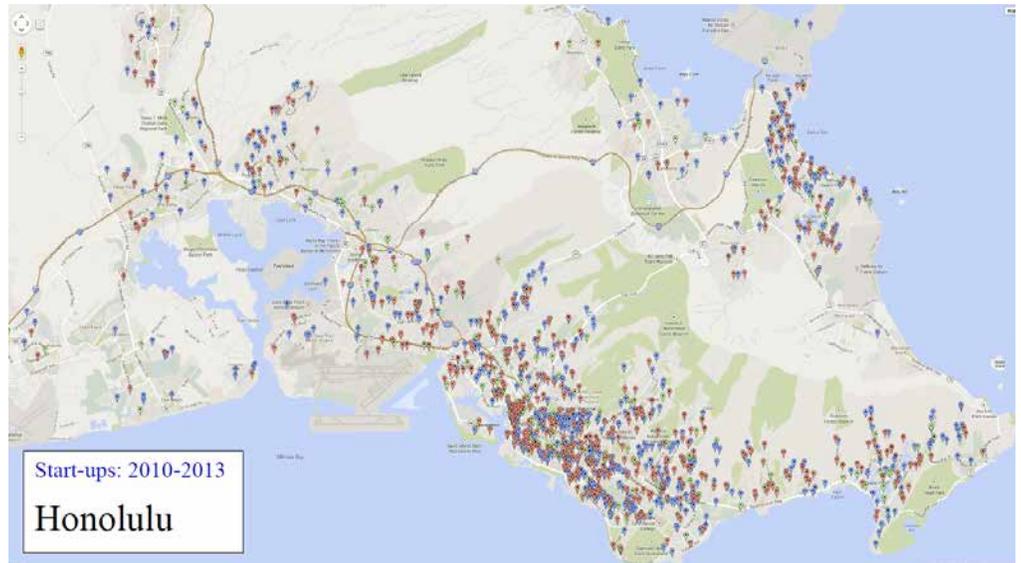
	2012			
	Number of Startups	Startups as Percent of Total	Number of Jobs	Jobs as Percent of Total
CORE TECHNOLOGY SECTORS	108	33%	194	33%
PERIPHERAL/FACILITATOR TECHNOLOGY SECTORS	80	24%	163	27%
CREATIVE SECTORS	138	42%	237	40%
Total	326	100%	594	100%

	2013			
	Number of Startups	Startups as Percent of Total	Number of Jobs	Jobs as Percent of Total
CORE TECHNOLOGY SECTORS	78	36%	113	25%
PERIPHERAL/FACILITATOR TECHNOLOGY SECTORS	54	25%	164	36%
CREATIVE SECTORS	84	39%	179	39%
Total	216	100%	456	100%

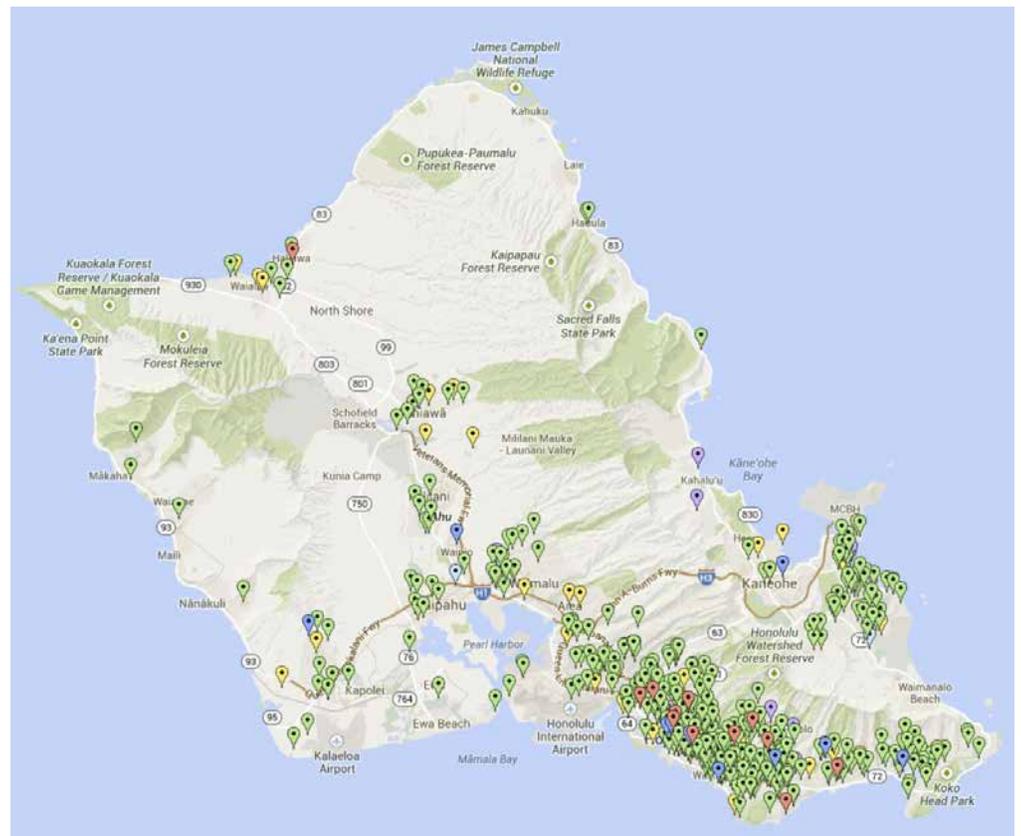
26 The Quarterly Census of Employment and Wages (QCEW) program publishes a quarterly count of employment and wages reported by employers covering 98 percent of U.S. jobs, available at the county, MSA, state and national levels by industry.

Honolulu Innovative Technology & Creative Start-ups

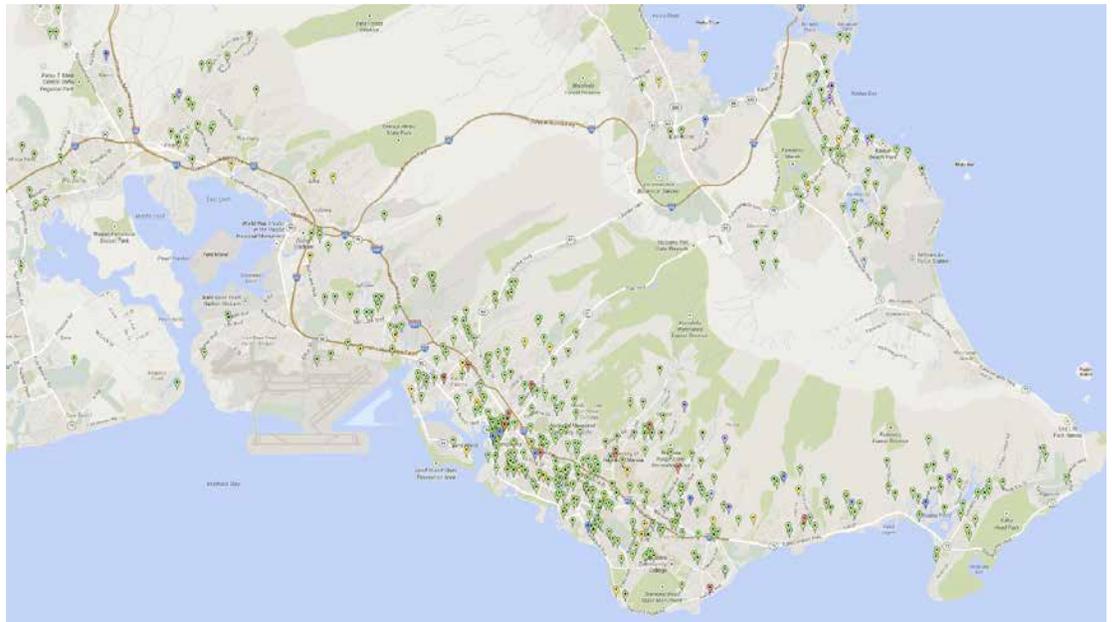
New Company Formation
2010-2013: Core Technology,
Peripheral Technology,
Creative Sector



Oahu: Innovative Technology
& Creative Sector Companies
by industry Sector



Honolulu: Core Technology start-up Companies by industry sector — 2010–2013



Venture Capital Investment – Hawai'i²⁷

	deals	investment	percent of total investments
Q1 1996	1	\$ 394,000	0.10%
Q4 1996	2	\$ 20,150,000	5.05%
Q2 1997	2	\$ 700,000	0.18%
Q4 1997	2	\$ 796,000	0.20%
Q2 1998	1	\$ 3,800,000	0.95%
Q3 1998	1	\$ 600,000	0.15%
Q4 1998	1	\$ 65,000	0.02%
Q2 1999	2	\$ 12,550,000	3.14%
Q3 1999	1	\$ 200,000	0.05%
Q3 2000	1	\$ 6,000,000	1.50%
Q4 2000	2	\$ 197,000,100	49.32%
Q1 2001	2	\$ 34,811,000	8.72%
Q3 2001	3	\$ 3,000,000	0.75%
Q2 2002	1	\$ 2,900,000	0.73%
Q4 2002	1	\$ 1,495,000	0.37%
Q1 2003	1	\$ 778,000	0.19%
Q2 2003	1	\$ 166,000	0.04%
Q3 2003	1	\$ 1,000,000	0.25%
Q4 2003	4	\$ 15,885,000	3.98%
Q1 2004	2	\$ 8,065,000	2.02%
Q4 2004	3	\$ 5,625,000	1.41%
Q1 2005	2	\$ 1,055,000	0.26%
Q2 2005	2	\$ 1,150,000	0.29%
Q4 2005	2	\$ 12,349,800	3.09%

	deals	investment	percent of total investments
Q1 2006	1	\$ 6,600,000	1.65%
Q2 2006	3	\$ 1,845,000	0.46%
Q3 2006	2	\$ 1,410,000	0.35%
Q4 2006	5	\$ 25,058,000	6.27%
Q1 2007	1	\$ 200,000	0.05%
Q2 2007	2	\$ 3,200,000	0.80%
Q3 2007	1	\$ 1,500,000	0.38%
Q4 2007	2	\$	0.00%
Q2 2008	2	\$ 6,100,000	1.53%
Q3 2008	1	\$ 300,000	0.08%
Q4 2008	4	\$ 1,100,000	0.28%
Q1 2009	2	\$ 7,093,000	1.78%
Q4 2009	1	\$ 271,000	0.07%
Q1 2010	1	\$ 4,200,000	1.05%
Q3 2010	2	\$ 5,299,900	1.33%
Q1 2011	1	\$ 600,000	0.15%
Q2 2011	1	\$	0.00%
Q3 2011	1	\$	0.00%
Q1 2012	1	\$ 645,000	0.16%
Q4 2012	2	\$	0.00%
Q3 2013	1	\$ 1,760,000	0.44%
Q4 2013	2	\$ 709,000	0.18%
Q1 2014	2	\$ 271,000	0.07%
Q2 2014	1	\$ 350,000	0.09%
Q3 2014	1	\$ 350,000	0.09%

27 Source: PwC/NVCA MoneyTree™ Report, Data: Thomson Reuters

Although not included in the main report SBIR and STTR grants awarded to Hawai'i companies are listed here:

The Technology Program Office administers the Small Business Innovation Research (SBIR) Program and the Small Business Technology Transfer (STTR) Program. Through these two competitive programs, SBA ensures that the nation's small, high-tech, innovative businesses are a significant part of the federal government's research and development efforts. Eleven federal departments participate in the SBIR program; five departments participate in the STTR program awarding \$2 billion to small high-tech businesses.²⁸ Hawai'i companies were awarded more than \$8 million in funding in 2013.

Title	Agency	Branch	Program	Year	Phase	Award Amount	SBC	City
Uncued Faint Object Detection in LEO and GEO	DOD	DOD	SBIR	2013	2	\$729,865	Pacific Defense Solutions, LLC	Kihei
Feature Identification from Unresolved Electro-optical Data	DOD	DOD	SBIR	2013	2	\$740,259	Pacific Defense Solutions, LLC	Kihei
Self Powered Biosensors	DOD	DOD	SBIR	2013	1	\$149,995	Archinoetics, LLC	Honolulu
Compact Full-Framing Hyperspectral Sensor for On-The-Move Ground-to-Ground Applications	DOD	ARMY	SBIR	2013	1	\$99,988	Spectrum Photonics, Inc.	Honolulu
Next Generation Passive Hearing Protection	DOD	DOD	SBIR	2013	1	\$80,000	Oceanit Laboratories, Inc.	Honolulu
Field Drying System using no power for clothing and boots	DOD	DOD	SBIR	2013	1	\$150,000	Oceanit Laboratories, Inc.	Honolulu
Integrated or Fused Multi-spectral Sensor Technologies for Missile Warning Sensors (MWS), Hostile Fire Indication (HFI), and Laser Warning (LW)	DOD	DOD	SBIR	2013	2	\$750,000	Oceanit Laboratories, Inc.	Honolulu
Submarine Radar Vulnerability Reduction	DOD	DOD	SBIR	2013	1	\$80,000	Oceanit Laboratories, Inc.	Honolulu
Wide Spectral Band Laser Threat Sensor	DOD	NAVY	STTR	2013	1	\$80,000	Oceanit Laboratories, Inc.	Honolulu
Synthesis of Active Passivation for Aluminum Nanoenergetics via Micro-emulsion based chemical route	DOD	DOD	SBIR	2013	1	\$150,000	Oceanit Laboratories, Inc.	Honolulu
Nanostructured Thermal Interface Materials for Power System Components	DOD	DOD	SBIR	2013	1	\$150,000	Oceanit Laboratories, Inc.	Honolulu
GPS-Denied Positioning Using Networked Communications	DOD	DOD	SBIR	2013	1	\$150,000	Oceanit Laboratories, Inc.	Honolulu
Dive Helmet Noise Quieting	DOD	NAVY	STTR	2013	2	\$500,000	Oceanit Laboratories, Inc.	Honolulu
Space Signatures for Rapid Unambiguous Identification of Satellites	DOD	DARPA	SBIR	2013	1	\$100,000	Oceanit Laboratories, Inc.	Honolulu
Improved Coupling Factor of Personal Cooling Systems	DOD	DOD	SBIR	2013	2	\$750,000	Oceanit Laboratories, Inc.	Honolulu
Physics-Based Models for Transient Behavior of Two Phase Flow Cooling Systems	DOD	USAF	SBIR	2013	2	\$750,000	Oceanit Laboratories, Inc.	Honolulu
Optimization Algorithm to Enhance Antenna Array Beamforming for Radar and Early Warning (EW) Application	DOD	USAF	SBIR	2013	2	\$750,000	Oceanit Laboratories, Inc.	Honolulu
Ultra-Wideband Radio Frequency (RF) Vector Signal Generator for Early Warning (EW) Applications	DOD	DOD	SBIR	2013	2	\$749,080	Oceanit Laboratories, Inc.	Honolulu
Signal Isolation w/ Frequency Tuning Filter (SIFTer)	DOD	ARMY	SBIR	2013	1	\$99,858	TeraSys Technologies LLC	Honolulu
A Software Suite for Integrated Design of Aerodynamic Shape, Structural Topology, Subsystem Topology, and Structural Sizing of Air Vehicles	DOD	DOD	SBIR	2013	2	\$748,859	Hawaii Evolutionary Development llc	Kula
CAN THE "BLASTER" IMPROVE THE PROFITABILITY, ENVIRONMENTAL HEALTH AND EXPANSION OPPORTUNITIES FOR MARINE AQUACULTURE?	USDA	USDA	SBIR	2013	1	\$99,998	KAMPACHI FARMS, LLC	Kailua Kona
Semi-Autonomous, Reliable, Safe Recovery of the Remote Multi-Mission Vehicle (RMMV) in Various Sea States.	DOD	DOD	SBIR	2013	1	\$79,997	Creative Technology Applications, Inc	Kailua
SBIR Phase I: A Smartphone Incentive System to Align Electricity Demand with Intermittent Supply	NSF	NSF	SBIR	2013	1	\$150,000	Ikehu Natural, LLC	Kailua Kona
Formulating a Competitively Priced Poultry Feed in Hawai'i Rendered from Organic Wastes Using a Protein-Synthesizing, Beneficial Insect	USDA	USDA	SBIR	2013	1	\$88,168	PROTA CULTURE, LLC	Kaneohe
2013 Total						\$8,176,067		

28 <http://www.sba.gov/category/about-sba-navigation-structure/sba-programs/contracting/technology-sbirsttr>; accessed November 5, 2014.

ACKNOWLEDGMENTS

Hawai'i Innovation Assets Report

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