



HARNESSING SCIENCE AND TECHNOLOGY IN SUPPORT OF HAWAI‘I’S FUTURE

The Hawai‘i Science and Technology Plan 2020-2025

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MESSAGE FROM DR. DAVID LASSNER, PRESIDENT, UNIVERSITY OF HAWAII

David Lassner
President



UNIVERSITY
of HAWAII

Science and technology are critical to the success of Hawai'i pandemic environment. The University of Hawai'i is proud of our many partnerships with
st Hawai'i.

Our Governor, David Ige, has noted the "critical role that science and technology play in the economic and educational life of our community" and he actively encourages our young people "to reach for the stars, literally and figuratively." Hawai'i's legislature has

Foundations 10 Big Ideas, this Plan calls for our state to "surf the wave" of data science,
paying, meaningful jobs for Hawai'i

A handwritten signature in black ink that reads "David Lassner".

President, University of Hawai'i

2114 Dole Street, Bachman Hall
Honolulu, Hawai'i 96822
Telephones: (808) 956-8207
Fax: (808) 956-5206

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1. EXECUTIVE SUMMARY

Innovation and exploration have been characteristics of Hawai‘i throughout history. The first Polynesians who populated these islands were at the forefront of science and technology for their times, designing and sailing canoes and navigating by the stars in search of new land and new opportunities. They adapted to the environments they discovered by learning to live in harmony with the natural world to meet their daily needs. They experimented with new concepts to build their knowledge of the world; the same processes we call science a millennium later. This history and tradition of innovation is embedded in Hawai‘i’s diverse, multi-cultural society and represents an intangible and unique characteristic of our state. Our recent and future endeavors in scientific and technological research represent continuations of this long tradition and highlight the need for such activities to be undertaken with respect for and consideration of our indigenous culture. Working together, we can leverage Hawai‘i’s past and present to continue our long tradition of discovery and application.

This Framework is the product of a consultative process initiated via the Hawai‘i EPSCoR Statewide Science and Technology Committee and reviewed by university and community stakeholders. The updated framework responds to one of the National Science Foundation Big Ideas, *Harnessing Data for 21st Century Science and Engineering*. Data have the potential to shape Hawai‘i’s Science and Technology (S&T) future positively but harbor a looming digital divide if Hawai‘i does not strategically embrace the digital age. The driving questions for the development of this plan are:

- How can the S&T endeavor support Hawai‘i’s future health, sustainability, prosperity and social justice?
- How can the S&T endeavor in Hawai‘i be a regional and global model for synthesis of indigenous strengths, community engagement and broad societal support?
- What are key developmental needs of the State S&T endeavor to continue to grow research competitiveness, responsiveness to community priorities and inclusivity?

The framework recapitulates and updates the General Objectives from prior statewide plans, which continue to provide a focusing function for the development of S&T in Hawai‘i. New General Objectives in this edition of the framework focus on **DATA SCIENCE AND HAWAI‘I’S STEM ENDEAVOR**. This updated framework recommends that Hawai‘i pursues the strategic goals of becoming a data-rich, data-driven and data-empowered state with a globally relevant and inclusive cadre of data workers that impact economic and social sectors in support of State and regional development. Key recommendations of this plan include: **CLOSING OF DATA GAPS** that impede data driven-decision making; **GROWTH OF A DATA WORKFORCE** through training, education and reskilling; strategic investments in **CYBERINFRASTRUCTURE AND DECISION SUPPORT** facilities; and investment in **DATA SCIENCE FOR RESEARCH COMPETITIVENESS** across domains.

Key **BENCHMARKS** for this plan are increases in data workforce, research competitiveness and the ability to collect, access and use data to support statewide decision-making and economic development.

2. COMPREHENSIVE ASSESSMENT

The economy of the State of Hawai‘i has historically been driven by two components: tourism and government spending. Dependency on these two sectors has subjected the state to constant uncertainty due to fluctuations in national and global economic conditions. The current pandemic has exacerbated this exposure and brought the need for additional economic pillars to the forefront. Diversification of the economy from near complete reliance on tourism and government spending is a renewed and revitalized focus of state policy and community aspiration. This framework highlights key challenges Hawai‘i must address, and opportunities it can pursue, to further develop a sustainable economic sector based on S&T, and leverage S&T in support of current and future economic goals. It provides a pathway for sparking conversations and actions that will bring to bear the latest knowledge and technology to grow, diversify and strengthen a resilient state economy, and improve the overall quality of life for Hawai‘i residents.

2.1. HAWAI‘I’S STRATEGIC ADVANTAGES IN SCIENCE AND TECHNOLOGY

Hawai‘i’s mid-Pacific geographic location, resources and assets position the state well for strengthening and diversifying the science and technology sector, particularly in areas relating to the land, water, ocean, sky, and ethnic diversity of the islands. Each of these represents an opportunity to advance science and technology for the benefit of Hawai‘i’s people and beyond.

Hawai‘i has a favorable climate and a natural, diverse terrestrial and marine ecological environment. The islands’ volcanic origin and lack of continental shelf facilitate ready access to pathogen-free, nutrient-rich deep water and an impressive variety of marine habitats and geographies, making Hawai‘i an unparalleled natural laboratory for ocean research and development. Over 90% of the coral reefs in the United States are located in Hawai‘i, affording unprecedented opportunities to study ecosystem dynamics, while our location within the Pacific affords detailed analysis of the terrestrial, coastal and oceanic biomes. The state is also ideally situated to grow and develop many different kinds of terrestrial and ocean plants and animals, and to monitor and respond to the effects of climate change. Opportunities are therefore abundant for research in areas such as plant pathogens, invasive species management, agricultural technologies, and postharvest product development. Hawai‘i has 27 of the 38 life zones recognized on the Holdridge Life Zone System and is the most geographically isolated place on earth. It represents a unique laboratory for the study of biodiversity, evolution, ecology and adaptation, as well as a sentinel site for the study of anthropogenic impacts on natural systems and the services they provide. The clean, clear air, and significant topography of Hawai‘i affords some of the best viewing platforms in the world for astronomy and space science.

Hawai‘i’s population is one of the most ethnically diverse in the United States. It is therefore a critical location to learn about health differences and develop new interventions that serve human health and mitigate health inequity. Scientific research in health sectors such as public health, pharmaceutical development and health informatics can therefore have a positive impact on Hawai‘i’s residents, improving health care quality and delivery and reducing healthcare costs. Hawai‘i’s location means that such developments have the potential to have both local and broad Asia-Pacific impact.

Hawai‘i’s agricultural industry has a powerful historical base and was the primary industry well into the 20th century. Currently, however, almost 90% of food in the state is imported, which makes it particularly vulnerable to natural disasters or global events can disrupt the food supply chain. The state’s land and water

resources and mild climate make Hawai'i an ideal place to conduct agricultural research, cultivate food locally and pursue nutrition and culinary research and training. S&T can power solutions that support sustainable and productive agriculture, manage natural resources and connect the food supply to the health and well-being of our community.

The state's existing, more traditional industries of tourism and defense also offer a strategic advantage as they provide a base from which to build and provide new benefits to its citizens. Tourism is the strongest economic contributor to the islands; developments in S&T offer faster, greener, air and ground transportation, improved communication systems, data analytics-driven marketing and logistics, and the potential for enhanced visitor interactive experiences using augmented and virtual reality. These can ensure that Hawai'i sustains this critical industry for years to come but acknowledges the pitfalls of over-tourism and the inextricable links between the success of the tourism sector and Hawai'i's management of its ecosystems and natural resources. Similarly, the large presence of the U.S. military in Hawai'i means that the state is particularly well positioned to develop partnerships that advance the development and commercialization of dual-use technologies in areas such as clean energies, sensing, communications, aerospace and space, cybersecurity and analytics.

To further leverage these advantages, core developments or changes are required to support the S&T base. Findings from key national data sources set the context for Hawai'i's current position in the science and technology sector in relation to other U.S. states and territories and identify areas where Hawai'i needs to focus its improvement efforts.

2.2. ECONOMIC CONTEXT

Today the global economy is driven by open markets, reliable transportation and seamless communication. These attributes diminish the role of location and position Hawai'i well for participation in an economy built with strategies that focus on innovation and entrepreneurship. The new collaboration economy is increasingly central to building competitiveness and providing export opportunities that will facilitate job growth and sustainable economic prosperity.

As a geographically isolated island state, Hawai'i is especially vulnerable to fluctuations in global markets, specifically in relation to heavily imported goods such as energy or food. To address and protect against this vulnerability, we need to ensure that our economy is diverse and sustainable, that we can produce much of our own energy and food, that our citizenry is healthy, and that we can stay connected across the islands and to the rest of the world. Innovation must also permeate our legacy industries of agriculture and tourism to keep them competitive in the future, a future that requires skills in science, technology, engineering and math (STEM), as well as broad-based skills in critical and analytical thinking, effective communication, and teamwork. These challenges can be addressed by establishing an economic sector based on research and development in science and technology.

2.3. NATIONAL COMPETITIVENESS AND INDICATOR ANALYSIS

The relationship between scientific discovery and its translation into products and technologies that provide benefits to society is indisputably complex. To better understand Hawai'i's ability to compete, four nationally

recognized indexes can measure performance that gauges, in different ways, the state's performance in key areas critical to the development and sustainability of a new economy. Taken together these indicators can help guide government, academic and private sector leaders to identify opportunities and develop strategies to pursue them. The primary index rankings are presented as appendices to this framework and detailed rankings and comments can be found within the individual referenced index reports. The indexes used are:

- The Beacon Hill Institute State Competitiveness Index (BHI) identifies how well a state performs in its ability to cultivate competitiveness. It underscores the importance of human capital - well-educated workers as well as risk takers who can draw venture capital - as well as a state's commitment to strong governance and transparency. The BHI Index is based on a set of 46 indicators divided into eight sub-indexes: Government and fiscal policy, Security, Infrastructure, Human resources, Technology, Business incubation, Openness, and Environmental policy. The breadth of the BHI index distinguishes it from more narrowly focused measures of competitiveness that target only taxes, high technology, or economic freedom.
- The Kauffman State New Economy Index (KNE) uses 25 indicators to measure the extent to which state economies are structured for participation in New Economy activities and examines the degree to which they are knowledge-based, globalized, entrepreneurial, IT-driven, and innovation-based. This index focuses more narrowly on a simple question: to what degree does the structure of state economies match the ideal structure of the New Economy?
- The Milken Institute State Tech and Science Index (MS&T) represents over a decade of tracking and examining the key factors behind technology-based economic development in the United States. Since its inception in 2002, the index has provided a means to examine the components that allowed leading states to build and maintain their preeminence in high technology and enabled others to develop their strengths in the field. The index measures 78 indicators comprising five categories of factors behind technology-based economic development: Research and development, Risk capital and entrepreneurial infrastructure, Human capital investment, Technology and science workforce, Technology concentration and dynamism.
- The National Science Foundation's (NSF) National Center for Science and Engineering Statistics (NCSES) is the nation's leading provider of statistical data on the U.S. science and engineering enterprise. The Science & Engineering State Profiles provide annual data on research and development, the science and engineering workforce, the condition and progress of STEM education, and U.S. competitiveness in science, engineering, technology, and R&D.

These data sources build a picture of Hawai'i's position in science and technology with respect to other US states. The most recently available data were examined to identify trends over the last decade that help identify strengths and weaknesses in Hawai'i's S&T enterprise and new economy climate. All four indices show declines since peaking in the late 2000's when technology investments peaked under Act 221, the state's high technology tax credit.

Overall rankings place Hawai'i low in both the 2017 KNE (40th) and 2016 BHI (49th), however, in the more narrowly defined MS&T index Hawai'i ranked 35th in 2018. A key driver of the growth of high technology and research-based economic sectors is the availability of a well-trained scientific and engineering workforce. Despite Hawai'i's surprisingly high KNE ranking of 16th in Workforce Education, its rank in Scientists &

Engineers' employed in the private sector is 46th, IT Professionals 47th, and High Tech jobs 48th. Higher rankings in the BHI Human Resources (11th) and MS&T Workforce (34th) indexes that look more closely at availability of a skilled workforce and number of higher degrees, suggest an underemployed labor force in the state.

The MS&T indicators have dropped dramatically from 2008 - 18. The overall ranking has decreased by 7 to 35th in the country driven largely by a 20-point decrease in risk capital and entrepreneurial measures that determine success in converting research into commercially viable technology services and products. While the state ranks very high in the number of business incubators, #1 in 2016, it lacks general sources of funding to commercialize ideas¹. The state continues to work to recover from a steep decline (16 positions) in the 2010 Human Capital Investment Composite Index rankings, largely due to a 6.1 percent decline in state appropriations for higher education.

From 2014 through 2018, the number of Hawaiian Science and Engineering degrees conferred at all academic levels increased by 16%, from 1,208 to 1,401. The 'brain drain' of migration of S&T workers is captured in Hawai'i's overall KNE ranking of 40, and ranking for managerial, technical and professional positions is 41.

Interestingly, the ranking of knowledge workers moving into Hawai'i from outside of the state is 25th for KNE. Together these measures indicate a workforce growing from within the state and while they are noteworthy, Hawai'i is not producing enough graduates in STEM fields. In 2018, the percentage of STEM degrees conferred by academic level were: Bachelor's at 76%, Master's and Research Doctorate's at 15%, and Associate's at 9%. From 2014 to 2018, growth rates for STEM degrees conferred by academic level were: Bachelor's increased by 19%, from 890 to 1,059; Master's and Research Doctorate's decreased by 11.3% from 238 to 211; and Associate's increased 64%, from 80 to 131. At this level, the state is ranked 44 for the number of science and engineering degrees awarded per 100,000 inhabitants in the BHI Index.

Studies show that it is not the amount of capital, but the effectiveness with which it is used, that accounts for as much as 90 percent of the variation in growth of income per worker and recent efforts to align elements of innovation capacity in Hawai'i are showing promise. The state is making steady gains in measures of entrepreneurship and building a business-friendly ecosystem. Business incubation rankings went from 23 in 2016 to 43 in 2017 (BHI) rankings and the KNE Index shows that Hawai'i ranks 37 for economy dynamism and 31 for innovation capacity. The number of SBIR awards in Hawai'i has remained steady over the last 10 years averaging about 120 awards per year.²

These national rankings are reflected in DBEDT's 2019 Hawai'i's Targeted & Emerging Industries update. Hawai'i's technology industry groups are still a relatively small percentage of Hawai'i's total economy, compared with the technology industry groups at the national level. Jobs in the Declining industry group, that includes among others Information & Telecom Technology, Computer Systems Design & Related Services, and Engineering and Research & Development, totaled an estimated 38,284 in 2019 (4.3% of all civilian jobs), representing a loss of about 3,623 jobs from 2009. Average earnings of the eleven technology industry groups all exceeded the average for Hawai'i's economy. However, workers in most of the Hawai'i Technology Sector groups were not paid as much as the U.S. average for the same activities.

¹ Milken State Tech & Sci Index 2016

² NSF Science and Engineering State Profile data 2008-18

In summary, these data tell us that Hawai'i can do better to improve its standing in science and technology. Although the state is attractive as a place to work, Hawai'i is not producing enough graduates in STEM fields and still loses many of its best local students and skilled workers to other locales. The costs and difficulty of doing business are high. The cost of living is high. Salaries are not commensurate with those in other states. More must be done to attract investment and venture capital, and commercialize research outputs, especially those arising from federal research dollars. New businesses must be encouraged and nurtured with policies put in place to support their success.

3. DATA AND HAWAI'I: CHALLENGES AND OPPORTUNITIES

A DATA-RICH, DATA-DRIVEN AND DATA-RESPONSIVE STATE FUTURE. One of the National Science Foundation's '10 Big Ideas', *Harnessing Data for 21st Century Science and Engineering*, acknowledges the centrality of data to every aspect of human endeavor. The data revolution is a wave that Hawai'i can surf, or a tsunami that can engulf us. Data analytics offer a real potential for a new S&T sector in Hawai'i that requires relatively low physical infrastructure investment, has a global reach and can strengthen every type of organization in the state, from healthcare, education, business, energy, tourism, agriculture, non-profits, and the military to finance, government, sustainability and natural resource management. Equitable development of this sector will require appropriate attention to data ethics, privacy and minimizing the potential for digital divides and disenfranchisement.

Leveraging prior investments, responding to emerging needs, and minimizing redundancy with other state plans such as the State's Comprehensive Economic Development Strategy (CEDS), this 2020-25 Statewide S&T plan offers a simple vision and premise: that harnessing the data revolution is central to every aspect of Hawai'i's future development. This vision has three elements:

- a **data-driven** state, where decision support based on data is available to all stakeholders;
- a **data-rich** state where data are collected and analyzed, equitably, inclusively and with respect for privacy and agency, to transparently highlight the state's strengths, weaknesses and opportunities;
- a **data-empowered** state, where a diverse data-savvy workforce has well-paid jobs supporting every sector of the economy.

Employment and the Data Science education pipeline. Hawai'i has recognized that within Data Science (DS) and analytics lies tremendous potential for increased economic competitiveness and diversification, addressing social inequities, increased research competitiveness and improved decision support and resource allocation. Employers across economic sectors are beginning to hire, under various job titles, analysts, data specialists, statisticians, marketing analysts and communications professionals, all of whom participate in some activities that can be termed 'Data Science'. The lack of a specific Bureau of Labor Statistics code for data science hampers tracking of these opportunities but there is clear growth and expressed need for data analysts across business and non-profit sectors. There is a growing sense of urgency that Hawai'i prepare to 'surf the data wave' to avoid the potential of a digital divide that leaves the state (government, employers, community) lagging both in data jobs and the use of data to empower our growth and resilience. This urgency is illustrated by initiatives such as the Association of Hawaiian Civic Clubs 2019 Resolution to support and advocate for Data Science that addresses Hawaiian advancement and enfranchises the Native Hawaiian community into the data endeavor.

Educational institutions in the state are responding to this emerging area of need and, in parallel, advocating to students, families and communities about the importance and potential of data science as a career choice. There is a particular challenge in the fact that there are few Bureau of Labor Statistics job codes that accurately reflect the current and emerging engagement of data professionals across multiple sectors that emerge from our stakeholder engagement. In fact, employers from diverse sectors report the need for data professionals and are requesting capacity building in data science education both for traditional undergraduates and graduate degrees, as well as training programs for upskilling and reskilling of currently employed workers. Employers that are reported to have engaged with emerging educational programs in DS during the development of this plan include (but are not limited to): finance, banking and insurance, defense contracting, public utilities, natural resource managers, non-profits, sports teams, small businesses, agriculture, energy, academic researchers across domains, acute and community healthcare facilities and systems, transportation providers, tourism, educators, social non-profits, travel and tourism, the criminal justice system and the military.

A robust ecosystem of coding challenges, hackathons, computer science initiatives and curriculum development are establishing a K-12 pipeline into CS, and increasing specifically into DS, in Hawai'i. The emerging nature of the educational opportunities at the college level for DS in Hawai'i make it difficult to track or predict any enrollment trends or the strength of this pipeline, but pioneering efforts such as the Chaminade BS and certificate program in Data Science, the UH Hawai'i Data Science Institute Data Fellows program, UH Information and Computer Sciences track in Data Science, the UH Hilo Certificate program in Data Science and numerous efforts in certificate and course development in other departments (Shidler College of Business, UHM Mathematics Department, UH West O'ahu, Honolulu Community College, JABSOM) and at other campuses are evidence of progress that is now positioned to be coordinated and grown strategically. Most of these programs are embedding employer-facing internships and leveraging project-based learning to educate an employer-ready, data literate, workforce of the future.

The state of Hawai'i has been moving towards a data-rich operating environment for the State economy. Recently, Hawai'i embraced an open-data initiative with some success, moving in national rankings from C to B+ in just two years (reference). The state CIO plan calls for increased collection, aggregation, open access and utilization of data to active statewide goals. There have also been significant efforts by the University of Hawai'i and other academic partners to build the requisite ecosystem, cyberinfrastructure and expertise to advance data science in Hawai'i. These include:

THE HAWAI'I-DATA SCIENCE INSTITUTE AT THE UNIVERSITY OF HAWAI'I (HI-DSI). The Hawai'i Data Science Institute (HI-DSI) is a University of Hawai'i System-wide effort focused on interdisciplinary research and data science education. HI-DSI provides a hub to support data intensive research, facilitate the creation of new degree and certificate programs that meet student and employer needs, and foster partnerships with industry. The Hawai'i Data Science Institute will be a world-class venue for education, training, and collaborative research in data and computational sciences. Achieving this vision will require a focused effort to develop a symbiotic partnership with industry and business community partners to guide workforce development. The Hawai'i Data Science Institute will capitalize on the University of Hawai'i's unique position and international excellence in key

research domains to pursue high-impact collaborative projects. These projects will span beyond academia, with the principal objective of developing real-world applications that benefit Hawai'i's economy and citizens.

THE UNIVERSITY OF HAWAI'I HIGH PERFORMANCE COMPUTING (HPC), SCIENCE GATEWAYS AND CYBERINFRASTRUCTURE INITIATIVE. Since 2013, the UH System has invested in a strategy to create an advanced cyberinfrastructure program to support the research mission of UH and all 10 campuses. In partnership with the HIDSII, the team provides access and support for high performance computing, software frameworks to support computational workflows and pipelines for reproducible research and full support for data management, data sharing and advanced visualization of research discoveries. UH continues to lead R&E Networking in the Pacific and provides an advanced 100G international network by partnering with international and national network hubs and exchange points. The SX-TransPORT backbone and the Pacific Island R&E Network (PIREN) links play a significant role in the support of international research efforts worldwide with an emphasis on increased capacity and resiliency for paths from Australia and New Zealand and now from Guam's strategic location. The new 100G PIREN links

datascience.hawaii.edu

UNIVERSITY OF HAWAI'I

HAWAI'I DATA SCIENCE

The Hawai'i Data Science Institute (HI-DSI) is a University of Hawai'i System-wide effort to support data science education, collaborative research and partnerships with industry.

COLLABORATIVE WORKSPACE
Affiliated faculty have access to state of art collaborative workspaces as part of the Laboratory for Advanced Visualization and Applications.

HIGH-PERFORMANCE COMPUTING (HPC)
The University of Hawai'i HPC is the core of Cyberinfrastructure's advanced computing services. Free accounts for the 290 node (6168 core) compute cluster are available for UH students, faculty, staff and affiliates.
Request a free account:
<https://www.hawaii.edu/its/ci/hpc-account-request/>

WORKSHOPS
Workshops that meet the demand for quantitative and computational skills on state-of-the-art topics, ranging from machine learning and databases to probabilistic programming and cloud computing.

15 CYBERCANOES IN HAWAI'I
The Cyber-enabled Collaboration Analysis Navigation and Observation Environment are rooms equipped with ultra high resolution display walls, that enable teams of users to work together either locally or remotely sharing visualizations and data. Locations include UH Hilo, UH West Oahu, Honolulu Community College.

3 AREAS OF FOCUS

- EDUCATION
- COLLABORATIVE RESEARCH
- INDUSTRY PARTNERSHIPS

Screenshot

between Hawai'i, Guam and Los Angeles increase capacity and resiliency and soon will connect with the Hawai'i Cable connecting New Zealand, Hawai'i and Pacific Wave in Seattle. The new Guam Open R&E Exchange (GOREX) in Guam supports a wealth of international science efforts with scientists in Japan, Australia, Singapore, Hong Kong and mainland US, as well as the newest submarine cable system in the region (Japan-Guam-Australia JGA cable).

ADVANCED VISUALIZATION CAPABILITY: LAVALAB. Research at the UH Mānoa Laboratory for Advanced Visualization and Analysis (LAVA) focuses on big data visualization techniques and their application in cutting ed domain science, engineering, and training applications. LAVA is a core laboratory of the Hawai'i Data Science Institute which serves the data intensive science, engineering and training needs of UH's 10 campuses (Mānoa, Hilo, West O'ahu, Hawai'i Community College, Honolulu Community College, Kapi'olani Community College, Kaua'i

Community College, Leeward Community College, Maui Community College, Windward Community College, as well as Chaminade University). LAVA is equipped with the world's highest resolution hybrid reality visualization system as well as numerous ultrahigh-resolution stereoscopic 3D and 2D, touch-enabled display walls, Head Mounted Displays and Augmented Reality Displays. These systems are connected to a 10 gigabit/s network link, which gives LAVA access to 100 gigabit/s bandwidth to the US and Australia.

WEST O'AHU AUGMENTED VISUAL EXPERIENCES (WAVE).



WAVE is a new laboratory at the new \$33.3M Academy for Creative Media (ACM) building at UH West O'ahu (UHWO). WAVE will give UHWO students primarily Native Hawaiians (NH), Pacific Islanders (PI), and

Filipinos, the opportunity to design, develop and demonstrate applications of computational creative media. The ACM has strong ties to companies who regularly recruit at UH. Hawai'i is strategically important to them because the diversity of its population mirrors the diversity of the world - the future markets for these companies. UHWO students will have access to the necessary networking infrastructure to collaborate with their counterparts in the rest of the world, sharing digital media assets, such as code, 3D models, sound files, and computer generated animations.

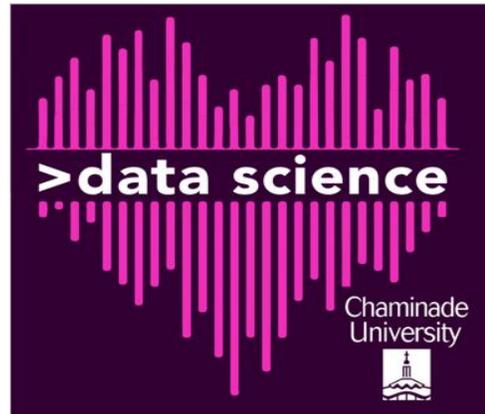
THE DATA SCIENCE FOR COMMUNITY IMPACT PROGRAM AT CHAMINADE UNIVERSITY. The CUH DS program was a result of significant stakeholder engagement across the business, non-profit, agency, K-12 and Native Hawaiian communities in Hawai'i. The CUH DS program has new faculty, a well-equipped new DS Center, and a curriculum developed in alignment with the 2018 National Academies report on *Data Science in Undergraduate Education*. CUH has built a culturally-sustaining curriculum and pathway into STEM for NH, PI and low-income students. Faculty co-authored a historic 2020 Resolution by the Convention of the Association of Hawaiian Civic Clubs in support of data science as a priority for Hawaiian self-determination. CUH also has two military focused programs VICTOR-DS (Veteran Intelligence Community Training Off-Ramp in Data Science) and ARDENT-DS (A4I Readiness through Data Education and Training). The DS curriculum offers major, minor, certificate and 'proficiency' options to students from CUH and community/workforce members who desire upskilling or reskilling. On-ground, online, hybrid modalities are available. The CUH DS program explicitly connects to culture through content, pedagogy, opportunities to demonstrate learning to family and community, and

protocol, within the epistemology of the DS program. A ‘Data ‘Auwai’ (irrigation channel) model underpins the CUH DS program where community and business Data Partners from Hawai‘i and the U.S. affiliated Pacific region flow data into student project-based learning, and data products are ported into the community for decision support.

4. DEVELOPING AND SUSTAINING S&T, INCLUDING DATA SCIENCE IN HAWAI‘I

Data Science is an interdisciplinary field that integrates statistics, computer science, communications, design, and ethics and to create the societal capability for conversion of data into actionable knowledge. Data are being generated across all economic and social sectors at an unprecedented rate. Locked up in these data is the tremendous potential for improved decision making, enhanced economic competitiveness and the mitigation of social inequity.

Unlocking this potential requires concerted, and parallelized, efforts in data collection and management, data access and dissemination, training of an expert and ethical data workforce and the routine production and use of data products in decision support. This data literacy requires a statewide commitment to data science, analytics and visualization coordinated by educational institutions, industry, the State and the social sectors using a Collective Impact framework. Traditional, and non-traditional educational opportunities from K-12 to graduate level and incorporating upskilling and reskilling of currently employed, unemployed or underemployed workforce are key to this commitment.



4.1. OBJECTIVE 1: STRENGTHEN HAWAI‘I’S STEM EDUCATION WITH A FOCUS ON BUILDING AN EXCELLENT AND INCLUSIVE S&T WORKFORCE, INCLUDING DATA SCIENTISTS.

RATIONALE.

Advancing the science and technology workforce needs of the state requires a highly skilled, adaptable and agile workforce that can respond to both current and future demand. For Hawai‘i and its residents to be competitive globally, we must increase the educational attainment of our residents.

The College and Career Readiness Indicators Report by Hawai‘i P-20, a partnership between the Hawai‘i State Department of Education and the University of Hawai‘i, provides a summary of the key readiness indicators, data sources, and other relevant information about how well Hawai‘i’s high school graduates are prepared for college and future careers. The indicators, chosen on the basis of the accessibility of the data source and its impact on improving student readiness for the workforce or postsecondary education, shows that the college-going rate for public high school graduates increased to 56 percent in 2014, up from 54 percent each of the previous two years and from 50 percent five years ago and moves the state closer to its goal of a 71 percent college-going rate by 2018. Nationally, 66 percent of graduates last year enrolled in college after high school. The Hawai‘i P-20 Council has also set a goal of "55 by ‘25" where 55% of Hawai‘i’s working age adults will have a two- or four-year degree by 2025. This goal aligns with the University of Hawai‘i’s Hawai‘i Graduation

Initiative (HGI), which aims to increase the educational capital of the state by increasing postsecondary participation and completion, and with the Hawai'i State Department of Education's goal that all students graduate college- and career-ready. Similarly, Chaminade has a major Retention and Graduation Initiative (RGI) focused on low income (Pell-eligible), first generation and Native Hawaiian/Pacific Islander students using a combination of transformational financial aid to mitigate economic barriers, intensive student support by specialized academic navigators and intrusive, just-in-time and intervention-coupled advising, and culturally-sustaining education that maintains connections to family, community and indigenous identity. Key performance indicators (KPIs) in the Chaminade RGI include >90% 1st to 2nd year retention of NH students and Pell-eligible students; increasing by ~20% the 6-year graduation rate compared to 2010; for NH, first generation and Pell-eligible students to equate or outperform the university averages in retention and graduation rates. Specific KPI for STEM at Chaminade include to approach 100% graduation rates for NH, and for all STEM graduates realize >50% placement in graduate school and >80% placement in STEM jobs after graduation. Each of these KPIs has been met in 2019 at Chaminade.

FACILITATING STRATEGIES:

- Prepare more students for higher education and technical careers by continuing to advance Hawai'i P-20 Partnership for Education initiatives, particularly in relation to STEM education, math and reading, and essential skills in team-working, critical thinking, collaboration and problem-solving.
- Promote inclusivity and enfranchisement into S&T and data science for all populations in Hawai'i including those marginalized by trauma, socioeconomic disparities and privilege.
- Develop a statewide approach to data science preparation in higher education, through an integrate set of 'Data Pathways' that clarify data science preparation opportunities for traditional and non-traditional students, from pre-college to graduate school, and with modalities that range from certifications and training to degree programs delivered both on-ground and online.
- Encourage and provide opportunities for teacher participation in high-quality, STEM- and data science-specific professional development activities.
- Foster partnerships between public and private educational institutions and industry to match workforce needs to education goals, link industry resources and expertise to educational efforts, and provide programs that give students applied learning opportunities and entrepreneurial skills.
- Promote pre-college, early college and academic transition programs to encourage and facilitate the progression of student academic achievement from Grade 12 to undergraduate and from community colleges to public and private 4-year institutions including additional STEM pathways to 2- and 4-year degrees in priority areas of state workforce needs such as agriculture, renewable energy and sustainability systems, information technology and data analytics, medicine and healthcare, behavioral health, digital media, and environmental stewardship.

- Respond to the changing higher education landscape by advocating for public and private colleges and university return on investment and value proposition, as well as the importance of higher education in the State’s economic and social future.
- Prioritize ‘excellence here at home’ to promote affirmative decisions to seek higher education in Hawai‘i close to family, community and culture, and develop explicit linkages to fulfilling, well-paying jobs in Hawai‘i after graduation through employers across economic sectors.
- Facilitate and support non-traditional student pathways and retraining of incumbent workers to gain high-value data-literacy skills and experiences that support outcomes in concert with traditional academic ‘Data Pathways’.
- Promote widespread development and use of data product and coding ‘portfolios’ to enable trainees to unequivocally demonstrate employer-readiness.
- Facilitate, and promote intentionally, the return of kama‘āina after graduation from mainland colleges and graduate schools via returning pathways that act in opposition to the talent drain.

4.2. OBJECTIVE 2. CONNECT PROMISING RESEARCH, TECHNOLOGY TRANSFER AND ENTREPRENEURSHIP TO CREATE NEW BUSINESS OPPORTUNITIES AND ATTRACT INVESTMENT INTO HAWAI‘I’S INNOVATION ECONOMY.

RATIONALE.

Local and national partnerships built around science and technology and across the business, government and education sectors have the potential to diversify Hawai‘i’s economy and produce high-wage jobs. Collaborations between public and private based enterprises should be emphasized to promote knowledge and technology transfer, foster the development of dual-use technologies with the defense industry, and support entrepreneurial endeavor. Hawai‘i must build and encourage venture capital to help support Hawai‘i technology businesses and create an environment that sustains innovation over time.

The University of Hawai‘i System (UH System) is one of the largest enterprises in the state and is comprised of three universities and seven community colleges across the islands. Because of Hawai‘i’s tremendous geographic diversity that encompasses erupting volcanoes, frozen summits, tropical rain forests and the deep ocean, UH research is equally as diverse with its world-renowned research programs in astronomy, medicine, data visualization, oceanography, genetics, biosciences and tropical agriculture. As Hawai‘i’s only public university and one of only a few Land, Sea, Sun and Space Grant universities in the nation, UH has a dual mission to forge ahead with new discoveries and to energize economic development.

The UH research enterprise is evolving as solutions to complex problems faced by the region, the nation and the planet are addressed increasingly by multi-disciplinary teams of researchers with both inter and intra-institutional collaborations. Research conducted across the 10-campus UH System, the innovative solutions derived from it and the ability to rapidly translate a good idea into purposeful products and services, are key factors that will help drive economic prosperity and support the quality of life here in Hawai‘i and around the world.

The University of Hawai'i annually brings in hundreds of millions in research dollars, \$421.8 million for FY2019, an increase of 9.2% over the previous year across a myriad of scientific areas, creating opportunities to generate cutting edge discoveries and intellectual property (IP) that has great potential economic value as well as important societal benefits. Given the level of research funding into the university, a challenge for UH is to dramatically improve its identification of promising intellectual property and successfully translate outcomes into viable companies competing in the global marketplace.

In 2011, UH launched the Hawai'i Innovation Initiative (HII), a strategy to partner with Hawai'i community groups and businesses to build a \$1 billion research industry. The larger, long-term benefit of the HII investment will be the creation of an 'Innovation Ecosystem' across UH and private universities in Hawai'i whereby world-class faculty, highly trained students, and dedicated staff inculcate a culture of entrepreneurship; one where new discoveries are translated into products to benefit the public and people are nurtured to become business leaders. Today, the University of Hawai'i System has a suite of programs and resources across the 10 campuses to encourage student innovation and entrepreneurship and support students who desire to take their ideas and discoveries to the next level and there is robust innovation ecosystem in the state including incubators, product accelerators, and innovation spaces.

UH Mānoa opened the iLAB, which serves as an innovation playground at the center of UH Mānoa campus. The iLAB provides program facilities, resources and support to act as a catalyst to drive other interdisciplinary innovation initiatives within the UH System. MIND Hawai'i @ iLAB is a program that bring together students and faculty from various fields such as business, medicine, engineering, law, and marketing to develop solutions to challenging medical problems. The Pacific Asian Center for Entrepreneurship (PACE) at the UH Mānoa Shidler College of Business offers over 20 programs to UH students and faculty designed to encourage entrepreneurial thinking across disciplines and inspire entrepreneurs to move their ideas from conception to commercialization. PACE programs include the Breakthrough Innovation Challenge, UH Venture Competition, Summer Startup LaunchPad, Liftoff Advisors and the UH Ventures Accelerator. The Mānoa Innovation Center is a facility to assist and incubate companies that are commercializing intellectual property generated by or affiliated with University research, providing leases at market and subsidized rates. It also houses the University's STEM Pre-Academy program and the Applied Research Laboratory. UH Ventures LLC provides startups with access to early stage funding, including follow on funding.

In addition, a number of the other campuses across the University of Hawai'i System also have innovation centers, including the Maui Food Innovation Center and the Kauai Innovation Center. The seven University of Hawai'i Community Colleges are part of the Pacific Center for Advanced Technology Training (PCATT), a not-for-profit consortium that offers programs in the STEM areas at its innovative training center. In addition, Chaminade University has established a social incubator in 2020, there is a new Education Incubator, and several Native Hawaiian-focused incubators have been founded (e.g. WaiWai collective, Purple Maia, Mana-UP).

UH Office of Innovation and Commercialization (OIC) is uniquely positioned at the center of the University's and the State's iE ecosystem. In 2020, the OIC pivoted to implement a novel approach to finding solutions to Hawai'i's challenges, exacerbated by the COVID-19 pandemic. The OIC proposes to start by looking at and understanding the challenges Hawai'i faces, identifying challenges to solve, bringing innovation to solve those challenges to ensure the end result falls in line with the original need. These real-life solutions to Hawai'i's challenges can then benefit from the existing resources in the innovation and entrepreneurship ecosystem to

accelerate their development and bring them to market. The OIC also recently launched the 2020 ‘Hacking for Recovery’ entrepreneurship bootcamp in response to COVID-19.

With these foundational tools and programs in place to support our innovation and entrepreneurial ecosystem, the University has shifted its focus to strategically building the pipeline of research, innovation and technology by taking targeted and deliberate steps to



collaboratively identify, develop and commercialize Hawai‘i innovation and technology for resilient and sustained local and global impact with the recent launch of its Innovation Impact Challenge (IIC) Initiative. The IIC Initiative’s goal is to build a sustainable platform based on University + Industry/Community/Government (including DoD) partnerships that leverage the expertise & creativity at UH, inspire cross-disciplinary collaboration, foster the development of novel and innovative ideas and solutions for Hawai‘i’s challenges, and create more opportunities to impact Hawai‘i (e.g. utilize Hawai‘i innovation to solve local and global challenges, create a pipeline for Hawai‘i talent to stay local, and stimulate economic development with new industry).

FACILITATING STRATEGIES

- Enhance and sustain the iE ecosystem across UH, other higher education partners and the state workforce innovation ecosystem.
- Nurture and support spinoff and startup companies and non-profits from Hawai‘i’s universities and seek to enhance local business community in its ability to sustain the growth of such companies.
- Strengthen technology transfer to the private sector by developing a collaborative infrastructure that will accelerate commercialization of publicly funded research and development, thus providing broader public benefit.
- Advocate for review and streamlining of government permitting and regulatory processes so that they are less burdensome for Hawai‘i businesses and research enterprises.
- Create mechanisms to enable regular networking and collaboration among public and private entities, including research, education, business, and government agencies to build local equity and expertise in science and technology.
- Incubate new local business ventures and incentivize existing businesses to adapt and innovate by offering tax incentives, venture capital, and follow-on funding for commercialization.

- Pursue an integrated approach to promoting Hawai‘i’s existing public and private technology facilities, incubators (business and social sector), accelerators and innovation spaces and business incubators to make them more attractive to local and out-of-state businesses.
- Facilitate remote working through broadband growth and promote Hawai‘i as a destination for global companies seeking a data-skilled trained remote workforce, including concerted efforts to showcase talent and product portfolios of the emerging talent pool.

4.3. OBJECTIVE 3: INVEST IN SCIENCE AND TECHNOLOGY CYBERINFRASTRUCTURE TO STRENGTHEN RESEARCH COMPETITIVENESS AND INNOVATION IN HAWAI‘I.

RATIONALE.

A world-class communication and information infrastructure underpins successful connections among the Hawaiian Islands, the Asia-Pacific region, and the rest of the world. As a geographically isolated state, Hawai‘i must leverage world class cyberinfrastructure, information technology, and telecommunications to support individuals’, businesses’ and institutions’ local and global interactions. Hawai‘i’s existing supercomputing facilities and telecommunications nodes provide a high level capability and as new frontiers in data analytics are addressed, require sustained development of cyberinfrastructure capacity and workforce for cyberinfrastructure and IT. Cyberinfrastructure areas such as data management and analysis, digital media, informatics, software development, modeling, simulation, high performance computing and visualization, applied to areas across the state and university’s shared priorities (health, education, sustainability, resilience, economic development, social justice and research competitiveness) can help assure that Hawai‘i is an innovative hub in the evolving information society.

FACILITATING STRATEGIES:

- Leverage advanced broadband applications for e-learning and distance education to ensure equitable access to education throughout all islands, from K-12 through higher education.
- Identify state and federal funding mechanisms to support investment in common infrastructure needs that will support multiple science, technology and innovation efforts.
- Develop, maintain and support a robust digital infrastructure for statewide priorities in health (e.g. telehealth, EMR, predictive and personalized medicine), education (distance learning and enhanced learning solutions), sustainability and resilience, economic development (wide spreads business analytics, prediction and decision support), social justice and research competitiveness.
- Collaborate across business, military and academe to establish Hawai‘i as a global leader in cybersecurity research and development.
- Develop world-class, secure, sustainable, large scale data storage and processing facilities, linked to robust and widely accessible decision support facilities and expertise, to establish Hawai‘i as an attractive place to store, access, process, visualize and create knowledge from data.

4.4. OBJECTIVE 4: ADVANCE SCIENCE AND TECHNOLOGY FOR A HEALTHY AND SUSTAINABLE ISLAND STATE.

RATIONALE.

The development and application of innovative science and technologies can have a significant positive impact on the health of Hawai'i's citizens, and the way in which Hawai'i connects to and collaborates with the rest of the world. With an ethnically diverse population in an often rural, remote location, Hawai'i is well placed to be a leader in the study of health disparities, rural health, and translational medicine to discover new means of preventing or treating such serious health issues as type 2 diabetes which has become epidemic, particularly affecting Native Hawaiian, Filipino and Pacific Islander populations. Long-term research and strategies to control COVID-19 in a unique island setting with high rates of tourism and a backdrop of ethnically-disparate pre-existing conditions will be critical to Hawai'i's future. Fostering bench-to-bedside excellence in the study of cancer, cardiovascular disease, aging-related neurodegeneration and the development of novel imaging and diagnostic tools can serve Hawai'i's health priorities and contribute globally to healthcare solutions. Hawai'i is also a compelling venue for the study of linkages between environment and health, both positive and negative. At the frontier of these studies, for example, new types of convergent research are being explored in Hawai'i examining the interplay between environmental and human-hosted microbiomes and their influence on health.

Resiliency and sustainability are critically important for Hawai'i's future. In 2014, the Hawai'i State Legislature declared that "climate change is the paramount challenge of this century, posing both an urgent and long-term threat to the State's economy, sustainability, security, and way of life." The most visible manifestations of this threat is the growing pressure on the supply of fresh water due to reduced rainfall, higher evaporation rates, sea level rise, and demand from an increasing population. Groundwater supplies 99% of Hawai'i's domestic water use and groundwater levels have been steadily dropping in many areas. Indeed, economic development is likely to be significantly restricted in certain parts of the State due to uncertainty about the availability of sustainable water resources. Consequently, it is essential that Hawai'i pursues multiple strategies to preserve water security in coming decades including promoting conservation, reusing wastewater, and increasing knowledge about the complex hydrogeology of the islands.

As an island-state, Hawai'i is particularly vulnerable to volatility in global markets. The state imports 90% of its energy (through oil) and almost 90% of its food needs, and is therefore exposed to increased risks relating to its energy and food supplies. As an island state, there are no options should there be a water shortage due to, for instance, climate change. Indeed, economic development is likely to be significantly restricted in certain parts of the State due to the lack of sustainable water resources. Technologies that drive import substitution in these critical areas have a two-fold impact: they provide resiliency in our supply chains and decrease our dependence on external sources of key provisions; and the money that no longer flows offshore to food and energy providers can be invested locally. For example, petroleum accounts for about 97.4 percent of those expenditures. Investment in scientific and technological research to help Hawai'i produce more of its own energy and food for domestic use and exportation will help to ensure that the state is protected.

As set out in the Hawai'i Clean Energy Initiative, the state has the potential to be a world-leader in renewable and clean energy technologies. By responsibly and respectfully harnessing Hawai'i's natural resources such as wind, solar and geothermal, the state can significantly reduce dependence on imported fossil fuels. Clean

energy technologies such as bio-fuels, electric and hydrogen-fueled vehicles could also be advanced as a means of reducing the state's carbon emissions more generally. Both energy-related endeavors would help to protect Hawai'i's economy by ensuring that we have the needed energy and have a positive impact on the ecological environment and quality of life for Hawai'i's citizens. Hawai'i must also focus on producing and consuming more of its own food to reduce reliance on imported provisions. However, as an island state Hawai'i is at risk of invasive species and pathogens that could affect crop yield and performance. Part of the state's sustainable future therefore relates to continued investment in agriculture research and agricultural technologies. A reduction in energy and food imports means that the money Hawai'i used to spend on necessities can be reinvested in-state to diversify these sectors, creating more jobs for local people, and strengthening the local economy through locally based enterprises. The challenge therefore is to bolster the research base in energy and food production. We must also balance and find ways to maximize the links between them while pursuing scientific and technological research with respect for Hawai'i's limited island resources and heritage conservation.

FACILITATING STRATEGIES:

- Encourage scientific research and development across sectors in the study of biomedical, behavioral and public health.
- Prioritize redressing health disparities, strengthening rural health, developing translational medicine and researching public health strategies to address infectious disease.
- Provide depersonalized access to health-related information where appropriate to support research and improvement in health care and social services.
- Encourage more public and private sector research and collaboration on sustainable farming methods and agricultural technologies, ecosystems and environmental health including management of invasive species and plant pathogens to protect our crops, improve food safety, and support the production and consumption of local foods.
- Promote stakeholder-driven research, community engagement in the research agenda and the inclusion of historical and contemporary indigenous knowledge and approaches in Hawai'i's research endeavor.
- Develop a comprehensive roadmap for the state, defined at the local level for each island, for building a world leading sustainable food and energy economy.
- Cultivate a 'green workforce' by providing programs and courses in Hawai'i's education sector that will ensure Hawai'i has the skilled workers to solve its energy and food sustainability challenges.

4.5. OBJECTIVE 5. HARNESS DATA SCIENCE FOR RESEARCH COMPETITIVENESS AND INNOVATION IN HAWAI‘I.

RATIONALE.

Innovation and research competitiveness for UH and Hawai‘i may be in part limited by silos that separate domain science and data science. There is an opportunity for an integrated research, education and workforce development effort that will fundamentally move the capacity of the state in data science support of, and integration with, domain sciences. Investment in Data Pathways for education and training, expert human capital (specialists and faculty), enabling cyberinfrastructure and capacity in the form of science gateways need to be contextualized by an intentional effort to leverage data science to power domain science discoveries and impact in Hawai‘i. We identify priority areas for the integration of domain and data sciences in the state:

FACILITATING STRATEGIES.

LEVERAGE DATA ANALYTICS RESEARCH FOR COVID-19 RESPONSES. We have entered a world with an ongoing, ever ready to re-emerge, pandemic of a highly infectious disease with high morbidity, high mortality and the potential to overwhelm acute care settings. Data- and computationally-intensive research is needed in Hawai‘i to generate predictive frameworks that govern risk reduction at the individual and populations levels. Hawai‘i needs to initiate a major collaborative statistical, computational, and epidemiological research effort to develop a framework for assessing individual and population level risk and protection factors that determine COVID and future outbreak outcomes in our community.

USE DATA SCIENCE TO COMBAT PRE-EXISTING CONDITIONS AND HEALTH DISPARITIES. COVID-19 is not an equalizer. It is becoming clear that who contracts it, how sick they get and whether they die is likely to be governed by a constellation of risk factors that are in turn influenced by socioeconomic factors and systemic biases. Pre-existing conditions should no longer be viewed as chronic, ‘lifestyle’, diseases; they can kill a COVID-19 patient in just days, and they are primary vehicles for the disparate impact of the virus on minorities, the elderly and the poor. Data analytics approaches are needed to assess risk and protection variables as they are manifest in our population contextualized by Hawai‘i’s unique demographics, genetics and social determinants of health.

POWER BIOMEDICINE, AND PERSONALIZED MEDICINE WITH DATA ANALYTICS AND AI. Biomedical and behavioral research of benefit to Hawai‘i can be advanced by integration with computationally-intensive data science, especially machine learning and AI. Areas of particular focus include genetics, transcriptomics and epigenetics (how does personalized medicine apply to and become implemented for Hawai‘i’s specific health and populations?), retrospective analysis of massive healthcare data sets (how can prior investment in large cohort studies, biorepositories and an ongoing EMR collection be integrated and leveraged to support our understanding of health status and delivery of care?), and the application of AI and ML to areas such as diagnostic image analysis. Telemedicine can be enhanced and improved by integration with technologies such as AI, supporting health in rural, remote populations as well as emerging needs during COVID-related periods of restricted movement.

PROMOTE DATA-INTENSIVE APPROACHES TO SUSTAINABILITY AND RESILIENCE. Hawai'i needs to plan for resilience, safety nets and internal capacity to meet both stochastic and deterministic threats. Planning for resilience to stochastic events needs to be robustly data-informed such that we can overcome short-term expediency in economics, politics and budget cycles. Data priorities for climate science assessment include that we assess and mitigate data collection needs (new and continuing data collection in ecology, climate change monitoring sets, inundation, economics, land use, population, tourism, transportation, health, education, food and energy production), develop cutting edge capability in modeling, prediction and integrate with social, economic and human factors research to confront barriers to carbon neutrality and discern response to climate change.

PERFORM DATA INTENSIVE ECOLOGY, BIODIVERSITY AND MICROBIOME STUDIES. Hawai'i has 27 of the 38 life zones recognized on the Holdridge Life Zone System and is the most geographically isolated place on earth. Hawai'i has long been a major site for the study of biodiversity, evolution, ecology and adaptation, as well as a sentinel site for the study of anthropogenic impacts on natural systems and the services they provide. The study of biodiversity from the macro- to microbiome, from ridge to ocean and across gradients of ecological disturbance, when combined with cutting-edge data science, has the



potential to generate new solutions to understand, restore and manage our ecosystems. UH has a strong track record in the development of microbiome sciences, which it is now poised to take to the next level through the development of capacity to harness the power of microorganisms to influence the health of their hosts and ecosystems. Microbiomes can be manipulated to increase host health - from nutrition and defense to fitness and yield - with important implications for our local economy, natural resource sustainability, and human health. Specifically, the application of custom prescription microbiomes has great potential in habitat restoration, agroecosystems, and human health in Hawai'i.

SUPPORT DATA INFRASTRUCTURE AND ANALYSIS NEEDS FOR PHYSICAL SCIENCES AND ENGINEERING. The Institute for Astronomy is one of the premier astronomical research centers worldwide. The 3,000-meter peak of Haleakala on Maui and the 4,200-meter peak of Mauna Kea on Hawai'i Island collectively host 13 telescopes on Mauna Kea and 11 on Haleakala including the Daniel K. Inouye Solar Telescope (DKIST). The PanSTARRS and ATLAS telescopes provide early warning asteroid detection as well as gather massive data sets for astronomy research. UH particle physicists participate in the international Alpha Magnetic Spectrometer experiment on the International Space Station and Hawai'i is becoming a destination for communications satellite and other space launches. Physics, astronomy and astrophysics offer remarkable opportunities for data science to improve understanding of the universe, prepare for and predict astronomical events and support manned and unmanned exploration.

ENABLE DATA-INTENSIVE OBSERVING NETWORKS AND DISASTER PREPAREDNESS. Decision support using data gathered by observing systems will strengthen Hawai'i's preparedness and responses to natural disasters, as well as improving understanding of anthropogenically-generated climate change, how to respond to it and assessment of mitigation efforts. From networks such as Pacific Islands Ocean Observing Systems (PacIOOS, one of eleven

regional observing programs in the U.S.) to extensive networks of sensing and sampling instrumentation that are assessing our island environment in real time, constantly, there are opportunities for data science to dramatically enhance our preparedness and resilience.

SUPPORT ECONOMIC ANALYSIS AND MODELING, BUSINESS DEVELOPMENT AND ECONOMIC DIVERSIFICATION WITH DATA ANALYTICS. Economists and social scientists in organizations such as the UH Economic Research Organization (UHERO) focus on economic analysis and are the premier source for forecasts and analysis in Hawai‘i. Their leadership in prediction and modeling, and data-science powered decision support will be critical to forecasts of economic outlooks for the state and understanding the impacts of initiatives to diversify our economy and achieve social justice. UHERO has been on the frontline of forecasting economic impacts of COVID-19 on the state economy and support of human capital, computational power and dissemination of their messages is key to the data-empowered state that this Plan envisages.

CONFRONT BIAS AND PROMOTE SOCIAL JUSTICE THROUGH DATA SCIENCE. Data are a source of tremendous potential to advance social justice, and strengthening data analytics expertise, capacity and access to usable data in the service of the criminal justice, social and health sectors is a priority to leverage this potential. Hawai‘i also has the potential to lead in confronting and mitigating systemic bias that limit the impact of data analytics on our most pressing social issues. These include the identification and redressing of gaps in data sets, biases in collection of analytic algorithms and a transparent effort to lead in addressing issues around privacy and data sovereignty.

INNOVATE IN DATA SCIENCE, ANALYTICS AND VISUALIZATION AS A DISCIPLINE. The key to boosting innovation is the recruitment and retention of new talent. Recent investments by UH (UHM, UH Hilo, UH West O‘ahu, the UH CC system) and its educational partners, such as Chaminade, in computational and visualization infrastructure, new academic data science programs and new faculty directly respond to national needs articulated in the National Science Foundation’s Big Ideas’, Harnessing Data for 21st Century Science and Engineering. Critical expertise gaps remain: UH Mānoa lags behind many R1 institutions in disciplines such as data science, artificial intelligence and computational science and future recruitments must focus in these areas.

EDUCATE AND PREPARE THE FUTURE WORKFORCE IN DATA SCIENCE. Emerging visions (e.g., the Aloha Aina initiative) seek to define Hawai‘i’s future in the COVID-era, with a focus upon sustainable tourism, responsible and inclusive economic growth, economic and social justice, food and energy security, a pro-entrepreneurship environment and equity of opportunity. Data science is a priority area that underpins all of these areas of development, and envisages a Hawai‘i that is rich in data, uses data for systematic decision-making and has a thriving workforce of data science professionals serving all sectors. A statewide effort in data science education, including traditional, non-traditional education pathways from K-12 to graduate school, and upskilling and reskilling the current workforce will accelerate the development of this new workforce. This is a top priority for UH across all 10 campuses and as part of statewide collaborations with Chaminade University and other institutions.

5. STATEWIDE S&T FRAMEWORK IMPLEMENTATION PRINCIPLES

This framework sets out steps that must be taken to fully leverage the State's strategic advantages and apply them in a way that drives science and technology forward to address some of the most serious challenges facing Hawai'i. Now is the time to take bold action and address today's challenges so that the State can succeed in the future.

Action against the framework objectives requires dynamic, sustained collaboration and coordination across multiple sectors. No one sector or agency can accomplish this singularly. With that in mind, Hawai'i must employ the following four principles to advance the objectives and strategies outlined in this framework:

- **FACILITATE DISCUSSION AND COLLABORATION:** Convene working groups comprised of stakeholder representatives to discuss, develop and enact action plans for advancing each objective, including identification of relevant progress indicators for each objective. These working groups should involve key business, education, research, government, and local community leaders who are in a position to solve problems and influence change. Clear deadlines for enactment of plans must be set.
- **REACH OUT TO STAKEHOLDERS:** Develop a communications plan that markets and clearly and persuasively conveys the benefits of addressing the objectives set out in the framework. This should involve developing communication strategies appropriate for different stakeholder groups, including the general public.
- **IDENTIFY AND ADDRESS LEGISLATIVE (REGULATIVE AND INSTITUTIONAL) BARRIERS TO IMPLEMENTATION:** Work with stakeholder representatives and the Hawai'i state legislature to identify and resolve any barriers to implementation of this framework.
- **MONITOR PROGRESS:** There are two aspects to monitoring progress: (1) against the framework itself, and (2) Hawai'i's position in science and technology compared to other U.S. states. (1) Monitor progress against this framework by annually reporting against progress indicators for each objective. (2) Annually monitor (or as relevant reports are issued) Hawai'i's overall position in science and technology against other states using the State Technology and Science Index and the State New Economy Index as key data sources.

Advancement of S&T, and in particular data science, over the 5 year course of this Plan in Hawai'i - from education to the workforce, from research to application, from private development to public benefit - will have a significant impact on the quality of life for Hawai'i's citizens.

6. HAWAI'I STATE SCIENCE AND TECHNOLOGY COMMITTEE ROSTER: 2020-2025

Government

Len Higashi

INTERIM EXECUTIVE DIRECTOR, HAWAI'I TECHNOLOGY DEVELOPMENT COUNCIL

University of Hawai'i Leadership and Statewide Steering Committee

David Lassner

PRESIDENT, UNIVERSITY OF HAWAI'I

Michael Bruno

PROVOST, UNIVERSITY OF HAWAI'I AT MĀNOA

Garret Yoshimi

VICE PRESIDENT FOR INFORMATION TECHNOLOGY AND CHIEF INFORMATION OFFICER

Vassilis Syrmos

VICE PRESIDENT FOR RESEARCH AND INNOVATION

Steve Auerbach

INTERIM DIRECTOR, OFFICE OF INNOVATION AND COMMERCIALIZATION

Academic Leadership

Randy Holcombe

DIRECTOR, UNIVERSITY OF HAWAI'I CANCER CENTER

Margaret McFall-Ngai

DIRECTOR, PACIFIC BIOSCIENCES RESEARCH CENTER, NATIONAL ACADEMY MEMBER

Lynn Babington

PRESIDENT, CHAMINADE UNIVERSITY OF HONOLULU

J. Keawe Kaholokula

CHAIR, DEPARTMENT OF NATIVE HAWAIIAN HEALTH, JOHN A. BURNS SCHOOL OF MEDICINE.

Business and Industry

Robert Harrison

CEO, FIRST HAWAIIAN BANK

Richard Wacker

CEO, AMERICAN SAVINGS BANK

Peter Ingram

PRESIDENT AND CEO, HAWAIIAN AIR

Catherine Ngo

CEO, CENTRAL PACIFIC BANK

Peter Dames

EXECUTIVE VICE PRESIDENT FOR DISTRIBUTION, MARKETING & DIGITAL, SERVCO

Ian Kitajima

DIRECTOR OF CORPORATE DEVELOPMENT, OCEANIT

Lauren Nahme

VICE PRESIDENT FOR STRATEGY AND TRANSFORMATION, KAMEHAMEHA SCHOOLS

Health Care

Mark Mugiishi

CEO HAWAI'I MEDICAL SERVICES ASSOCIATION

Sheri Daniels

EXECUTIVE DIRECTOR, PAPA OLA LOKAHI

Raymond Vara

PRESIDENT AND CEO, HAWAI'I PACIFIC HEALTH,

Jill Hoggard Green

CEO, THE QUEEN'S MEDICAL CENTER

Ex Officio

Gwen Jacobs

DIRECTOR OF CYBERINFRASTRUCTURE, UNIVERSITY OF HAWAI'I, DIRECTOR, HAWAI'I EPSCoR, AND CO-DIRECTOR, HAWAI'I DATA SCIENCE INSTITUTE

Jason Leigh

DIRECTOR, LABORATORY OF ADVANCED VISUALIZATION AND PROFESSOR OF COMPUTER SCIENCE, UNIVERSITY OF HAWAI'I AND CO-DIRECTOR, HAWAI'I DATA SCIENCE INSTITUTE

Philip Johnson

PROFESSOR OF COMPUTER SCIENCE, UNIVERSITY OF HAWAI'I AND CO-PRINCIPAL INVESTIGATOR, HAWAI'I STATE EPSCoR

Helen Turner

VICE PRESIDENT FOR STRATEGY AND INNOVATION, AND PROFESSOR OF BIOLOGY, CHAMINADE UNIVERSITY AND CO-PRINCIPAL INVESTIGATOR, HAWAI'I STATE EPSCoR