Annual Report 2020

Applied Research Laboratory University of Hawai‘i

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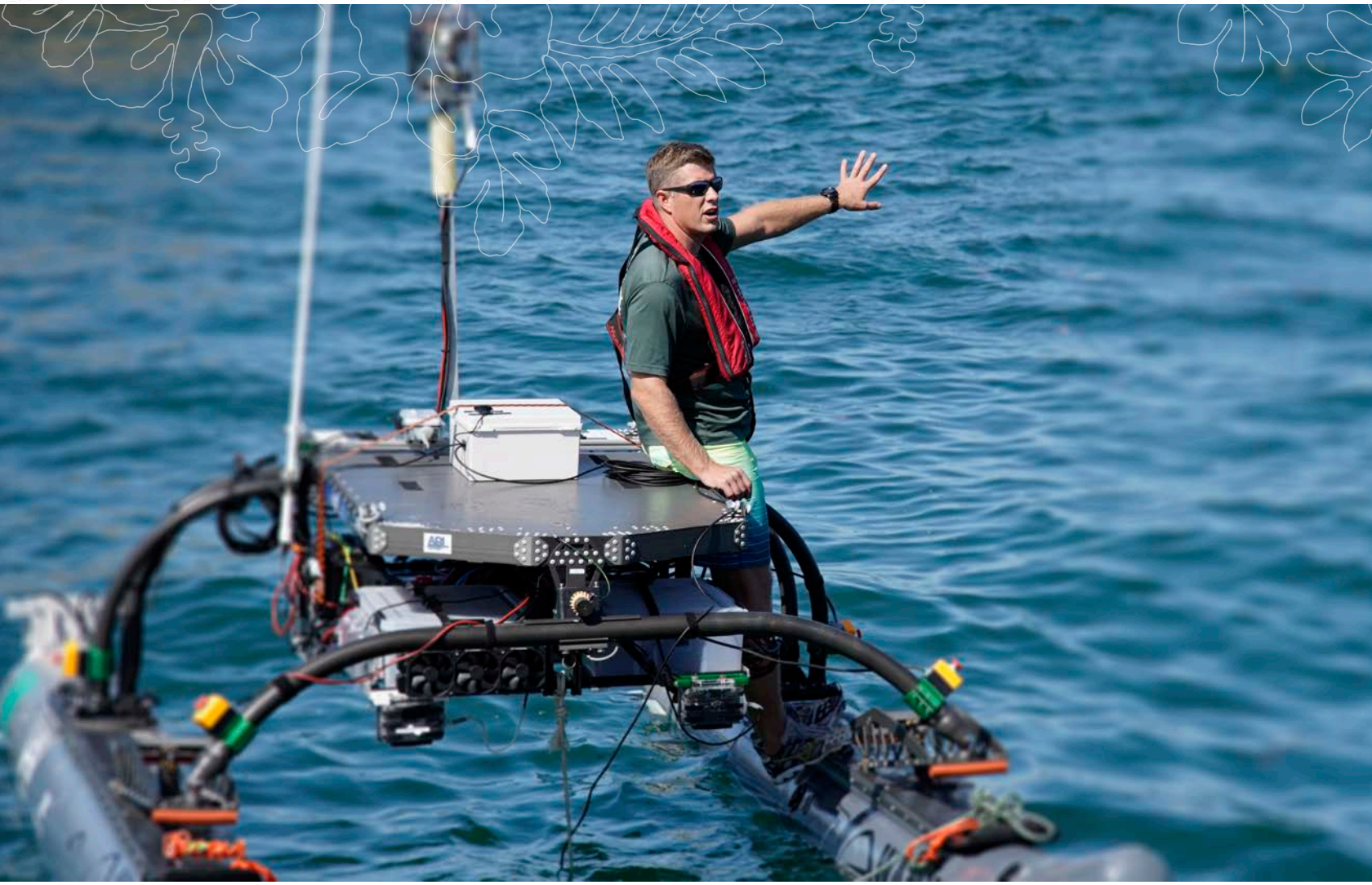
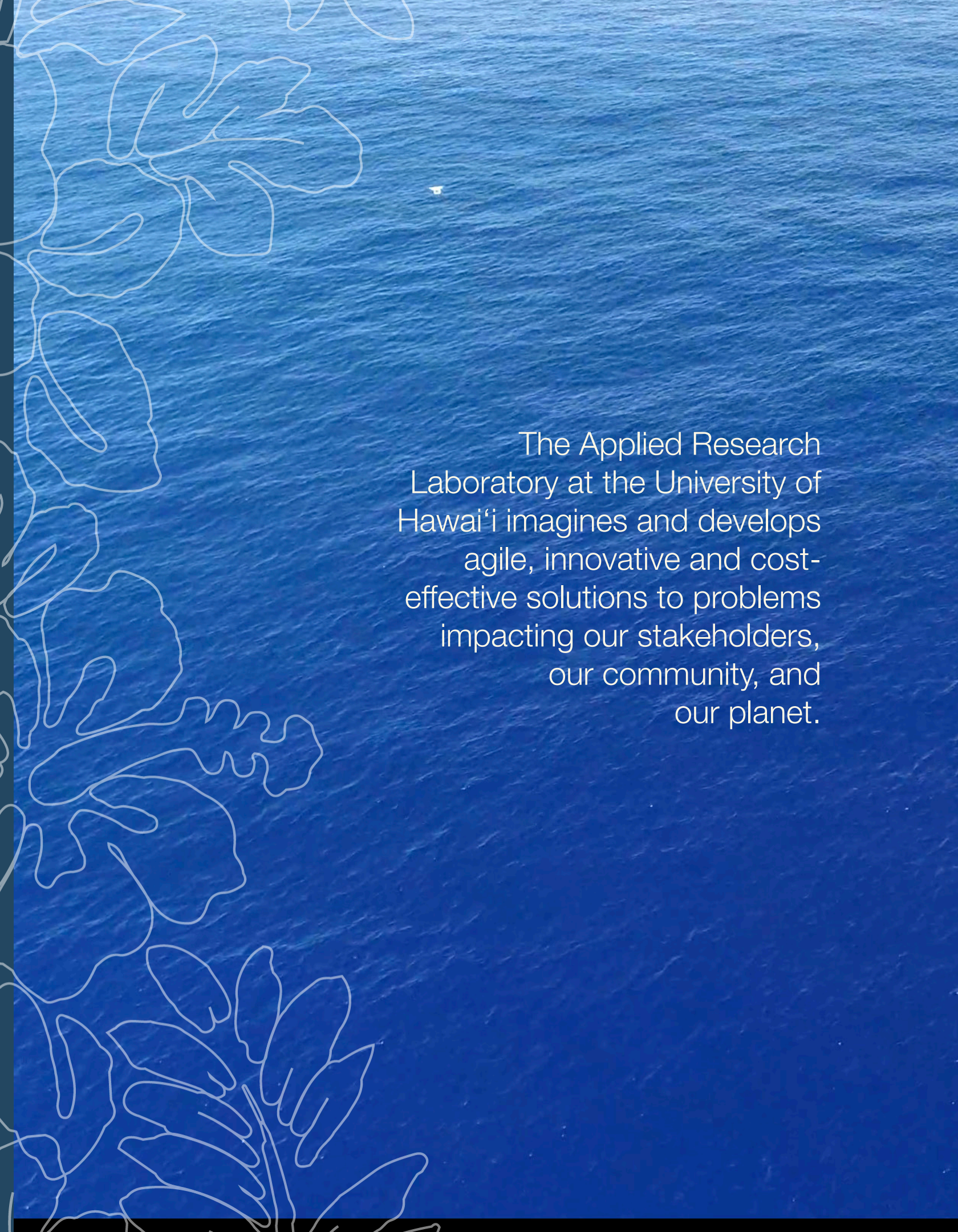
Traditional Hawaiian blessing
of Ocean Energy's wave
energy converter

ARL at UH

Established in 2008, the Applied Research Laboratory at the University of Hawai‘i (ARL at UH) is the fifth of five Navy-sponsored University-Affiliated Research Centers. The ARL at UH serves as a center of excellence for critical Navy and national defense needs, conducting research, development, testing and evaluation (RDT&E) to address challenging and emerging problems. ARL at UH efforts focus on Ocean Environmental Effects; Astronomical Research; Advanced Electro-Optical Systems, Detectors, Arrays and Instrumentation; Environmental Sensor Research and Remote Sensing; New Renewable Energy; and Mission-Related and Public-Services-Oriented Research and Development. On May 13, 2019, Naval Sea Systems Command awarded a five-year Indefinite Delivery/ Indefinite Quantity contract to the ARL at UH to continue its support of critical Navy and Department of Defense requirements. This report highlights accomplishments of the ARL at UH during year one of the 2019 contract.



Inside Cover: Photo by Josh Bauer
This Page: Photos by Mary Baghdady



The Applied Research Laboratory at the University of Hawai‘i imagines and develops agile, innovative and cost-effective solutions to problems impacting our stakeholders, our community, and our planet.

Innovating

Delivering packages to an underway submarine via small unmanned aircraft system (sUAS) is a unique operation with limited precedents. This task required routine, iterative testing of the sUAS, concurrent innovation of the delivery and capture systems, and most importantly, input from Navy personnel to understand the physical and logistical integration requirements with submarine structural and mission attributes. Additive manufacturing and computer-aided design enabled rapid iterative innovation of the capture mechanism, increasing the effectiveness, portability, and robustness of the system between successive testing and evaluation exercises.

First off-shore package delivery to a Navy submarine using a commercial quadcopter.

Previous pages:
Photo by NIWC PAC

Above Photo by Josh Levy
Left Photo by US Navy, Petty Officer 2nd Class ND, Michael B. Zingaro

Transferring Knowledge

Military Sealift Command estimates that 70% of the requested critical packages for submarines weigh less than five pounds (5 lbs). Delivery of critical parts and medical supplies for underway ships and submarines is generally limited to three primary delivery methods: pier-side delivery or near-harbor transfer via tug, vertical replenishment from rotary-wing aircraft, and underway replenishment from other vessels. Each of these methods have considerable associated time and monetary costs. For many small payloads with high-mission impact, rapid delivery via sUAS to vessels at sea can dramatically reduce time and cost requirements.

The Submarine Force, US Pacific Fleet (SUBPAC), recently sponsored an effort at ARL to conduct an operational evaluation of a proof of concept to deliver lightweight supplies to underway submarines. This effort included developing a training curriculum for Navy sailors that would support the safe, successful delivery of small packages to underway submarines. In October 2019, SUBPAC personnel successfully delivered a lightweight package containing computer parts, medicine and food to a submarine transiting west of the island of O‘ahu, Hawai‘i.

The submarine delivery concept required assessing Federal Aviation Administration and Department of Navy rules and regulations required for sUAS operations, implementing a command-and-control solution, understanding the capabilities and limitations of the sUAS and payload capture device, and efficiently training novice sUAS pilots. ARL at UH personnel developed and executed a submarine-delivery-specific training program over the course of the twelve-month effort that, thanks to the hard work and dedication of SUBPAC personnel, enabled SUBPAC sailors to successfully conduct the logistics-delivery demonstration without operational assistance from ARL at UH personnel. Prior to the demonstration SUBPAC and ARL at UH personnel conducted fifteen training sessions totaling about eleven hours of UAS flight time.

Photo by
Josh Bauer

Since 2014 the Hawai‘i Natural Energy Institute (HNEI) and ARL at UH have conducted Verification and Validation (V&V) tasking for independent wave energy converters (WECs) at the Navy’s Wave Energy Test Site (WETS) that involves performance assessment (power and durability), environmental monitoring, logistics support, and critical infrastructure maintenance. WETS is located on the windward side of O‘ahu, north of Marine Corps Base Hawai‘i, and consists of three test berths installed at 30-meter, 60-meter, and 80-meter water depths. Each berth can host point absorber and oscillating water column WECs to a peak power of 1-megawatt. To date HNEI and ARL at UH have completed V&V assessments for four device deployments: two for the Northwest Energy Innovations Azura WEC and two for the Fred.Olsen Lifesaver WEC.

Hawai‘i as a Natural Laboratory

A fundamental objective of WETS tasking is to document the effects of long-term exposure to the elements on WEC devices and supporting infrastructure. Known for its mild climate, Hawai‘i nevertheless exacted a toll on the WETS mooring systems over the past five years. In 2019 HNEI and ARL at UH, under the guidance of Naval Facilities Engineering Command, completed a major redesign of the WETS deep-berth mooring systems and installed and tested these upgrades at the 60-meter berth in May and June 2019. Similar upgrades at the 80-meter berth are planned for late 2020 or 2021. The redesign involved a substantial increase in the size of mooring chain, improvement in the type of joining links, modification of surface floats, and the inclusion of a “no-WEC hawser” system to provide pretension in the moorings when no WEC is installed. HNEI personnel also redesigned the cable offshore terminations and anchors, reducing their weight to facilitate recovery by smaller vessels and adding flexibility for accommodating umbilical cables of future WECs. All elements of the redesign were aimed at improving mooring fatigue life with the intent of supporting many WEC deployments in the coming years.

On December 1, 2019, the Ocean Energy (Ireland) OE35 WEC arrived in Pearl Harbor after a long journey from its port of fabrication in Portland, Oregon. This 866-ton oscillating water column WEC, fitted with a 500-kilowatt Siemens turbine generator, represents a major increase in size and power production as compared with WECs previously deployed at WETS. The OE35 WEC will be deployed for one year at the WETS 60-meter berth in late 2020 or early 2021.

Traditional Hawaiian blessing ceremonies, in this instance conducted for a wave energy converter, involve untying a maile lei.

Building Capability in Hawai‘i

ARL at UH subcontracted a local engineering company, Sea Engineering, Inc., to modify the 85-foot vessel Kupa‘a to support activities at WETS. Kupa‘a, Hawaiian for ‘steadfast,’ comes equipped with 10-ton A-frame lift capacity, a 4-point mooring system, a versatile knuckle-boom crane, the ability to support a remotely operated vehicle, sufficient space on the back deck for containers or large equipment, ample space and functionality for science crews, and a modified hull for greater stability. Berthed at Honolulu Harbor, Kupa‘a provides HNEI and ARL at UH with quick access to WETS and supports other seagoing operations around O‘ahu when they do not conflict with WETS activities.

Photo by Patrick Cross

ARL Maui

ARL at UH is working with the Department of Navy (DON) Modeling and Simulation (M&S) Office to develop an enterprise digital collaboration engineering environment at MHPCC. The enterprise environment hosts a library of M&S capability that includes processes, standards, tools and best practices to enable enterprise-wide discovery, access, and reuse of software products. ARL at UH will continue to work with the DON M&S Office to integrate digital engineering workflows into the ecosystem to support the DoD digital engineering strategy released in July 2018. The strategy promotes the use of digital representations of systems and components and the use of digital artifacts to design and sustain national defense systems. The goals of the strategy include formalizing the development, integration, and use of models to inform enterprise and program decision making; providing an enduring, authoritative source of truth; incorporating technological innovation to improve the engineering practice; establishing a supporting infrastructure and environment to perform activities, collaborate and communicate across stakeholders; and transforming the culture and workforce to adopt and support digital engineering across the lifecycle. By focusing on creating a centralized authoritative source of digital truth data that is fully integrated, the goal is to improve timeliness and accuracy of program decisions across the system lifecycle.

Photos by Lance Terada

In May 2020 ARL at UH was awarded a four-year Indefinite Delivery/Indefinite Quantity contract by the U.S. Air Force Research Laboratory to operate the Maui High Performance Computing Center (MHPCC). The contract calls for ARL at UH to provide essential engineering, research and development capabilities in emerging computer technology. The tasking is intended to lower barriers to a modern high-performance computing ecosystem and high-performance computing-backed solutions.

High Performance Computing

At the direction of DoD's High Performance Computing Modernization Program (HPCMP), ARL at UH has supported expansion of High Performance Computing (HPC) for science and engineering organizations through the use of a web-enabled Portal. Production version HPC Portals are currently available and supporting all five DoD Supercomputing Resource Centers. Any user workstation on any network can access HPCMP systems and HPC-backed capabilities via HPC Portal. The HPC Portal supports Windows, MacOS, Linux, Android and iOS clients with a DoD Common Access Card (CAC) or HPCMP Yubikey. The HPC Portal uses well-known web ports and client web browsers like Chrome or Internet Explorer. Due to a significant increase in teleworking that resulted from the COVID-19 pandemic, the HPC Portal has seen a 38% increase in utilization. The ARL at UH maintains the HPC Portal software for the HPCMP program and this year worked to enhance the effectiveness of the file management web graphical user interface and internal deployment management of the software.

Photo by Alyssa Creps

Technology
Incubation
Demonstration
Experimentation
Support

Incubating Innovation

ARL at UH is uniquely positioned to conduct air, ocean surface, ground and underwater testing in Hawai‘i due to proximity and access to DoD and non-DoD test sites, engagement of local warfighting units, and Hawai‘i’s mild climate and environmental diversity. In 2020, with support from DoD’s Indo-Pacific Command (INDOPACOM) joint combatant command and industry partners, ARL at UH established Technology Incubation, Demonstration and Experimentation Support (TIDES) a test and evaluation (T&E) platform where innovative technologies can be incubated in Hawai‘i and tested and assessed with warfighter involvement in operationally relevant environments. TIDES takes place in three phases. The first phase (incubation) involves initial testing of emerging technologies in Hawai‘i to assess the technology’s readiness in isolated or integrated settings and to identify problem areas that need to be addressed before introducing the technology to the warfighters. After follow-on development has been conducted to resolve technical issues, the second and third phases of TIDES (demonstration and experimentation) insert the technologies, with unit sponsorship, into exercises or training events for operational assessment.


Photo by Mary Baghdady

Fostering Collaboration

The inaugural TIDES event, held on March 5, 2020 showcased one non-DoD and one DoD example of Hawai‘i’s available test areas: Coconut Island (Moku o Lo‘e) and Bellows Air Force Station (BAFS). Coconut Island, located in Kāne‘ohe Bay, O‘ahu, is operated by the Hawai‘i Institute of Marine Biology at the University of Hawai‘i and hosts a world-class laboratory and supporting infrastructure including docks and vessels, workshops, classrooms, and conference rooms. Surrounded by a shallow-water, littoral reef environment, Coconut Island has served the ARL at UH as an ideal T&E site for aerial, surface, and underwater vehicles with controlled public access.

Located in Waimānalo, O‘ahu, BAFS serves a morale, welfare and recreation mission for military families. ARL at UH regularly conducts T&E operations involving unmanned systems and other emerging technologies in support of INDOPACOM and component services at BAFS, helping expand BAFS’s functionality as a T&E and innovation site for emerging technologies. BAFS has multiple terrains for testing including a former active airfield, an unpopulated coastline, open fields, deep forest canopy, an abandoned cantonment, freshwater streams and ocean conditions that range from still water to active surf.

Discovery-based field experimentation, where program sponsors, technologists and users work together in the operating environment, accelerates critically necessary steps in evolving warfighter support. TIDES was designed to provide a realistic, uncontrolled setting for technology development and enhancement from incubation to operations. Through facilitating access to relevant and realistic environments, and providing proximity to INDOPACOM, ARL at UH and partners are working to create a crucible for innovation and field experimentation.

Adaptive Optics

The ARL at UH supports IfA in developing an autonomous laser-adaptive-optics system for the U.S. Naval Observatory's 1.8-meter altazimuth (Alt-Az) telescope that will be commissioned in Flagstaff, Arizona. The Robotic Laser Adaptive Optics System is the first autonomous laser adaptive optics system. It uses an eye-safe ultraviolet (UV) laser guide star and corresponding opto-electronically-gated UV wave-front sensor to measure atmospheric turbulence, and a micro-electromechanical-system deformable mirror to correct the light based on the turbulence data. The system robotically executes large-scale surveys, monitors long-term astrophysical dynamics and characterizes newly discovered transients, all at the visible diffraction limit.

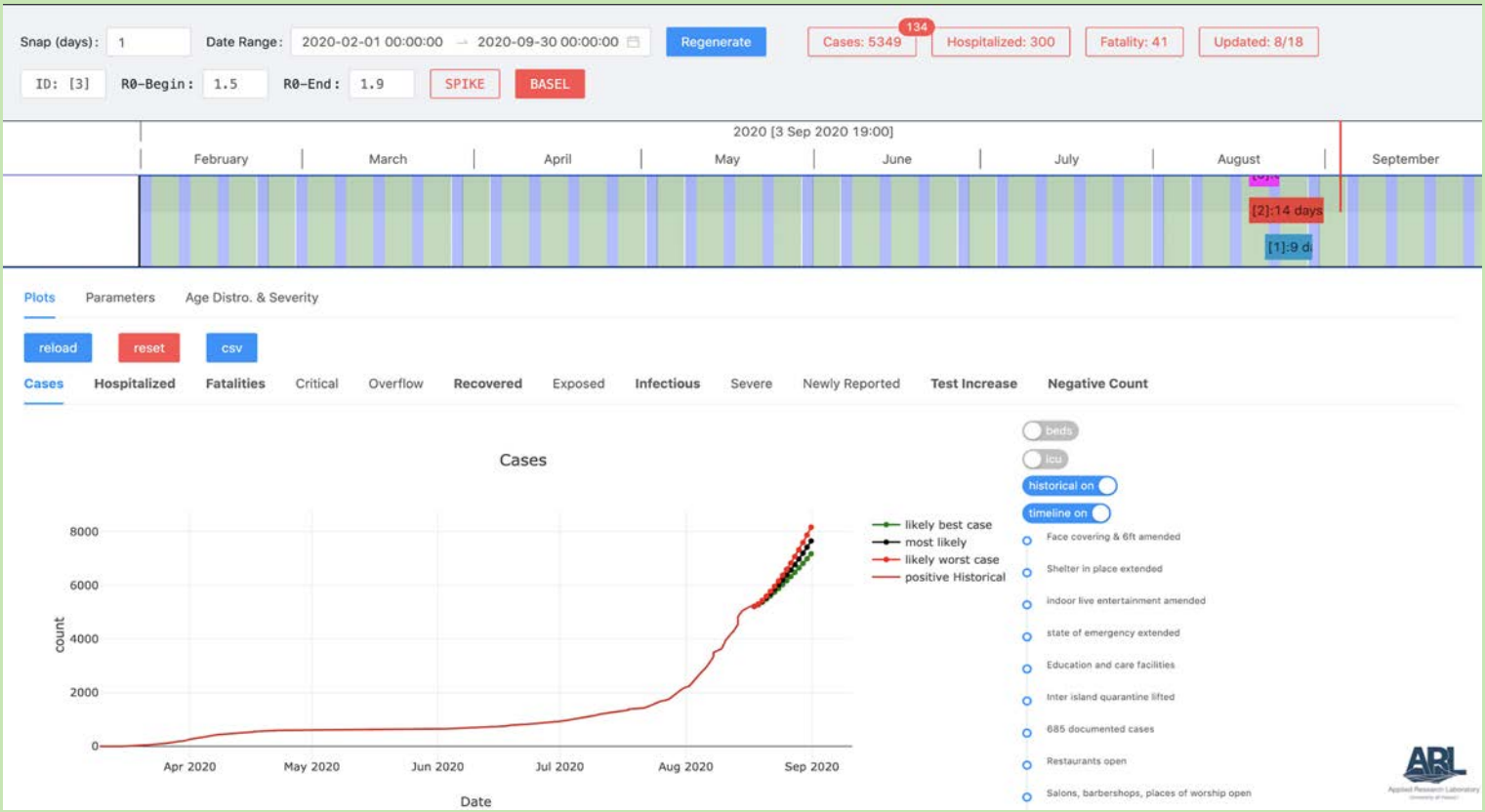
Extraordinary Resources

Maunakea, located on Hawai'i Island, is unique as an astronomical observing site. At ~14,000 feet elevation Maunakea is above the Earth's thermal inversion layer, so the atmosphere is extremely dry and free from clouds. The exceptional stability of the atmosphere above Maunakea significantly improves measurements of infrared and sub-millimeter radiation from celestial sources and permits detailed studies that are not possible elsewhere in the world. ARL at UH supports the Institute for Astronomy (IfA) in conducting operations and management of the United Kingdom Infrared Telescope (UKIRT) on Maunakea, for example, working in 2019 to enhance secure, remote-control operations of UKIRT from remote sites.

Photo by Mary Baghdady

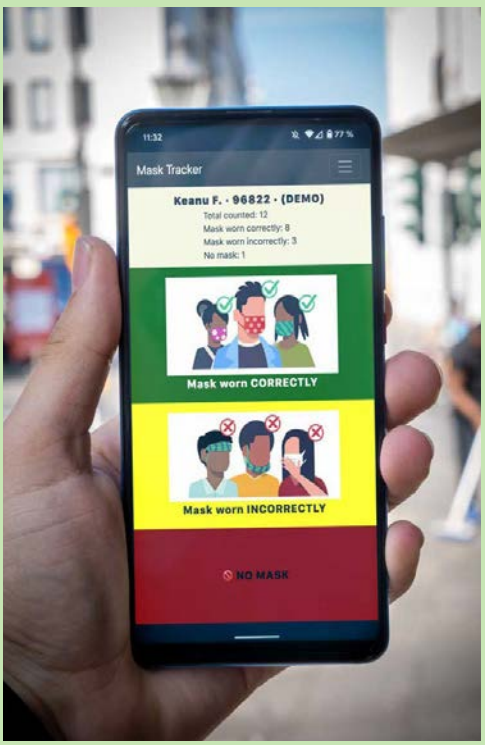
IfA astronomers use telescopes on Maui and Hawai'i to research the Solar System, stars, galaxies and the formation and evolution of the universe.

Photos by Margo Edwards



Assisting Emergency Managers

ARL at UH developed multiple web applications to rapidly support the State of Hawai‘i’s Emergency Management Agency and Department of Health in responding to the COVID-19 pandemic. The first application, created in partnership with the Hawai‘i Pandemic Applied Modeling Work Group, helps model various scenarios as the State considered approaches for re-opening. Using existing open-source models, the scenario application allows epidemiologists to project the impact that events such as increasing the number of visitors allowed to fly to Hawai‘i or re-opening public schools could have on public health. This application frequently updates available data for Hawai‘i’s pandemic status to provide timely and relevant simulations. A second application, created in partnership with the UH School of Nursing and Dental Hygiene, provides a simple and effective way to gather metrics gauging public adherence to wearing masks throughout the State. Using their cell phones or home computers, volunteers observe whether people at specific sites wear masks correctly, incorrectly, or not at all, and upload their tallies to a secure site where researchers can rapidly analyze and disseminate the information to medical personnel and decision makers. The third application is a symptom screener for COVID-19, which assists those using the program and their employers by promoting daily consideration of personal health. If the user has none of the symptoms listed in the application, they are given a Quick-Read (QR) code that can be logged as they enter their place of employment.



Apps by
Ray Farias and Baseem Missaghi

Photos by
Hawaii Pacific Health

Enhancing Hospital Capability

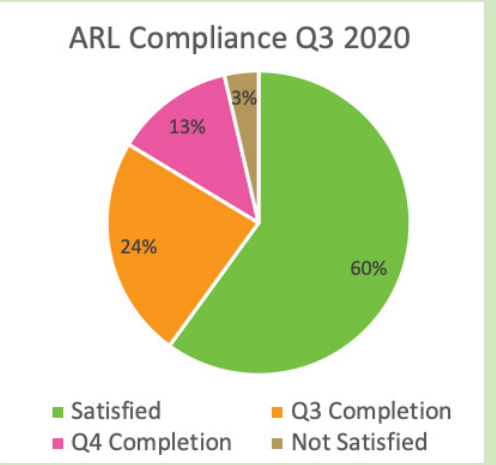
During the early weeks of the novel coronavirus (COVID-19) pandemic in the United States, public health officials predicted a ventilator shortage for critically ill patients in Hawai‘i. To address this predicted shortage, a team of physicians, respiratory therapists, and engineers from the Hawai‘i Pacific Health system, UH’s John A. Burns School of Medicine, the UH College of Engineering, and the ARL at UH collaborated to develop the novel Quad-Split Ventilator System (QSVS). The QSVS is an airflow apparatus that allows physicians to provide individualized ventilation for up to four patients attached to a single ventilator. Basic split-ventilator concepts have been implemented in the past, notably during the 2017 Las Vegas mass shooting tragedy; however, the basic split-ventilator system has been criticized for being unable to meet individualized ventilatory needs of each patient, adversely affecting all of the patients in the system during sudden tube occlusion or disconnection, and allowing cross-contamination between patients.

QSVS improved upon previously developed split ventilators by individualizing ventilation (tidal volume, peak inspiratory pressure, peak end expiratory pressure, and oxygen concentration) with individualized monitoring and decoupling flow between patients using bacterial/viral filters, one-way valves, and flow restrictors. QSVS is made from low-cost materials available in any local hardware store that can be readily sterilized. Within five weeks of development, the team deployed the novel QSVS at four hospitals in Hawai‘i for evaluation by dozens of medical professionals around O‘ahu and launched preliminary animal testing trials.

The Quad-Split Ventilator System: Ventilating up to four patients with individualized care

The Government Cloud

ARL at UH is constantly improving information security technology, practices and procedures through self-assessments, collaboration with partner University-Affiliated Research Centers (UARCs), data sharing with law enforcement organizations, and knowledge gained through cybersecurity tasks focused on risk assessments of DoD-sponsored information systems. As the first Navy UARC to move completely into a cloud environment for email exchange and unclassified data storage and handling, ARL at UH is blazing a trail that will provide many lessons learned applicable to the broader Defense Industrial Base. ARL at UH has learned that working in the cloud requires sharing many cybersecurity responsibilities with the cloud vendor. For example, whereas secure commercial enclaves meet many federal cybersecurity compliance requirements, a significant portion of the security tools must be procured separately and managed, maintained, and operated by the purchaser. Over the past year ARL at UH has added next-generation antivirus software to protect endpoint devices, configuration management tools, a centralized removable-media management and encryption solution and centralized monitoring of security logs. Additionally, ARL at UH has begun experimenting with vulnerability scanning and monitoring of applications developed in house both to protect networks during development and to advance the information assurance posture of new technologies during the early stages of development.



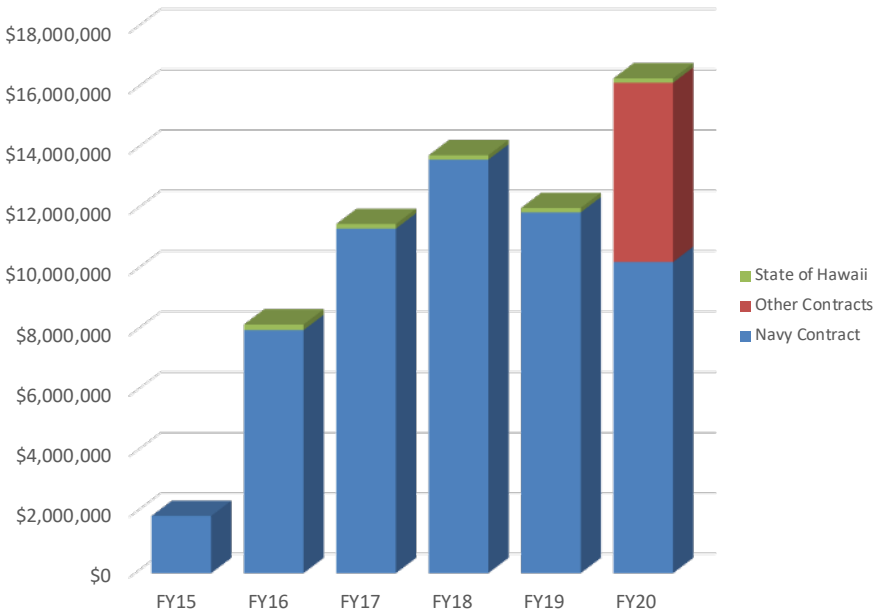
Cybersecurity Compliance

In 2019 ARL at UH made significant progress towards compliance with the National Institute of Standards and Technology (NIST) Special Publication 800-171, which governs handling of Controlled Unclassified Information (CUI) in non-Federal information systems and organizations. Taking advantage of a physical change in office locations, ARL at UH implemented a new physical security system, completed a network rebuild, and implemented a virtual private network. Additionally, ARL at UH rolled out new antivirus software, baseline-configuration software, and migrated the entire staff on O‘ahu to cloud-based office tools. ARL at UH also collaborated with Johns Hopkins University Applied Physics Laboratory on a proof-of-concept security tool for multi-UARC use. The tool is now implemented by both UARCs.

Over the next year ARL at UH expects to complete the final phases of migration to the cloud environment, which includes building a new active-directory domain for identity management, implementing mobile device management, improved digital auditing and log aggregation, and implementation of removable media protection and hard drives. ARL is working towards completing most of the remaining NIST 800-171 controls by the end of 2020. In addition to security controls addressed in NIST 800-171, ARL at UH has been closely monitoring developments with the new Cybersecurity Maturity Model Certification and has preemptively satisfied seven of the twenty additional controls that have been added to NIST 800-171 requirements.

Financial Health

ARL at UH was founded in 2008. As the youngest Navy UARC, the laboratory has been growing at a rapid pace, with annual revenues between Federal FY15 and FY20 increasing eight-fold. A new Indefinite Delivery/Indefinite Quantity (IDIQ) contract and tasking for the Air Force Research Laboratory awarded in FY20, combined with a steadily increasing number of projects for the Department of the Navy, are anticipated to yield an additional four-fold increase in revenue over the next five years.



Since the ARL at UH was founded, the U.S. Navy has been the laboratory's primary sponsor of the UARC contract (48%), followed by the U.S. Air Force (34%), the U.S. Army (8%) and the National Geospatial Agency (5%). On May 1, 2020 ARL at UH executed its second IDIQ contract, which is designed to support a growing portfolio of high-performance computing and digital engineering tasks. The addition of the second IDIQ contract is expected to shift the original UARC IDIQ contract towards Navy objectives.

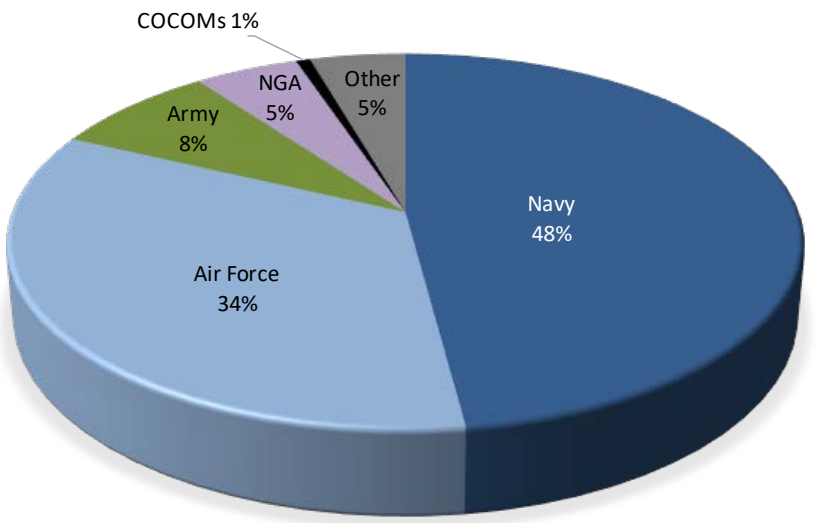
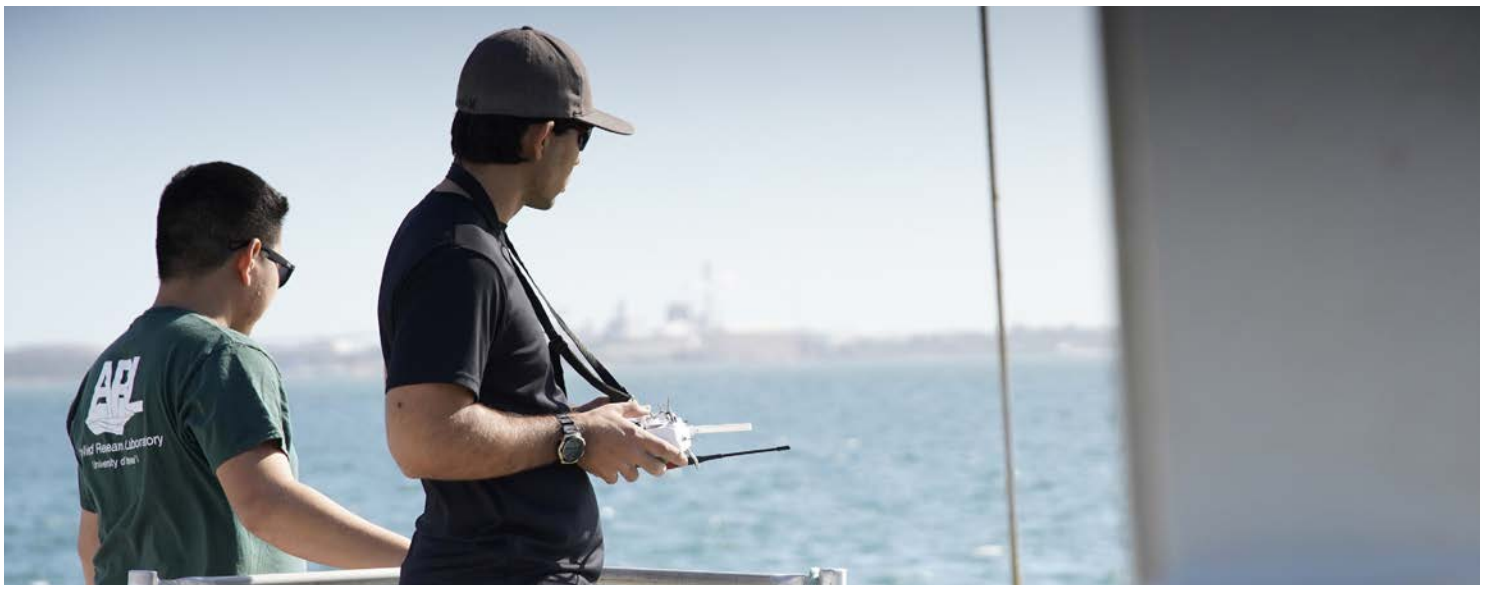


Photo credit:
Above photo by Sam Cadotte
Below and top right photos by Mary Baghdady
Bottom photo by Team Kanaloa

Workforce Expansion

As recently as 2015 ARL at UH staff consisted almost entirely of administrative personnel whose function was to support tasks developed and led by faculty on the UH campus. Over the past five years ARL at UH hired multiple scientific and technical staff to provide in-house subject matter expertise and business development for new tasking. In 2017, personnel working at the Maui High Performance Computing Center were folded into the ARL at UH team. Now there are seventy employees working for ARL at UH on O‘ahu and Maui, a ten-fold increase since the laboratory was established in 2008. Technical personnel areas of expertise include unmanned aerial systems (UAS), sensor fabrication, communications, data analytics, software/applications development, mechanical engineering, high-performance computing, digital engineering information assurance, cybersecurity, database management and system administration. During the same period ARL at UH increased its administrative staff to include a media publications specialist to more effectively market ARL, an event planner to organize multiple field demonstrations, workshops and conferences, and an office manager to lead the fiscal and administrative teams.



Future Workforce

ARL at UH focuses on the students of Hawai‘i and designs projects to develop and train a high-tech workforce that can locally support DoD and the State of Hawai‘i. In 2018 and 2019, ARL at UH supported graduate students and undergraduate students in completing projects for UH faculty. ARL mentored local high school students through project-based learning efforts during two-month-long summer internship programs. ARL at UH is working with the State Government to develop new pathways for attracting public high school students to internships throughout the UH system. Most importantly, ARL invites students to participate in field exercises with DoD and local stakeholders to introduce the students to potential employers. ARL is moving into a new role as a resource for DoD organizations such as Air Force Research Laboratory, Naval Special Warfare, Defense Intelligence Service Agency, Pearl Harbor Navy Shipyard and industry that desire to create a “pipeline” for student interns to support their organizations and needs.

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