APPLIED RESEARCH LABORATORY

UNIVERSITY of HAWAIʻI

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The Applied Research Laboratory at the University of Hawai‘i (ARL at UH) develops pioneering solutions to address challenges facing our stakeholders, our community, and our planet. Based in the heart of the Pacific Ocean, ARL at UH collaborates with the United States (US) Department of Defense (DOD), Pacific Rim allies and partners, national and local industry, and universities to engender a free and open Indo–Pacific and cultivate future generations of innovators.

Image (left page): ARL at UH divers deploy an Acoustic Doppler Current Profiler and survey local corals
Cover image: Reinforced concrete module designed to reduce wave energy and recruit coral larvae

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The R3D Consortium

Contributor: Joshua Levy

Rapid Resilient Reefs for Coastal Defense (R3D) Consortium, an academic–industry partnership between UH, Scripps Institution of Oceanography, Florida Atlantic University, Ohio State University, and Makai Ocean Engineering, successfully moved into phase two of a three–phase effort to develop a living breakwater: an engineered coral reef to protect coastlines. R3D is an ARL–led project that spans ten laboratories (five at UH Mānoa) funded by the Defense Advanced Research Projects Agency to develop a nature–based solution to mitigate the impacts of increased storms and higher sea levels on coastal infrastructure. The focus of phase two is scaling up newly developed technology and preparing for the deployment of the prototype breakwater system in 2025.

The novel thin–walled, porous, submerged breakwater modules called reef–mimicking structures (RMS), which effectively attenuate wave energy and minimize disturbance to natural water and sediment flow in the area, are being manufactured at concrete precast yards on Oʻahu.

Research efforts to facilitate the settlement of coral larvae and juvenile fish and optimize coral out–planting techniques are now being tested at the deployment site to evaluate performance outside of controlled testing environments.

The Consortium has conducted the first bay–to–bay transplant of coral to assess how thermally tolerant traits are conserved when corals are exposed to different environments. Additionally, the team is growing coral juveniles collected from second–generation colonies of thermally tolerant corals, a first in Hawaiʻi.

The R3D Consortium is preparing to deploy the 50m–prototype–living–breakwater array and biology solutions off Ulupaʻu Peninsula, on the Kailua Bay side of Marine Corps Base Hawaiʻi (MCBH) in 2025.

Prototyping on Demand

Contributor: Sean Mahaffey

The Naval Special Warfare Prototyping on Demand (NSW PonD) project sponsored by the NSW Undersea Systems program office (PMS 340) supports the Hawai'i SEAL Delivery Vehicle Team One (SDVT-1). Operational tasking and fieldwork have identified needs and gaps in technology, equipment, and services. ARL at UH has met many of those needs by the expansion and improvement of additive manufacturing capabilities and capacity, including the installation of a metal 3D printing system — the Markforged Metal X — housed at the Institute for Astronomy Instrument Shop. ARL at UH and the UH College of Engineering are currently conducting a material characterization study of the Metal X prints.

The ARL at UH excels in creative and agile design resulting in effective solutions. Coupled with the ability to provide efficient in-person discussion and hands-on demonstrations for SDVT-1, ARL at UH completed the second phase of the SEAL delivery vehicle (SDV) full-scale model for maintenance training, developed maintenance test sets for the newest generation SDV battery charging system, and created custom software for charging data analysis.

In partnership with the UH Marine Center Pressure Testing Facility, ARL at UH provides hydrostatic pressure testing for equipment used underwater by NSW units, eliminating the need to send equipment off-island for testing. Further, ARL at UH is growing an ecosystem of support in Hawai'i: by partnering with local small businesses, the unique and dynamic needs of SDTV-1 are being met while local Hawaiian businesses and the State's economy are simultaneously bolstered.

Lilipad

Contributor: Noah Hafner and Milton Garcés

The Low-cost Infrasound Location Informed Potential Anomaly Detection (LILIPAD) task was to design and build a maritime network of advance warning systems to detect, locate, and characterize vessels, aircraft, and other systems that emit acoustic and infrasound signatures. The ARL at UH combined commercial off-the-shelf (COTS) components including smartphones and Universal Serial Bus microphones with three dimensional (3D)-printed structures and open-source data processing tools to fabricate low-cost, rapidly deployable sensors. The systems were designed to operate autonomously and integrate seamlessly into existing data collection and communication frameworks.

LILIPAD provides a rapidly scalable and cost-effective solution for sensing and monitoring that enhance the situational awareness of surface activities, which directly supports operational missions focused on persistent surveillance, anomaly detection, and maritime domain awareness. LILIPAD's simple manufacturing and deployment processes reduce training burden and minimize maintenance in comparison to complex warning systems.

Ten “lilipads” were fabricated over a period of three months in the fall of 2024. Each lilipad consisted of a mast, ballast, electronics, float, and anchor. COTS water-resistant housings were purchased to hold one smartphone and microphone per lilipad, which recorded the acoustic signatures. Custom-built, 3D-printed components were designed and fabricated by ARL at UH to secure the phones, external batteries, and splitters inside the housings. The total cost of each lilipad was under $1,200.

In December 2024, the ten lilipads were deployed in the ocean east of the Daniel K. Inouye International (Honolulu) Airport Reef Runway. Deployment of the lilipads took an hour and was accomplished by two personnel operating from a dinghy. The lilipads were spaced approximately 340 meters apart to spread the array of sensors throughout the area and increase the timing differential of incident sound at individual lilipads. During the four-hour LILIPAD demonstration, all ten units successfully collected acoustic data from each source and also reported lilipad positions, timestamps, and station identifiers. LILIPAD yielded near-real-time spectrograms from signals of interest that were filtered to exclude noise and source Doppler to identify aircraft. Open-source systems were simultaneously used to analyze positions, times, and classifications for comparison with the LILIPAD results.

Space Situational Awareness

Contributor: Ned Davis

The Space Domain is crucial to modern communications, navigation, and intelligence, especially in the Pacific Theater, where there are vast expanses of ocean between terrestrial sensors and communications stations. As part of the mission to provide high performance computing resources in the Pacific Theater, ARL at UH collaborates with the US Air Force's Maui High Performance Computing Center (MHPCC) to provide Space Situational Awareness (SSA) by developing novel applications using state-of-the-art machine learning methods to collect information critical for DoD's SSA on relevant timelines. This project focuses on using optical and synthetic aperture radar observations to rapidly produce high-resolution representations of objects in orbit above Earth. The ARL at UH and MHPCC have demonstrated fusion of optical and radar data of space objects in varying poses and from differing perspectives. The fused information allows the important aspects of an object to be quickly registered without human intervention. Reconstruction algorithms have been applied to create 3D models of space-borne objects from individual two-dimensional images without using any prior knowledge of the object. Lastly, ARL at UH and MHPCC have demonstrated a fast model for characterizing satellite features with the uncertainty of the model quantified using image segmentation and cutting-edge vision transformers.

** Technical Information Approved under PA Approval # AFRL-2024-2526, Images and the balance of general information is all academic / open source.*

Above images: Model of the Hubble Space Telescope

Desalination

Contributor: Sean Blanks

Image above: Solar-thermal desalination system model

The Energy Transport and Conversion Laboratory (ETCL) at the University of Hawai'i at Manoa led by Dr. Woochul Lee is a research group operating within the Department of Mechanical Engineering. In 2024, with the support from ARL at UH, ETCL made progress in developing drinking water solutions aimed at humanitarian aid and disaster relief by demonstrating an interfacial solar-thermal desalination prototype device capable of producing pure drinking water.

Photo above: 21cm In-situ prototype

Water scarcity is a global issue, and the Pacific region is no exception. Water stress, exacerbated by natural disasters, disrupts communities, as evidenced in Lahaina, Maui. Ensuring access to low-cost, grid-independent drinking water is essential for addressing existing and emerging water security. Solar thermal desalination technologies offer a promising solution to critical water scarcity challenges. Traditional thermal distillation processes, which evaporate water and condense the vapor to produce distilled water, are well-established, however solar thermal interfacial desalination offers distinct advantages over conventional methods. The prototype desalination device utilizes a porous, polyvinyl alcohol pretreated hydrophilic polyurethane foam substrate yielding enhanced wettability and a reduced graphene nanoplatelet and polydimethylsiloxane nanocomposite solar absorber.

This durable and efficient evaporator achieves an average solar-to-vapor conversion efficiency of 70%. The evaporator is further complemented by a polymer-coated hydrophobically enhanced condensing cover, which efficiently collects the generated steam as pure fresh water, achieving an overall condensation efficiency of 86%. The produced water was independently analyzed by a third-party lab and found to meet the Environmental Protection Agency's guidelines for drinking water.

Photo above: Lab scale closed evaporation.

Hoʻolana

Contributor: Gloria Choo and Margo Edwards

Hoʻolana "Launching" Innovation for Global Impact, organized by the UH Office of Innovation & Commercialization and the Defense Innovation Unit, was designed to leverage university innovative research as a catalyst for growing Hawaiʻi's technology sector and provide a mechanism for US DoD to rapidly adopt mission–relevant capabilities. Hoʻolana supports UH's efforts to build and support partnerships between DoD and academic institutions, discover and advance emerging technologies, create a highly skilled technology and entrepreneurial workforce, and accelerate transition of novel technology into acquisition programs and operational use.

Hoʻolana launched a collaboration between academia, industry, and City and County of Honolulu experts to participate in a groundbreaking initiative called the Hoʻolana Water Resilience Prize Challenge. Beginning with a series of workshops, the collaboration steered discussion towards water resilience as a focus topic, with the goal to support water innovation solutions in Hawaiʻi. US DoD Naval Facilities Engineering Expeditionary Warfare Center partnered with the UH System, with support from DIU and One World One Water of Honolulu and launched the pilot program in the Fall of 2023 with solicitations for water resilience proposals across UH. There were 13 proposed solutions ranging from solar thermal desalination techniques to wastewater treatment solutions. The program concluded with an exciting pitch competition for five of the 13 proposed solutions. The Water Resilience Innovation Challenge was designed in two parts: (1) down selection to five proposals to invite to the Pitch Event, and (2) execution of the Pitch Event and selection of two winners to each receive research and development funding.

The two winning pitches were entitled, "Detecting Cloud Immersion through Analytical and Machine Learning Image Analysis," and "Restorative Aquaculture for Water Quality and Habitat Improvement in Pearl Harbor." The cloud immersion team's goal was to develop machine learning algorithms that reliably recognize fog in Hawaiʻi's tropical montane cloud forests to promote better understanding of the relationship between fog and the availability of water in cloud forests. The cloud immersion team has deployed cameras in Nahuku to acquire images, then test and refine their algorithms. The aquaculture team's goal is to improve water quality in Pearl Harbor using oyster bivalves to filter out excess phytoplankton, settle sediment, and maintain water clarity. The aquaculture team has located and identified native and local bivalve species and transported them to UH Hilo's hatchery for spawning and conditioning so that they can be moved to new sites for restoration. Both teams will conduct final demonstrations of their projects in the fall of 2025.

Test and Evaluation of Miniature Sondes for Community Outreach

Contributors: Kai Santos and Martine Bissonnette

Miniature Sondes (MiSos), maritime-deployable sensor platforms designed and developed by ARL at UH, are built from COTS and 3D-printed components. MiSos are ideal tools for training Science, Technology, Engineering, and Mathematics (STEM) students, fostering hands-on experiences in research, development, testing and evaluation. In 2024, ARL at UH instituted the Test and Evaluation for Community Outreach (TECO) program, designed to mentor high school and college students working in STEM through assembly, testing, and evaluation of MiSos. In addition to providing project-based technical experience to students, TECO highlighted the socioeconomic impact of using MiSos and other agile sensors and platforms in humanitarian assistance and disaster relief situations.

The TECO team supplied kits containing MiSo components and detailed assembly instructions to four asynchronous cohorts of college and high school students. Participants were mentored through the assembly of the MiSos, then they tested and undertook troubleshooting to produce a functioning platform. Skills learned and practiced during TECO workshops included soldering, electromechanical assembly, time management, communications, and teamwork. At the end of each cohort, the participants were surveyed to provide feedback on the program and technical instructions. Student feedback was incorporated into subsequent TECO sessions with new cohorts in support of ARL at UH's ultimate objective: promoting the rapid design, fabrication, deployment, assessment, and enhancement of sensing systems by and for the people who desire to use them.

POST FX

Contributor: Margo Edwards

Since 2022, ARL at UH has supported Field Experimentation (FX) at the United States Indo-Pacific Command's (USINDOPACOM) annual international meeting, the Pacific Operational Science & Technology (POST) conference. POST connects policy, military, industry, and academic leadership from the US and its Pacific allies and partners, focusing on emerging challenges in the Indo-Pacific region. The theme for the POST 2024 conference, facilitated by the National Defense Industrial Association, was "Posturing for Tomorrow — Partnered / Positioned / Prepared."

POST FX 2024 was conducted on March 7, 2024, at the MCBH in Kāneʻohe, Hawaiʻi. Approximately 600 attendees from 13 countries observed technologies representing 45 organizations or vendors. All POST FX 2024 technologists linked their demonstrations to USINDOPACOM's innovation priorities, with All-Domain Awareness, Joint Command-and-Control, and Contested Logistics having the most representation. POST FX 2024 was designed to foster collaboration around identified innovation priorities, provide visibility to promising non-traditional defense performers, and identify novel transformative technology solutions to emerging challenges.

Acronyms & Abbreviations

3D	three-dimensional
ARL at UH	Applied Research Laboratory at the University of Hawai‘i
COTS	Commercial-off-the-shelf
DoD	Department of Defense
ETCL	Energy Transport and Conversion Laboratory
FX	Field Experimentation
LILIPAD	Low-cost Infrasound Location Informed Potential Anomaly Detection
MHPCC	Maui High Performance Computing Center
MiSo	Mini Sonde
NSW PonD	Naval Special Warfare Prototyping on Demand
PMS 340	NSW Undersea Systems program office
POST	Pacific Operational Science & Technology Conference
R3D	Rapid Resilient Reefs for Coastal Defense
RMS	reef-mimicking structures
SDV	SEAL Delivery Vehicle
SDVT-1	SEAL Delivery Vehicle Team One
SSA	Space Situational Awareness
STEM	Science, Technology, Engineering, and Mathematics
TECO	Test and Evaluation for Community Outreach
UH	University of Hawai‘i
US	United States
USINDOPACOM	United States Indo-Pacific Command

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