RESEARCH CLUSTERS AND CENTERS
IN THE COLLEGE OF ENGINEERING
The College of Engineering at UH Mānoa has a diverse faculty employed in over 80 distinct research areas in three main departments, Civil and Environmental Engineering, Electrical Engineering and Mechanical Engineering. As the College faculty pursue these interests they naturally team together to pursue larger projects and opportunities. In this document we describe eight research clusters, where the College is investing special emphasis and a UH Board of Regents designated research center.

There are many traditional areas of expertise that the College faculty members work in such as structural engineering, transportation engineering, materials engineering, fluid dynamics etc. and some emerging areas new to the College such as optical engineering, in association with the Institute for Astronomy at UH Mānoa. As new areas emerge and take shape they will be added to this document. The College Departments can give complete details of the areas of interest and their faculty.

THE EIGHT RESEARCH CLUSTERS ARE:

- Autonomous Systems and Robotics
- Big Data and Cyber Security
- Biomedical Engineering
- Coastal Infrastructure
- Computer and Computational Engineering
- Renewable Energy and Island Sustainability
- Sustainable Material and Manufacturing Technology
- Water, Waste and Environmental Engineering

UH BOARD OF REGENT’S RESEARCH CENTER:

- Hawai‘i Center for Advanced Communications

These areas have been chosen to reflect faculty interest and expertise as well as the evolving needs of Hawai‘i. They also represent some of the main interests of the College’s collaborators in these research efforts, inside the university, in the local Hawai‘i community and further afield. The College is especially interested in extending these relationships to local companies, U.S. mainland universities, and Asian universities as well as many other potential partners.

We have listed two faculty members who serve as leaders for each research cluster as well as many of the faculty involved in these efforts. We invite the reader to contact these faculty members directly to gain more information and explore possible partnership opportunities. Full details of contact information are listed at the back of this publication.
AUTONOMOUS SYSTEMS AND ROBOTICS

LEADERSHIP TEAM:
Peter Berkelman & Brian Bingham

The University of Hawai‘i at Mānoa has nationally ranked programs in ocean and planetary sciences. The College’s faculty is working closely with these programs in a range of areas, particularly in autonomous systems and robotics technology for space and ocean applications.

PARTICIPATING FACULTY:
Gürdal Arslan
Dilmurat Azimov
Song K Choi
David Garmire
Reza Ghorbani
Marcelo Kobayash
Aaron Ohta
Wayne Shiroma
Trevor Sorensen

COLLABORATING ORGANIZATIONS:
UH Mānoa Hawai‘i Space Flight Laboratory (HSFL); UH Center for Island, Maritime and Extreme Security (CIMES); UH Mānoa School of Ocean and Earth, Science and Technology (SOEST); UH John A Burns School of Medicine (JABSOM); Tokyo Institute of Technology (TIT); Waseda University (WU); Korea Advanced Institute of Science and Technology (KAIST); Istanbul Technical University (ITU); Russian University of People’s Friendship (RUPF); National University of Uzbekistan (NUU); Battelle Memorial Institute (BMI); Space and Naval Warfare Systems Command (SPAWAR) SSC Pacific; Intellisis; Liquid Robotics; Woods Hole Oceanographic Institute

RESEARCH ACTIVITIES:
• Spacecraft bus and mission payload design, including nano-satellites and pico-satellites
• Guidance, navigation and control in space systems
• Astrodynamics and applications
• Unmanned underwater vehicle and system design
• Unmanned maritime security systems
• Underwater communications and navigation
• Autonomous unmanned system workspace optimization
• Autonomous manipulation systems
• Sensors for autonomous vehicles and systems
• Control systems in robotics and exploration systems
• Machine learning, neural networks and adaptive signal processing
• Alternative power supply technology
• Cleanerbots and robotics in sustainability
• Surgical robotics
Modern problems with large datasets present unique challenges not only because of the data size, but also because the data tends to be high dimensional and the questions asked are unlike anything before—from modeling complex and large order dependencies in biological data or sensor data with renewable sources to predicting rare and catastrophic events in nonparametric settings. As a consequence, the fifty-year old paradigm of representing and reproducing information is shifting to systematic knowledge extraction in the information sciences. This shift forms the first theme of research in this Cluster, reflected in reworking the foundations and algorithms of machine learning, information theory and statistics and therefore transforming a variety of applications in biology, finance, social networks. There is often a tension in what can be accomplished by the machine learning side versus what is desirable from a privacy/security standpoint, and this forms the second focus of the Cluster.

RESEARCH ACTIVITIES:
• Statistical approaches for high dimensional data and Bayesian non-parametrics, exchangeability and related estimation tools
• Large graphs: property testing, sampling from large graphs, and allied emerging theoretical connections with exchangeable processes
• Information theory and machine learning
• Risk management and information aggregation from biased processes—including rare event modeling, prediction, slow mixing random walks
• Estimating large scale dependencies in sensor data, gene and proteomic data
• Anonymous data sharing and storage systems
• Smart grid communication and security
• Mobile and wireless security, Internet and application security, security and privacy in cloud computing and social networks
LEADERSHIP TEAM:
Olga Boric-Lubecke & John Allen III

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The University of Hawai‘i at Mānoa enjoys active research in its medical school and in the biological sciences. College faculty members are leveraging these programs in interdisciplinary work at the boundary of the physical, life, and medical sciences and engineering. College faculty members have active programs in bio-devices and bio-inspired design, bio-imaging, biomechanics, cellular and molecular engineering, and system biology.

PARTICIPATING FACULTY:
Peter Berkelman
David Garmire
Reza Ghorbani
Magdy Iskander
Marcelo Kobayashi
Victor Lubecke
David Ma

Scott Miller
Aaron Ohta
Todd Reed
Narayana Santhanam
Tao Yan
Yi Zuo

COLLABORATING ORGANIZATIONS:
UH Mānoa College of Tropical Agriculture and Human Resources (CTAHR), John A. Burns School of Medicine (JABSOM), UH Mānoa College of Natural Sciences, Queens Hospital, UH Mānoa School of Nursing and Dental Hygiene

PRINCIPAL RESEARCH ACTIVITIES:
- Biodevices and Bioinspired Design: bio-MEMS, biosensors, bio-inspired air vehicles, microfluidics, novel measurement principles, smart structures, surface phenomena, surgical tools
- Bioimaging: acoustics, computational image analysis, high performance computing platforms, microwave imaging, position tracking
- Biomechanics: mechanics of flapping flight, primate capture kinematics, rehabilitation robots, surgical robots
- Cellular and Molecular Engineering: cell encapsulation, cell sorting, microorganisms, nanoparticle interactions
- System Biology: biological networks, bio-inspired topology, optimization, genetic algorithms, statistical genetics
Due to climate change, it is important to develop coastal infrastructure that can withstand natural hazards including hurricanes, storm surges, tsunamis, beach erosion and long term sea level rise. The College has a tradition of working in civil infrastructure, especially in coastal structures. Faculty members are focusing their efforts on developing simulation tools for hazard prediction and improved engineering design of resilient and sustainable coastal infrastructure.

COLLABORATING ORGANIZATIONS:
UH Mānoa Department of Ocean and Resources Engineering, UH Mānoa Department of Oceanography, UH Mānoa Sea Grant College Program, Hawai‘i Kaho‘olawe Island Reserve Commission, Hawai‘i State Civil Defense, Hawai‘i Department of Transportation, Oregon State University, Cornell University, University of Michigan, University of Puerto Rico, University of Alaska, Teck Alaska Incorporated, Engineering Research & Development Center – Coastal & Hydraulics Laboratory

RESEARCH ACTIVITIES:
• Prediction and modeling of tsunami and storm surge run-up and inundation
• Coastal transportation system resilience
• Improved structural design of coastal buildings and bridges for storm surge and tsunami inundation
• Improved foundation design for coastal structure
• Island and coastal sustainability
• Probabilistic risk analysis of coastal hazards and their impact
• Mitigating wave energy for harbor protection
• Modeling, design, and construction of submerged breakwaters and multi-purpose artificial reefs
• Increasing longevity of geotextile artificial reefs
• Meteorological and ocean processes on shoreline evolution, coastal/offshore structures in tropical and Arctic regions
• Wind-wave hindcasting/forecasting using modeling, field measurements, and statistical analysis
• Modernization of coastal engineering numerical models
• Remote sensing of coastal erosion by using aerial photos and satellite imagery (e.g., images from Landsat Thematic Mapper)
• Improved scour depth around piles (foundation design) using artificial intelligence-based methods
The computer engineering faculty have research strengths in security and networking, with emphasis on cyber security and privacy, wireless security, smart grid security, cloud security, mobile sensing, crowd-sourcing, real-time networking, broadband telecommunication networks, and survivable networks. In addition, the College has a new undergraduate degree in computer engineering in collaboration with the UH Mānoa Department of Information and Computer Sciences. Computational engineering uses high performance simulations to analyze engineering systems and solve design problems. Models and theories from disciplines of engineering and sciences are utilized to understand and predict engineered and natural systems. Faculty research emphasis is on the innovative application of computational methods to cutting-edge engineering problems such as fluid-structure and fluid-particle interactions, coastal processes, remote sensing data analysis, structural design, meteorological and environmental fluid dynamics, thermal fluid transport, and micro-electro-mechanical systems.
An important challenge Hawai‘i faces is to become self-reliant in energy, especially due to its geographic isolation and reliance on fossil fuels (oil). College faculty members are working on energy and sustainability issues ranging from renewable energy, smart grids, energy efficiency, energy harvesting, and energy storage. Faculty members collaborate across the UH Mānoa campus, the local Hawai‘i utility companies, UH community colleges, and other academic institutions. The Cluster is awaiting approval of a graduate certificate in Renewable Energy and Island Sustainability and provides many undergraduate courses in energy and sustainability. The Cluster also provides short courses in energy to the community and K-12 outreach both on campus and off campus from faculty and their students. Cluster faculty members have several research laboratories including the Smart Campus Energy Lab, the Composites and Smart Structures Lab, and Nanotechnology Lab.
For Hawai‘i to be sustainable as an island-state in the middle of the Pacific Ocean, it must succeed in not only being self-sufficient in energy, but also in materials and manufacturing, in areas such as advanced materials, nanotechnology, recycling and remanufacturing, and environmental degradation. Advances in recycling and remanufacturing are needed to minimize dumping and the high cost of importation. For a sustainable future, materials need to be conserved and reused where possible due to impending raw materials shortages and the rising cost of energy for extraction and manufacturing. Locally, advances in remanufacturing are important for improving the effectiveness of the activities at Pearl Harbor Naval Shipyard to maintain the naval fleet. Corrosion is also important to the Navy and Hawai‘i. The Hawaiian Islands experience some of the steepest climatic gradients on Earth, generating a spatially diverse climate, making Hawai‘i a premier natural laboratory for corrosion research.
LEADERSHIP TEAM:  
Roger Babcock & Tao Yan  
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PARTICIPATING FACULTY:  
John Allen III  
Sayed Bateni  
Oceana Francis  
Albert Kim  
Wellin Qu  
Yi Zuo  

COLLABORATING ORGANIZATIONS:  
UH Mānoa Water Resources Research Center (WRRC), UH Mānoa School of Ocean and Earth, Science and Technology (SOEST), UH Mānoa College of Tropical Agriculture and Human Resources (CTAHR), Hawai‘i State Department of Health, Hawai‘i State Department of Agriculture, Hawai‘i State Department of Land and Natural Resources, U.S. Geological Survey, Honolulu Board of Water Supply and the City and County of Honolulu

PRINCIPAL RESEARCH ACTIVITIES:  
• Water supply, aquifer sustainable yield, ground water modeling, water treatment, desalination  
• Watershed analysis and modeling, urban runoff, TMDL, coastal pollution  
• Pathogen contamination of beaches and recreational waters  
• Wastewater treatment and reuse including membrane systems  
• Computational environmental fluid dynamics  
• Solid and hazardous waste treatment, disposal, and remediation, including military energetic compounds  
• Fate and transport of pesticides and emerging contaminants (endocrine disruptors and pharmaceutically active substances)  
• Use of molecular tools for environmental studies

Water is becoming a more and more scarce resource due to population growth, industrial development and global climate change. Island states/nations must deal with finite fresh water resources impacted by sustainable yield of ground water from basal aquifers and surface waters impacted by urban runoff.  
Equally, the disposal and recycling of municipal and industrial wastewaters as well as solid and hazardous wastes must be part of the dynamic in sustainable water usage. On island states these issues are even more environmentally sensitive as coastal recreation competes with waste disposal. College faculty members have a tradition of effectiveness in these areas with connections to many University, government and commercial entities.
HAWAI‘I CENTER FOR ADVANCED COMMUNICATIONS

Mission

This Center is a multidisciplinary research center to do research on wireless communication systems. It aims to provide infrastructure for joint research among members of the Center and with researchers from industry and academia. It will provide students with a diversified education and will encourage industrial interactions, promote entrepreneurial activities, and provide technical leadership and expertise to the University and the State.

Research Faculty

- Indoor Antenna Range
- Wireless Communications Information Theory, Signal Processing
- Human-Robot Interaction
- Information Theory, Statistical Learning & DSP
- Antenna Design & Characterization
- Research Faculty
- Microfluidics for RF Devices
- High-Speed Devices, Circuits & Antennas
- Propagation Modeling & Ray Tracing
- Wireless Test Bed
- Microwave Network Analysis Laboratory
- RF Devices (Ferroelectric) Fabrication Facility
- Material Characterization Laboratory

Research Areas

- Electromagnetic Actuation for Wireless Active Endoscope Capsule Mobility
- Ultralow Power Electronics and Graphene-based Quantum Detectors
- Fundamental Limits of Energy-Efficient Communications in Sensor Networks
- Directional Networking Antennas and Applications
- Genetic Programming in Design and Optimization of Ultra-wideband Metamaterials
- Microwave Spectroscopy for Vital Signs and Measuring Changes in Lung Water Content
- Liquid Metals for Reconfigurable Antennas
- Radio Propagation Modeling and Prediction in Complex Environments

PI’s

- Peter Berkelman
- David Garmire
- Anders Host Madsen
- Maged F. Iskander
- M. F. Iskander
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Research Interest

Broadband and directional wireless technologies with focus on "integration of electromagnetics, antennas and RF devices, DSP and information theory assets in the design and optimization of communication technologies, wireless sensors networks, and advanced radar systems."