MIT INDUSTRIAL LIAISON PROGRAM ILP

MIT Industry Brief

MIT and Marine Systems and Ocean Science & Engineering

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MIT and Marine Sysems and Ocean Science & Engineering

The Massachusetts Institute of Technology (MIT) is a leading center of research and education on topics related to marine systems and ocean science and engineering, such as:

- *Acoustics*
- *Climate, Weather*
- *Hydrodynamics*
- *Marine Exploration*
- *Marine Robotics*
- *Modeling, Simulation*
- *Ocean Engineering, Ocean Systems*
- *Sensing/Sensors*
- *Ship Design & Technology*

Below are brief descriptions of a selection of MIT centers, departments, groups, and labs conducting research and education in these areas. Please note that this is not a comprehensive summary of research being conducted at MIT in the topic areas listed above and the center or lab, etc., may fall into more than one category.

The ***MIT Sea Grant AUV Lab*** is a leading developer of advanced unmanned marine robots, dedicated to the development and application of autonomous underwater vehicles. Because the lab's vehicles can function without tethers, cables, or remote control, they have a multitude of applications in oceanography, environmental monitoring, and underwater resource studies. The laboratory also serves as a training ground for graduate and undergraduate students, visiting engineers, and scientists, from around the world.

The ***Center for Clean Water and Clean Energy at MIT and KFUPM*** focuses on research in desalination, low carbon energy, related areas of design and manufacturing as well as curriculum development in mechanical engineering. Projects are in the areas of clean energy, clean water (including seawater desalination), and design.

The goal of the ***Center for Environmental Sensing and Modeling (CENSAM)*** is to provide constant monitoring and accurate modeling of the intricate climate, urban and marine ecosystems of Singapore at local, regional, and global scales. In the area of marine ecosystems, CENSAM researchers have developed a two-phase computer model capable of accurately predicting the path of a sediment plume (release of particles of various sizes) in marine waters.

The ***Center for Global Change Science (CGCS)*** seeks to better understand the natural mechanisms in ocean, atmosphere, and land systems that together control the Earth's climate, and to apply improved knowledge to problems of predicting climate changes. Building on existing programs of research and education in the Schools of Science and Engineering, the Center utilizes theory, observations, and numerical models to investigate climate phenomena, the linkages among them, and their potential feedbacks in a changing climate. The interdisciplinary organization fosters studies on topics as varied as oceanography, meteorology, hydrology, atmospheric chemistry, ecology, biogeochemical cycling, paleoclimatology, applied math, data assimilation, computer science, and satellite remote sensing.

The ***Center for Ocean Engineering*** has significant research efforts in fluid mechanics and hydrodynamics, acoustics, offshore mechanics, marine robotics and sensors, and ocean sensing and forecasting, as well as advanced graduate education on the design of naval ships and vehicles through the Naval Construction program. Center faculty and staff address a number of ocean-related activities, including: observation and exploration of the ocean; naval construction and engineering; ocean resource development; shipping and transportation; ocean energy; ocean acoustics; the role of the ocean in the global environment and in climate change; oceanographic engineering; marine robotics; and biomimetics.

The MIT ***Center for Transportation & Logistics (CTL) Port Resilience Project*** builds upon CTL's deep and continuing research on supply chain resilience, supply chain risk management, and supply chain security. This project, in partnership with the National Center for Secure & Resilient Maritime Commerce (CSR), is developing the principles and actions for making ports resilient to disruptions.

The ***Electric Ship Research and Development Consortium*** is a consortium of programs and institutions involved in electric ship design and construction, and electric power research. The ESRDC's stated goal is to develop the tools for designing the complex electrical systems for an all-electric fighting ship and to provide educational opportunities for students who will become the nation's electric power engineers in the future. Overall direction and management of the consortium resides with the US Office of Naval Research.

The focus of research in the ***Environmental Dynamics Lab (ENDLab)*** is on using meticulously planned and executed laboratory experiments to obtain insight into all manner of dynamical phenomena, from micro-scale diffusive processes to global-scale oceanic wave fields. The latest experimental techniques are used and advanced in these efforts. To complement this work the group pursues theoretical and analytical modeling, either in-house or through collaborations. Finally, the group regularly participates in field studies for ocean-related problems, which has included studies in Hawaii, the South China Sea and the Indian Ocean.

The ***Experimental Hydrodynamics Laboratory (EHL)*** has ongoing research focused on applications relating to advanced surface ship, offshore platform and underwater vehicle design. Research into complex hydrodynamic phenomena has direct implications on the design of vessels and structures operating in the ocean, as well as other areas of fluid dynamics such as boundary layers and wakes, internal flows, and geological and environmental flows. In order to advance research in these areas, the development of non-invasive flow measurement and visualization methods, including two- and three-dimensional particle image velocimetry (PIV), fluid shear stress measurement techniques and qualitative flow imaging, are necessary.

Research at the ***Laboratory for Ship and Platform Flows (LSPF)*** focuses on the modeling of free surface flows past conventional and high-speed vessels and the estimation of their resistance and seakeeping in deep and shallow waters. Recent studies have concentrated on the coupling of hydrodynamic simulations with modern optimal control theory for the minimization of the motions and the fuel-efficient navigation of high-performance and conventional vessels in a stochastic environment. Other research at the LSPF has concentrated upon the study of the hydrodynamics and dynamics of novel deep-water offshore platform technologies. Recent studies have concentrated on the development of floater concepts for the support of wind turbines to be deployed in large-scale offshore wind farms in shallow and deep waters.

The ***MIT Laboratory for Autonomous Marine Sensing (LAMSS)*** specializes in the development of new distributed ocean sensing concepts for oceanographic science, national defense and coastal management and protection. It continues two decades of multidisciplinary research and development into such systems by Department of Ocean Engineering and the MIT Sea Grant AUV Laboratory. The faculty, staff, and students provide a strongly multidisciplinary team with expertise in oceanographic sensing and modeling, sonar system technology, computational underwater acoustics, and marine robotics and communication networking.

Research in the ***Laboratory for Undersea Remote Sensing*** encompasses: Ocean exploration, undersea remote sensing of marine life and geophysical phenomena, wave propagation and scattering theory in remote sensing through random media and waveguides, statistical estimation and information theory in sensing, linear and nonlinear acoustics and seismics, Europa exploration.

The ***Marine Robotics Group***, part of CSAIL at MIT, research is fundamentally centered around the task of navigation for mobile robots in unknown environments. The group's projects are centered around the problems of navigation and mapping for autonomous mobile robots operating in underwater and terrestrial environments.

The ***Multidisciplinary Simulation, Estimation, and Assimilation Systems (MSEAS)*** group develops and transforms ocean modeling and data assimilation to quantify regional ocean dynamics on multiple scales. The group creates and utilizes new models and methods for multiscale modeling, uncertainty quantification, data assimilation and the guidance of autonomous vehicles. These advances are then applied to better understand physical, acoustical and biological interactions.

Naval Construction and Engineering @ MIT: Since 1901, MIT has maintained a graduate program in Naval Construction and Marine Engineering, in close cooperation with the United States Navy. The program prepares Navy, Coast Guard, foreign naval officers, and other graduate students for careers in ship design and construction. Besides providing students with a comprehensive education in naval engineering, their future roles as advocates in ship design and acquisition are emphasized.

The ***Numerics in Computational Engineering (NiCE)*** group at MIT Sea Grant–with expertise in multi-scale mathematics and high performance computing–aims to develop new modeling and simulation methods in order to complement and enhance ongoing funded experimental and field experiments related to many ocean-related areas, such as regional forecasting, exploring novel designs for underwater communications, or even designing new vessels based on novel hydrodynamic concepts.

Oceans @ MIT is a robust interdisciplinary initiative integrating the strengths of departments, centers, and laboratories across MIT and at Woods Hole Oceanographic Institution (WHOI). Researchers in fields from robotics to acoustics, marine ecology to environmental engineering, and economics to public policy are working in the areas of ocean engineering, coastal oceans, life in the oceans, oceans and climate, and ocean policy.

The ***Ocean Acoustics Group***'s research effort is both science and technology-development oriented. Thus, part of the research concerns improving the fundamental understanding of the propagation of sound and seismic waves in the ocean, while other research focus on the development of improved acoustic systems, e.g. for Autonomous Underwater Vehicle (AUV) communication and navigation.

The ***Parsons Laboratory for Environmental Science and Engineering*** has a long history of highly respected water and environmental research. From its inception as a hydrodynamics laboratory in the 1950s, the lab has evolved into a multidisciplinary research center focused primarily on natural waters and the environment. Water is a central theme in terrestrial, oceanic, atmospheric, agricultural and industrial systems alike. Research covers: Environmental Chemistry; Environmental Fluid Mechanics and Coastal Engineering; Environmental Microbiology; and Hydrology and Hydroclimatology.

The ***Program in Atmospheres, Oceans, and Climate (PAOC)*** oversees a broad program of education and research in atmospheric, oceanic, and climate sciences. Many of the most important discoveries in our science, such as chaos, the chemistry of the ozone hole and the physics of hurricanes were made by PAOC scientists. The phenomena under study involve a large array of scientific disciplines - geophysics, geochemistry, physical and chemical oceanography, meteorology, atmospheric chemistry, and planetary science. The program carries out research and gives instruction in areas such as: Air-Sea Interaction; Biogeochemistry & Marine Ecosystems; Ocean Modeling; Physical Oceanography; Tropical Meteorology; Weather & Forecasting.

The ***MIT Sea Grant College Program*** was initiated in 1970, and in 1976 MIT was formally designated by Congress as a Sea Grant College. MIT Sea Grant sponsors a wide variety of marine research, through an annual funding competition open to Massachusetts university-based researchers. The program's in-house research includes the work of the Autonomous Underwater Vehicle (AUV) Lab, and the Design Lab for naval architecture and systems. The MIT Sea Grant Marine Advisory Services group conducts applied research in coastal habitats, marine bioinvasions, water quality, climate change, fishing communities and policy, and offers innovative, hands-on marine science education programs.

The ***Towing Tank*** in the Center for Ocean Engineering at MIT is an experimental hydrodynamics testing facility. Research projects conducted are in the following broad areas: Bioinspired Flow Sensing and Control; Vortex-Induced Vibrations; and MEMS Pressure Sensors.

The ***Vortical Flow Research Laboratory*** focuses on the study of hydrodynamic flows, by theoretical analysis, numerical simulations, and experimental investigations.

The ***MIT-Woods Hole Oceanographic Institution (WHOI) Joint Program*** is one of the premier marine science programs in the world, drawing on the complementary strengths and approaches of MIT and the Woods Hole Oceanographic Institution (WHOI). Research is conducted within five sub-disciplinary areas, each administered by a Joint Committee consisting of MIT faculty and WHOI scientists: Applied Ocean Science and Engineering, Biological Oceanography, Chemical Oceanography, Marine Geology and Geophysics, and Physical Oceanography.

The mission of the Massachusetts Institute of Technology is to advance knowledge and educate students and others in science, technology, and additional areas of scholarship. MIT is committed to generating, disseminating and preserving knowledge and to working to bring this knowledge to bear on the world's great challenges. As part of its mission, MIT maintains relationships with industrial organizations that enable the exchange of ideas in the context of real-world problems and demonstrate how principles studied at MIT are applied to generate practical benefits for industry and society. MIT's Industrial Liaison Program helps develop these relationships by facilitating industry's access to MIT and its vast resources.