MATE
MARINE ADVANCED TECHNOLOGY EDUCATION CENTER

www.marinetech.org

ROV Technicians
Remotely Operated Vehicles

Contents

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Remotely Operated Vehicles (ROVs)

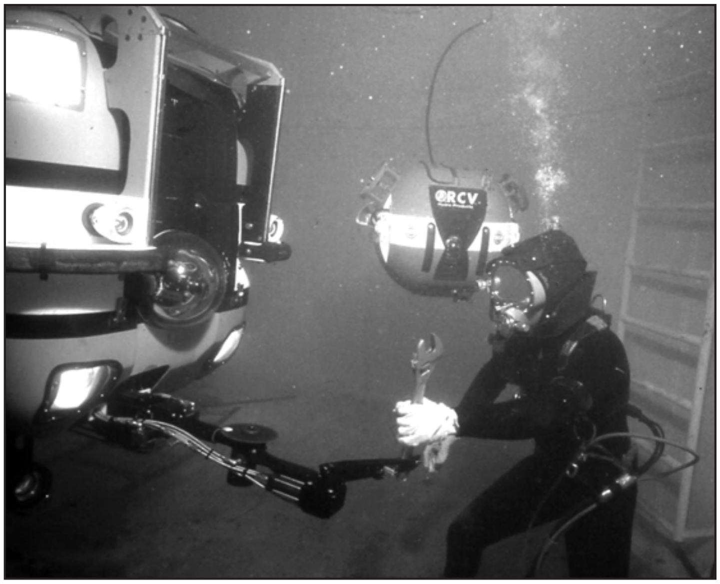
Drew Michel, ROV Technologies, Inc.

Background and History

The first step in understanding any technology is to understand why it exists. In the case of ROV technology, the reason is quite simple. There is no other practical, safe, and economically feasible way to perform deep underwater work or "underwater intervention," as it is called in the industry.

History tells us that humans have been working underwater for several centuries, from gathering food to salvaging cannons. Early attempts to improve diving efficiencies were recorded in the mid-sixteenth century, when the first diving "helmet" was used. From that early technology to the record 2,250-foot simulated dive made at Duke University in 1981, we have witnessed an incredible evolution in humankind's ability to work underwater. Open water dives have been made to nearly 2,000 feet in depth, and commercial dives have reached 1,750 feet, but these instances are very rare, involve high risk, and are not cost-effective.

For a short period, human-occupied vehicles (HOVs), formally called manned submersibles, appeared to be the solution to conquering the deep. Between the mid-1960s and mid-1970s it looked like HOVs would allow humans to work in deeper water for longer periods of time. However, HOVs required substantial dedicated support vessels and still put humans at risk underwater. They were also slow to launch and recover and had limited time on the bottom, which reduced their cost-effectiveness. The introduction of commercial ROVs in the mid-1970s has relegated HOVs to limited use in science and the tourist industry.



Courtesy of the Drew Michel Collection

This 1980 photo of a Diver handing a wrench to an *RCV 150* while an *RCV 225* observes is a perfect illustration of the "passing of the baton" from man to machine.

Exactly who receives credit for developing the first ROV will probably remain unclear. However, there are two milestones that deserve recognition: the PUV (Programmed Underwater Vehicle) was a torpedo developed by Luppis-Whitehead Automobile in Austria in 1864; and the first tethered ROV, named POODLE, was developed by the Frenchman Dimitri Rebikoff in 1953.

The United States Navy, in its quest to develop robots to recover underwater ordnance lost during at-sea tests, is credited with advancing the technology to an operational state. ROVs gained fame in 1966, when the US Navy CURV (Cable Controlled Underwater Recovery Vehicle) system recovered an atomic bomb lost off Spain in an aircraft accident. They gained further recognition by saving the pilots of the *Pisces* submersible with only minutes of air remaining when it accidentally sunk off Cork, Ireland in 1973.

The next step in advancing ROV technology was made by commercial firms that saw how ROVs could be used to support offshore oil operations. The transition from military use to the commercial world was quite rapid. Companies like ISE Ltd. (International Submarine Engineering Ltd.) in British Columbia, Canada; Perry Oceanographic in Riviera Beach, Florida; and Hydro Products and Ametek Strata in San Diego, California were quick to begin commercial activity based on work done for the military. From that very humble beginning, ROV technology and the industry of today have evolved.

(continued on page 11)

Introduction to MATE's Knowledge and Skill Guidelines

The process of developing a competent marine work force that is well prepared for employment requires collaborating with a wide range of people and organizations. One of the major tasks of the Marine Advanced Technology Education (MATE) Center is to identify and define marine technical occupations and the abilities that men and women need in order to perform well in these occupations. The major product that results from this work is a set of occupational Knowledge and Skill Guidelines (KSGs) for technical marine occupations. These guidelines describe what workers need to know and be able to do in order to perform their jobs well and they are different for each occupation. The KSGs developed by the MATE Center include those for marine technicians, remotely operated vehicle (ROV) technicians, hydrographic survey technicians, aquarists, and aquaculture technicians. All the KSGs developed by the MATE Center can be found at: www.marinetech.org/marineworkforce, or printed copies can be requested from the MATE Center.

A number of organizations have been instrumental in the development and validation of the ROV technician guidelines. We would like to thank the Deep Submersible Units Detachment of the U.S. Navy's Unmanned Vehicle Section; the Monterey Bay Aquarium Research Institute; Oceaneering International; Sonsub International; Jim MacFarlane of MacFarlane Marine Services; and Drew Michel of ROV Technologies, Inc. and the Marine Technology Society ROV Committee Chair.

—Deidre Sullivan,
Curriculum and Industry Manager
Co-Principal Investigator

About the MATE Center

The Marine Advanced Technology Education (MATE) Center is a national partnership of organizations working to improve marine technical education and in this way help to prepare America's future workforce for marine science and technology occupations. Headquartered at Monterey Peninsula College (MPC) in Monterey, California, the MATE Center has been funded as a National Science Foundation (NSF) Advanced Technological Education (ATE) Center of Excellence since 1997. The MATE Center works with community colleges, high schools, universities, research institutions, marine industries, professional societies, and working professionals to facilitate the development of courses and programs based on industry-established guidelines. In this way, the Center is working with industry to create an education system that meets the needs of employers and students, is flexible, and provides employers with direct access to students. The Center is also actively working to increase the awareness of marine-related careers and provide students, educators, workers, and employers with up-to-date information to assist them in making informed choices concerning their education and future.

The Importance of Marine Technology

The ocean economy is large and diverse, accounting for twenty percent of our national economy and supporting one in six jobs in this country.[1] Marine technology plays a vital role in supporting the ocean economy, from national security to transportation and commerce, energy and exploration activities, telecommunications, recreation and tourism, fisheries and aquaculture, search and recovery, environmental assessment and regulation, and research. Although these economic sectors are diverse, the technology behind them has many similarities. These similarities include: the collection and use of data from remotely operated vehicles and acoustic instruments; the use of advanced computing systems, such as GIS, for organizing and managing data; and the use of electronics and microelectronics for power, controls, and miniaturization in a remote, harsh environment. The need for highly qualified technical professionals who can design, build, operate, and maintain this technology has never been greater. A concerted effort is required to ensure that our work force is prepared for an economy currently and increasingly dependent on ocean activities and the technologies that make these activities feasible.

[1] *Vice President Al Gore, Opening Address (From the Cross-Cutting Issues Plenary Session), National Ocean Conference, June 11-12 1998, Monterey, California.*

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Knowledge and Skill Guidelines for ROV Technicians
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MATE's Strategy for Improving Marine Technology Education

Outcomes	Products
1. Needs Identification	List of critical workforce needs from industry queries
2. Occupational Definitions	Industry- and government-recognized occupational categories
3. Occupational Knowledge and Skill Guidelines	Industry-identified knowledge and skills for specific occupations
4. Skill Cluster Competencies	Knowledge and skill grouped by subject area
5. Instructional Materials and Services	Competency-based assessments, modules, courses, faculty development workshops, and internships
6. Educational Programs	Degree and certificate programs based on instructional materials
7. Career Management Programs	Job placement programs, professional development courses

Knowledge and Skill Guidelines for ROV Technicians

Working as an ROV operator/technician can be a challenging and exciting lifestyle. It is a lifestyle rather than just a career because it is far from an eight to five job, sometimes involving weeks or months at sea in remote areas of the world. These individuals must be resourceful, good at solving problems, and technically oriented, and they must be skilled at working closely with many different people.

The range of tools and equipment ROV operator/technicians use is vast and includes both general ship-board equipment and the tools and equipment that is used on the ROV itself. These include launch and recovery systems (LARS) consisting of A-frames, cranes, and winches on deck to hydraulic motors and pumps; specially design torque wrenches able to deliver a thousand foot pounds of torque; unique lifting devices; sampling devices; video equipment; electric motors; and fiberoptic transmitters and receivers.

As is common with many marine technical positions, people who do generally the same set of tasks may have widely different job titles. ROV technicians may be called ROV pilots; mechanical, electrical, or systems technicians; pilot, co-pilot, or pilot technician; or some type of supervisor.

Background training is essential, and the types of courses desired or required are as varied as the tasks ROV technicians perform. These courses might include or technical writing, algebra and trigonometry, hydraulics, basic hand tools, electronics, computer skills, and seamanship.

The ROV technicians who participated in MATE's workshop categorized their major responsibilities into six general job functions: operating equipment, piloting the ROV, performing maintenance/repairs on equipment, maintaining communications, using seamanship skills, and integrating system modifications into the ROV. Some of these areas are quite specific to ROVs, whereas others involve more general marine-related technology skills. For example, seamanship skills involve basic rigging and survival skills. The different types of equipment an ROV technician is expected to operate include cameras, acoustic positioning systems, sonar, manipulators, and launch and recovery systems.

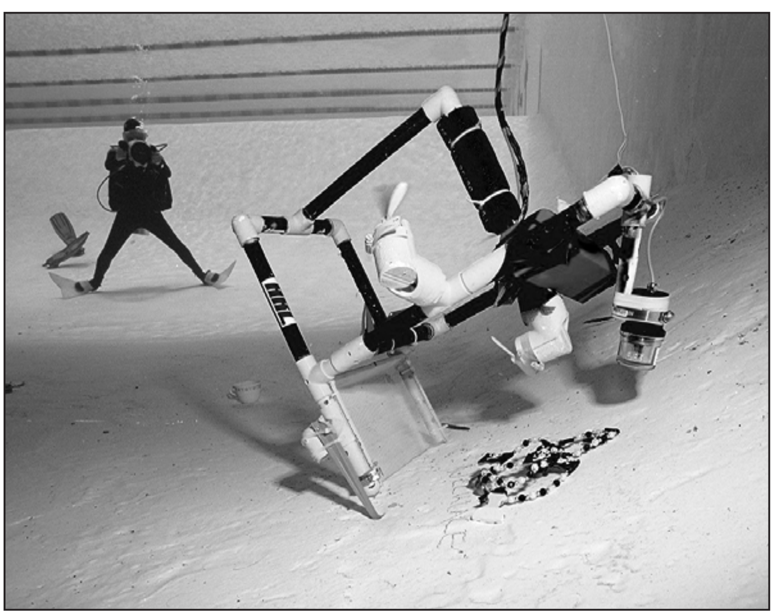
. . .it is far from an eight to five job, sometimes involving weeks or months at sea in remote areas of the world.

Workshop Participants

Workshop Coordinator: **Deidre Sullivan**
Workshop Facilitator: **Claire Denise**
Workshop Recorder: **Jill Zande**
Workshop Date: June 24, 1999
Monterey Peninsula College, Monterey CA

Panel of ROV Technicians

Jim Lewis	Sonsub International
Wayne Barber	Sonsub International
Buck Reynolds	Monterey Bay Aquarium Research Institute
Craig Okuda	Monterey Bay Aquarium Research Institute
Dan Chamberlain	Monterey Bay Aquarium Research Institute
Chuck Tolland	Deep Submersible Units Detachment, Unmanned Vehicle Section, Navy
David Yole	Deep Submersible Units Detachment, Unmanned Vehicle Section, Navy



Courtesy of Steve Van Meter

A student-built ROV recovers "sunken treasure" as judge from NASA looks on.

How these Guidelines are Developed

The process used by the MATE Center closely follows that outlined in the Skill Standards Guidebook I (October 1996) prepared by the Boeing Company, the Center for Career and Work-Related Education, and the Washington State Board for Community and Technical Colleges. Very simply, MATE selects a marine occupation based on employer surveys, the advice of experts in the field, and other labor market information. A highly-structured workshop (modified DACUM[2] – **D**eveloping **A CU**rriculu**M**) is then conducted with a group of eight to twelve technical professionals. These professionals work with a trained facilitator for one to two days to define the job functions and tasks associated with their specific marine occupation. The information gathered during the workshop is used to develop draft guidelines, which are then sent out to hundreds of technical professionals, representing large and small organizations from the public and private sector, for validation.

[2] *Norton, R.E. 1996. DACUM Handbook. Center on Education and Training for Employment, College of Education, The Ohio State University, 1900 Kenny Road, Columbus, Ohio 43210*

ROV Technician Job Description

Individuals who operate and maintain ALL aspects of an ROV, its ancillary equipment, and its integration into the ship or rig

Knowledge and Skill Overview Chart for Remotely-Operated Vehicle (ROV) Technicians

JOB FUNCTION	*TASK AREAS*					
A. Operate equipment	A1 Operate vehicle functions	A2 Operate cameras (video and still)	A3 Operate acoustic positioning system	A4 Operate sonar	A5 Operate manipulators (robotic arms)	A6 Operate LARS (launch and recovery systems)
B. Pilot the ROV	B1 Evaluate environmental conditions and hazards	B2 Dock/undock from TMS (tether management system)	B3 Navigate the ROV by acoustics, sonar and visual (video)			
C. Perform maintenance/ repairs on equipment	C1 Maintain/repair electronics	C2 Maintain/repair hydraulics	C3 Maintain/repair mechanics	C4 Use test equipment	C5 Calibrate and align equipment	C6 Perform general housekeeping and corrosion control
D. Maintain communications	D1 Maintain good customer relations	D2 Coordinate/ integrate with ship's crew	D3 Coordinate/ integrate with fellow crew members	D4 Write reports	D5 Maintain records	
E. Use seamanship skills	E1 Perform basic rigging	E2 Possess working knowledge of survival skills				
F. Integrate system modifications (advanced skills)	F1 Design, build, and interface electrical systems	F2 Design, build, and interface hydraulic systems	F3 Maintain technical documentation	F4 Design and construct mounting systems		

Personal Characteristics of an ROV Technician

The workshop participants felt that the following personal characteristics describe a successful ROV technician:

- Skilled at solving problems
- Resourceful
- Open-minded
- Skilled in multiple areas
- Compatible with others
- Able to work in adverse conditions
- Possessing spatial awareness
- Happy to work in the ocean environment
- Skilled at working in teams
- Able to be away from home
- Able to communicate well
- Disciplined
- Able to think innovatively
- Skilled at systems trouble-shooting
- Tolerant of "getting dirty"
- Cross-trained
- Willing to do all sorts of tasks (even tasks "beneath you"!)
- Skilled at working with people
- Good attitude

Knowledge and Skill Overview Chart for (ROV) Technicians

Critical work function A: Operate equipment

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
A1. Operate vehicle functions	• Vehicle is operated in a timely, safe, and successful manner. • Vehicle functions respond as expected. • Assigned tasks are completed in a timely, safe, and successful manner. • Customers are satisfied.	• Knowledge of vehicle systems, including deck handling equipment (LARS) and tether management systems (TMS), and their applications • Ability to operate all vehicle functions (e.g., lighting, cameras, altimeters, depth transducers, vehicle controls, auto functions, hydraulic valves) • Basic knowledge of computers • Ability to use spreadsheets, word processing, and databases • Ability to use operating systems and OEM (original equipment manufacturer) software • Ability to comprehend hardware and software manuals
A2. Operate cameras (video and still)	• Desired images are obtained. • Images are clear. • The appropriate camera is used for the desired results.	• Knowledge of and ability to operate cameras and video equipment • Knowledge of different camera types • Knowledge of video distribution systems • Knowledge of lighting and how it affects video images • Knowledge of environmental conditions (e.g., turbidity, sediment)
A3. Operate acoustic positioning system	• ROV arrives at destination in a safe and timely manner. • Customer items are positioned correctly. • ROV is tracked successfully. • Environmental parameters are measured correctly.	• Ability to operate acoustic equipment • Knowledge of and ability to apply principles of acoustic positioning • Knowledge of OEM-specific acoustic equipment • Knowledge of environmental conditions (e.g., salinity, temperature) and how to measure these parameters (e.g., using XBTs)
A4. Operate sonar	• Vehicle is deployed and recovered safely and without injury.	• Knowledge of sonar (theory and equipment) and ability to select proper settings • Ability to interpret images • Ability to locate target(s) • Ability to recognize and avoid obstacles
A5. Operate manipulators (robotic arms)	• Dock/undock is successful. • ROV arrives safely and without damage. • Telemetry is maintained during operations. • All environmental factors are considered properly.	• Ability to use manipulators and cameras • Ability to manipulate the position of the ROV • Ability to demonstrate hand-eye coordination and spatial awareness (3D interpretation of 2D images) • Knowledge of manipulator specifications and limitations • Ability to avoid collateral damage
A6. Operate LARS (launch and recovery system)	• ROV is launched and recovered successfully (without damage to ROV and/or vessel). • Safety is maintained during launch and recovery. • Environmental conditions are measured and considered properly.	• Ability to operate site-specific handling systems (e.g., winch and A-frame, knuckle boom crane) • Knowledge of and ability to implement all safety requirements

Salary Range

Entry level $35,000 or above, after two years $40-50,000, after five years up to $100,000, this includes overtime and bonuses that accumulate while working offshore.

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function B: Pilot the ROV

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
B1. Evaluate environmental conditions and hazards	• ROV arrives at destination in a safe and timely manner. • Target is located correctly. • Obstacles are avoided. • Sonar is operated properly.	• Knowledge of safe operating parameters (sea state limitations, weather, currents) • Knowledge of weather and currents • Ability to interpret sea state
B2. Dock/undock from TMS (tether management system)	• Desired manipulator task is completed safely and in a timely manner. • No collateral damage is sustained.	• Knowledge of tether management system • Ability to demonstrate hand-eye coordination and spatial awareness • Ability to measure environmental conditions and react properly
B3. Navigate the ROV by acoustics, sonar and visual (video)	• ROV arrives at destination in a safe and timely manner. • Customer items are positioned correctly. • ROV is tracked successfully. • Environmental parameters are measured correctly.	• Ability to fly the ROV • Ability to demonstrate hand-eye coordination and spatial awareness • Ability to read charts and maps • Knowledge of longitude and latitude • Ability to use various mapping systems • Ability to read a compass • Ability to calculate vectors

Tools and Equipment Typically Operated and Maintained

- A-frame
- Knuckle boom crane
- TMS (tether management system)
- Constant tension winch
- Motion compensated winch (ram tension winch)
- Traction winch
- Still, video, SIT (silicon intensify targeting), and digital cameras
- Video monitors
- Sonar (imaging, low resolution, high resolution)
- Lasers
- CTD (conductivity, temperature, density senor)
- Bathythermograph (CTD and altimeter, depth)
- Core samplers (sampling and other collection devices)
- Acoustic Doppler recorder
- Altimeter
- Acoustic positioning system (responders, transponders, pingers, homers)
- Manipulators (robotic arm)
- Flow meters
- pH probes
- Methane sensors
- Electric motors
- High-voltage transformers
- Hydraulic motors and pumps (HPU – hydraulic power unit)
- Hydraulic valves (solenoid, digital and servo, analog, infinite control over flow and pressure)
- Test equipment (electronic, TDR – time domain reflectometer and OTDR – optical time domain reflectometer, oscilloscope, multimeter, megohmeter, amp meter, power meters)
- Fiberoptic splicing equipment
- Computers (PCs, Unix, Windows-based programs, DOS) and peripherals (sonar, camera adjustments, sensors, valves, vehicle monitors) (interfacing between computers and other hardware)
- Gyros
- Ground-fault monitors (interrupt and detect)
- Electrical power distribution systems, modern work class ROV's are typically 100 to150 horsepower, operated at between 3300 and 4150 volts.
- Fiberoptic transmitters and receivers
- Telemetry systems
- Serial communications (used in computer field and have application in ROV technology)

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function C: Perform maintenance/repairs on equipment

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
C1. Maintain/repair electronics	• Electrical safety is maintained. • Electrical failures are minimized. • Electrical systems demonstrate increased reliability. • Inspection is completed regularly, as per schedule. • Repairs are completed safely, correctly, and in a timely manner. • Diagnostic programs are used properly. • Measurement data are accurate.	• Knowledge of basic electronics • Knowledge of electrical system safety (lockout, tagout) • Ability to inspect equipment (e.g., for corrosion, wear, damage, ground faults) • Ability to use diagnostic programs within the system • Knowledge of system layout • Ability to solder • Ability to replace faulty components
C2. Maintain/repair hydraulics	• Hydraulic safety is maintained. • Hydraulic failures are minimized. • Hydraulic systems demonstrate increased reliability. • Inspection is completed regularly, as per schedule. • Repairs are completed safely, correctly, and in a timely manner. • There are no environmental mishaps. • Diagnostic programs are used properly. • Measurement data are accurate.	• Knowledge of basic hydraulics and principles • Knowledge of hydraulic system safety (lockout, tagout) • Ability to inspect equipment (e.g., corrosion, wear, damage, leaks) • Ability to use diagnostic programs (e.g., flow monitors) within the system • Knowledge of system layout • Knowledge of basic physics
C3. Maintain/repair mechanics	• Mechanical safety is maintained. • Mechanical failures are minimized. • Mechanical systems demonstrate increased reliability. • Inspection is completed regularly, as per schedule. • Repairs are completed safely, correctly, and in a timely manner. • Diagnostic programs are used properly. • Measurement data are accurate.	• Knowledge of hydraulic system safety (lockout, tagout) • Ability to inspect equipment (e.g., corrosion, wear, damage, leaks) • Ability to use diagnostic programs (e.g., flow monitors) within the system • Knowledge of system layout • Knowledge of basic physics

Basic Courses Desired or Required

- English/technical writing
- Math
- Algebra
- Trigonometry
- Physics (basic, non-calculus)
- Basic hydraulics
- Basic hand tools course
- Marine instrumentation/marine technology and general applications
- Basic computer skills (e.g., word processing, spreadsheets, databases)
- Basic seamanship
- Additional course work to provide more specialization in electronics OR hydraulics
- Basic and Intermediate electronics (fiber optics)

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function C: Perform maintenance/repairs on equipment (continued)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
C4. Use test equipment	• Test equipment is used properly to accomplish required task(s). • Tests are conducted in a safe manner. • Correct instruments are chosen for each task. • Test and measurement data are used to troubleshoot and resolve problems successfully.	• Ability to determine the proper equipment for the test • Ability to operate various test and measurement instruments (e.g., oscilloscope, megohmeter, TDR, OTDR, multimeter) in a safe manner
C5. Calibrate and align equipment	• Equipment and instruments function accurately within manufacturer's specifications. • Calibration and alignment procedures are followed.	• Knowledge of equipment operations • Ability to calibrate and align instruments and equipment (e.g., CTD) per manufacturer specifications and procedures
C6. Perform general housekeeping and corrosion control	• Work environment is neat and orderly. • Cleaning materials are used, stored, and disposed of properly. • Hazardous materials are stored and/or disposed of properly. • Equipment damage due to corrosion is minimized.	• Ability to maintain a clean and efficient work environment • Knowledge of sanitation and hygiene procedures • Knowledge of HAZMAT storage and disposal • Knowledge of galvinic corrosion, seawater chemistry and how different metals behave under different conditions

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function D: Maintain Communications

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
D1. Maintain good customer relations	• Information is recorded accurately and legibly. • Logs and other records are current, correct, and well-documented. • Customer is satisfied.	• Ability to communicate verbal and written information clearly • Ability to solve problems • Ability to demonstrate good customer relations skills
D2. Coordinate/ integrate with ship's crew	• Briefing accomplishes objective(s). • Miscommunications are minimal. • Hand signals are used properly. • Debriefing provides good, positive feedback. • Mission is successful.	• Ability to conduct a briefing/debriefing (e.g., communicate mission and clarify terminology) • Knowledge of chain of command • Knowledge of ship's procedures • Ability to use hand signals
D3. Coordinate/ integrate with fellow crew members	• Team goals are accomplished. • Crew performance increases/improves. • Crew is content and happy. • Mission is successful.	• Ability to focus on team goals • Ability to get along with fellow members for extended periods of time and in cramped quarters

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function D: Maintain Communications (continued)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
D4. **Write reports**	• Records are current. • Information is recorded accurately and legibly. • Logs are current, correct, and well-documented.	• Ability to write information in a clear concise manner • Ability to format documents
D5. **Maintain records**	• Records are current. • Information is recorded accurately and legibly. • Logs are current, correct, and well-documented.	• Knowledge and ability to perform record-keeping • Knowledge of logs (e.g., pilot, maintenance, inventory, finance, video, customer)

Knowledge and Skill Guidlines for (ROV) Technicians

Critical work function E: Use seamanship skills

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
E1. **Perform basic rigging**	• Knots, gear, and rigging equipment are used properly. • Rigging is accomplished safely, correctly, and in a timely manner. • Items are moved or secured safely and without damage. • Hand signals are used properly.	• Knowledge of rigging equipment (e.g., shackles, eyes, snatch blocks, bridles, slings) • Knowledge of and ability to tie knots • Knowledge of salvage gear • Knowledge of trigonometry • Knowledge of physics • Knowledge of deck safety • Ability to use hand signals
E2. **Possess working knowledge of survival skills**	• Personal flotation devices (PFDs) and survival suits are used properly. • Life boats are accessed and used properly. • CPR/first aid certifications are current. • Environmental concerns are addressed adequately. • Overhead loads and other hazards are assessed properly.	• Ability to use PFDs and survival suits properly • Ability to use life boats • Knowledge of CPR/first aid • Ability to assess environmental conditions and react properly • Ability to be alert and look for danger at all times when on a moving and working deck

Job Titles

- ROV technician
- ROV pilot 1, 2, 3 (senior), and chief
- Mechanical technicians 1,2, 3, and senior
- Electronics technicians 1, 2, 3, and senior
- Mechanical technician 1, 2, and 3
- Electrical technician 1, 2, and 3
- Systems technician
- Handling system operator
- Pilot
- Co-pilot
- Pilot technician
- ROV maintenance technician
- Supervisor
- Trainee

Knowledge and Skill Guidelines for (ROV) Technicians

Critical work function F: Integrate system modifications (advanced skills)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What ROV technicians need to know and/or be able to do in order to perform this task well
F1. Design, build, and interface electrical systems	• Design and fabrication of electrical systems to meet the intent of the project. • Electrical systems are built and interfaced properly (with other peripherals or pieces of equipment). • Instrumentation works and receives proper data.	• Ability to design and fabricate electrical systems • Knowledge of protocols and ability to interchange subsystems, tools and sensors • Knowledge of analog signal data
F2. Design, build, and interface hydraulic systems	• Design and fabrication of hydraulic systems meet the intent of the project. • Hydraulic systems are built and interfaced properly (with other peripherals or pieces of equipment). • Circuitry is modified properly. • Operation of added equipment is successful.	• Ability to design and fabricate hydraulic systems • Ability to add components and modify circuitry as necessary • Ability to read blueprints/schematics
F3. Maintain technical documentation	• Documentation allows new personnel to understand changes. • Changes are communicated effectively. • Tools (e.g., CAD) are used properly.	• Ability to maintain and update technical documentation • Ability to communicate effectively, both orally and in writing • Knowledge of CAD • Ability to create and print a schematic
F4. Design and construct mounting system	• Test equipment is used properly to accomplish required task(s). • Design and fabrication of mounting systems meet the intent of the project. • Mounting system works. • Proper materials are used. • CAD is used properly.	• Ability to design and fabricate mounting systems • Knowledge of CAD • Knowledge of proper materials to use

Future Trends

- Technicians will be less dependent on flying skills; the ability to do repairs will be more important
- Individuals will need to adapt to new technology (e.g., mouse-driven movements)
- There will be more focus on electronics than hydraulics (it's easier to teach hydraulics to an electrician than vice versa)
- New advancements will be more electronics-focused
- The industry will continue to grow (e.g., the oil industry is routinely going to 5,000 feet and going down to 7,000 feet and more)
- "Oxygen" project laying fiberoptic cable
- Fiberoptic telemetry systems are now the norm
- There will be fewer, but larger, companies (Sonsub; Oceaneering; Canyon Offshore; Stolt Offshore; Fugro)
- ROVs will become larger because they will be required to do more and more work (not necessarily because they're going deeper)

Important Publications for the ROV industry

Sea Technology, Ocean News and Technology, Offshore, Offshore Source, Underwater Magazine

Remotely Operated Vehicles (ROVs)
(continued from page 1)

What is an ROV?

The Marine Technology Society ROV Committee's publication, "Operational Guidelines for ROVs" in 1984 and a National Research Council Committee's publication on "Undersea Vehicles and National Needs" in 1996 both describe an ROV as an underwater robot that allows the vehicle's operator to remain in a comfortable environment while the ROV performs the work underwater. An umbilical, or tether, carries power, command, and control signals to the vehicle and the status and sensory data back to the pilots topside. In larger ROV systems, a subsea garage and tether management system (TMS) are often included.

ROVs can vary in size—from a small vehicle fitted with one TV camera that is used for simple observation to a complex work system that can have several dexterous manipulators, video cameras, mechanical tools, and other equipment. ROVs are generally free-flying, but some move along the bottom on tracks (*see photo 1*).

Courtesy of Deep Ocean Engineering

Photo 2: Deep Ocean Engineering *Phantom* is an example of a small electric ROV.

Courtesy of Canyon Offshore

Photo 3: Canyon's *Quest* ROV being recovered off Hawaii in 2003 is an example of a workclass ROV.

ROVs are used in a variety of sectors of our economy, including the following: oil and gas exploration and extraction; telecommunications, such as the laying of fiberoptic cable; science and research; underwater archeology; search and recovery; safe navigation; defense and homeland security; and a variety of different types of inspections, from ships to bridges to nuclear power plants.

Small (Electric) ROVs

Many small, or "flying eyeball," ROVs—some as small as a bread box—are in use today. The best guess is that more than 1,000 of these vehicles are at work worldwide. This small vehicle class includes the majority of "low-cost" vehicles, most of which are typically all electric and operate above water depths of 300 meters(984 feet). These vehicles are used primarily for inspection and observation tasks (*see photo 2*).

There has been a recent surge in the development of small vehicles, due primarily to the improvement in technology for electrically powered systems. These improvements have resulted in an increase of capability, performance, and depth not previously achieved, while keeping costs between $10,000 and $100,000.

The low-end products have been classified for marine recreational use, while the more expensive systems have been used for inland water inspection projects and coastal offshore inspection and observation tasks. Today's low-cost ROVs are used widely for many tasks, including science; search and rescue; dam, waterway, and port inspection; training; shipping; and nuclear inspection.

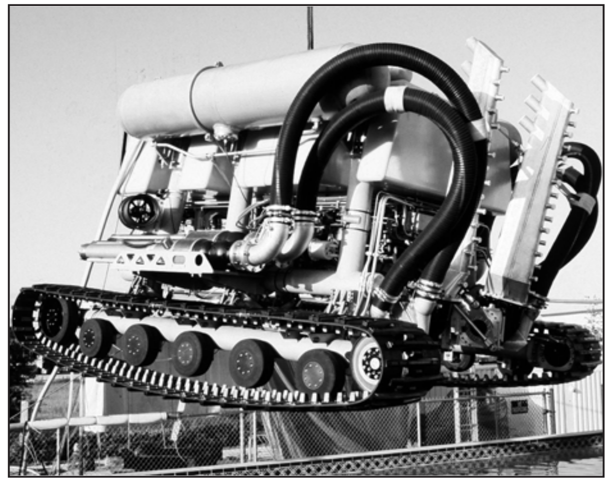

Courtesy of Perry Slingsby Systems

Photo 1: Perry Slingsby Systems trenching ROV system.

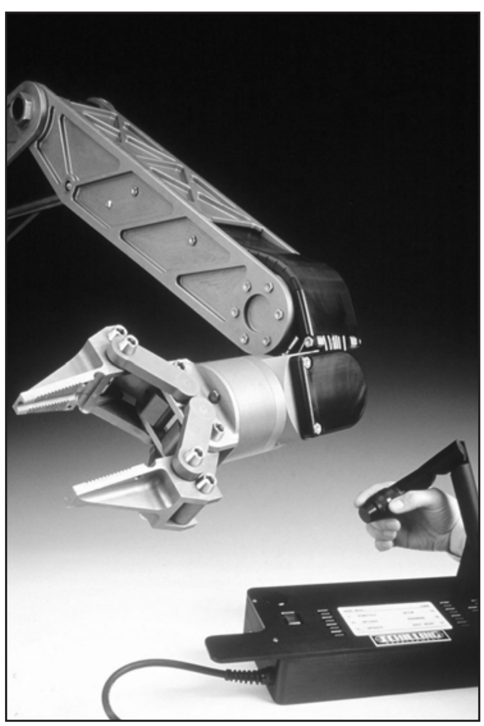

Courtesy of Schilling Robotics

Photo 4: Schilling Robotics spatially correspondent manipulator.

The ROV industry is dominated by large work-class electro-hydraulic ROV systems.

Work-Class ROVs

The ROV industry is dominated by large, work-class electro-hydraulic ROV systems (*see photo 3*). The largest of these vehicles weighs 8,000 pounds and resembles a small minivan in size. Systems capable of reaching a depth of 3,000 meters are now commonplace, with at least one system capable of attaining 6,000 meters. A cable burial system powered by four electro-hydraulic units totaling 1,000 horsepower is in use today, and at least one ROV that can lift and maneuver 1,600 pounds has been built. Cameras, lights, sonar, and other sensors necessary to operate at great depths are readily available. Manipulators capable of lifting hundreds of pounds are commonly installed on these vehicles (*see photo 4*).

The latest estimate is that approximately 430 work-class ROV systems are active in the world today (2004). A best guess is that this represents more than $1.5 billion in capital assets and the employment (direct and indirect) of nearly 10,000 people. Six major commercial operators own the majority of these systems, with a total of approximately 380 listed in their respective inventories.

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Remotely Operated Vehicles (ROVs)
(continued from page 11)

Smaller companies, academia, and other non-commercial organizations operate another fifty systems. This total does not include mine-hunting and other specialized military equipment.

The fortunes of the ROV industry track the level of activity in the offshore oil and gas industry. Companies that extract hydrocarbon reserves from the depths of our oceans in order to supply us with heat, light, and mobility own and operate the vast majority of the world's work-class ROV systems. The second most significant market for ROV technology is in support of installing and maintaining undersea cable systems for telecommunications. The number of ROVs in support of hydrocarbon production versus those that support undersea cables is hard to define because of the dual use of many systems, but of the approximately 400 commercial systems deployed worldwide, a fair estimate is that about 85 percent are used in hydrocarbon production and 15 percent in undersea cable support.

The latest estimate is that approximately 430 work-class ROV systems are active in the world today.


Courtesy of Deep Ocean Engineering

Pressurized Water Reactor ROV, the *P150,* is launched to conduct a nuclear power plant inspection.


Courtesy of Hydroid Inc.

Photo 5: The first small commercial AUV, *Remus*, being launched by hand.

The Future

Autonomous underwater vehicles (AUVs) represent the next step in the evolution of underwater intervention. A few AUVs are being used today by the military, science, and the commercial world for survey work (*see photo 5*) and AUVs that actually perform heavy physical tasks are in development. The amount of power an AUV can carry is the primary limitation of this technology at present.

Rather than making quantum leaps to AUV technology, ROVs will evolve to hybrid systems. Control and feedback will continue to be provided through thin fiber umbilicals, with power carried on board and charged by stations on the seafloor. They will be deployed to maintain subsea production systems and the associated pipeline manifolds. Undersea observatories will use a similar approach. Picture an AUV that swims from docking station to docking station to download data and recharge.

ROVs have come a long way from Luppis-Whitehead Automobile's PUV. Because they represent a safe and cost-effective underwater intervention tool, they are sure to continue in their role as critical support devices to many industries.


Courtesy of Drew Michel

Drew Michel, owner of ROV Technologies, Inc. and chairman of the Marine Technology Society's ROV Committee, is a pioneer in the ROV field. Michel has received numerous awards for his contributions to the industry, including the Lockheed-Martin Award for Ocean Science and Engineering to recognize his outstanding contributions to the development of ROV technology. Drew is also a member of the MATE Center's National Visiting Committee.

ROV Technician Career Profile

Leah Hebert—ROV Senior Supervisor

Leah Hebert describes herself as a 'first line of defense manager.' Her actual job title is ROV senior supervisor for Oceaneering International, a company that provides engineered services and hardware to customers that operate in marine, space, and other harsh environments.

"If there are any problems with the ROV while we're offshore, the client comes to me," she explains. Hebert also manages the projects on a day-to-day basis, making sure everything is operational and planning ahead for upcoming work.


Courtesy of Leah Hebert

ROV supervisor, Leah Hebert, working on a ROV's fiber optic cable.

Life Offshore

Hebert's work schedule is twenty-one days offshore followed by twenty-one days on shore. In theory, the time on shore is her own, but she admits that she actually works about a week of that time—typically going to the office and dealing with paperwork.

An offshore ROV crew consists of a supervisor, an electronics technician, and a mechanical technician. The job assignments vary widely.

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Leah Hebert
(continued from page 12)

Hebert has worked on oil and gas drill ships, been involved with construction work (setting pilings, getting the seafloor ready for a tension laid platform) and pipeline laying, and supported 'completion work.' (Once wells have been drilled, a structure is built to attach the pipelines to a production platform.) "That's the most fun," she says. "It's more diversified work, and at the end of the day, we get to see what we helped create."

Navy Training

Hebert received her electronics training while in the U.S. Navy. In total, she received eighteen months of electronics technician training. "That training was enough to get me hired at Oceaneering," she says. "The electronics training you get in the Navy is considered second only to MIT (Massachusetts Institute of Technology)."

While she didn't specifically work on ROVs then, her navy experience gave her a solid grounding in the practical side of electronics.

Because the crews work closely together and spend weeks at sea, getting along with others is one of the most important skills for this kind of work

"I learned how to work in the field—how to deal with day-to-day work offshore," she explains. "When you're in the middle of the ocean, you have to make do with what you've got."

Once at Oceaneering, she learned about ROVs, both through a formal six-week training program for new hirees as well as on-the-job training. "Then you're sent out as an extra, until you're ready to handle it on your own," she says.

Hebert began her career at Oceaneering as an electronics technician, and then moved up to supervisor before earning her current position.

Because the crews work closely together and spend weeks at sea, getting along with others is one of the most important skills for this kind of work, according to Hebert. The ability to troubleshoot logically and strong organizational skills are also key.

No Limits

Hebert has volunteered as a judge every year at the MATE Center's National ROV competition. In her interactions with the participants and their teachers, she's been asked how far she thinks women can go in this field. "My answer is very simple: as far as they want to," she says.

"I've experienced 'attitude' from a couple of customers before," she admits. "But it's all in how we portray ourselves. As soon as they see that I can do my job, it's never an issue again."

Turning an Internship into a Career

In years past I would look at the job market and see numerous paths that I could follow and be successful. I looked into every possible career area that used my education and talent. I wanted something technical and exciting, but nothing seemed right. After seeing an advertisement for the marine technology degree at Alvin Community College (ACC) and talking to Ike Coffman, the Electronics Department chair at ACC, my interest was sparked. The marine technology field has parts of almost every job I had ever done—electronics, microprocessor-based controls, hostile operating environments, and deep water—all at the same time!

At the end of my second semester, Ike recommended that I apply to the MATE Center Technical Internship Program. Shortly after submitting the MATE internship application, I attended the Offshore Technology Conference with my ACC class. When I saw the Oceaneering booth with its ROV simulator, I was sure that I had made the right decision. After talking to Tami Lunsford from the MATE Center and interviewing with John Peterson and Mark Philip at Oceaneering International, I was offered a three-month MATE internship at Oceaneering.

Initially I was assigned to the assembly and test section in the ROV tool shop. The first couple of days were spent testing various tools, reviewing safety procedures, and trying to absorb as much information as I could. I noticed right away that the people at Oceaneering treated each other like family.

Courtesy of Gary E. Lindemann

We all perform our individual jobs, but they are knitted together and orchestrated like a fine ballet.

I was then assigned to help with a jetter skid project (a jetter skid attaches under an ROV to find and bury cables) with more new people to meet and all new things to learn. At first it was confusing—the mechanics were doing electrical work, the electronics technician was doing mechanical work, and I was trying to figure everything out. That's one of the challenges with ROVs—you have to be able to 'do it all' comfortably.

In September, as my internship was coming to an end, I was offered an ROV technician job with Oceaneering in Morgan City, Louisiana. As I write this article, I'm about 150 miles off the Louisiana coast, working with yet another team of great people. Out here the team is not just the three of us from Oceaneering but includes the drilling company, rig hands, company man, galley hands, mud men, and many others—including the families and friends who support us. Working offshore is not just a job—it's a frame of mind. We all perform our individual jobs, but they are knitted together and orchestrated like a fine ballet. When we do our dives, they are televised around the rig because everyone is curious about what is on the bottom, 4,125 feet below us.

There is talk of moving the rig down towards Mexico and into much deeper water. I can't wait to see the bottom there, too. Until then, we will all continue to perform our jobs safely—helping our fellow team members here and at home.

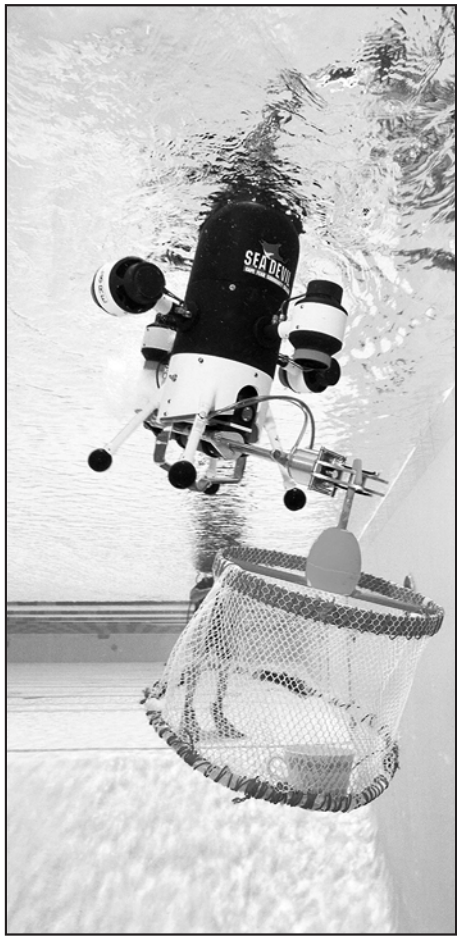
—*Gary E. Lindemann*
ROV Electronics Technician
Oceaneering International

Are you interested in learning more about ROVs? Would you like to work on ROVs or other underwater vehicles? Have you considered a career in marine technology? The MATE Center hosts and supports a variety of activities designed to provide information about marine technical fields and build an awareness of the career opportunities associated with them. These activities include:

ROV Competitions

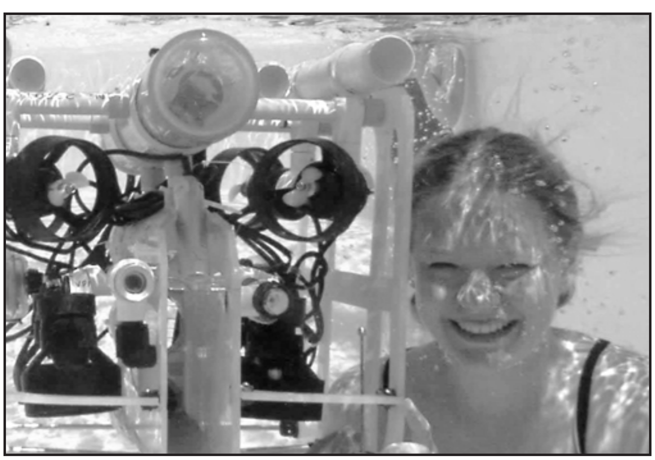
The MATE Center's national ROV design and building competition provides students with an exciting, hands-on learning experience. Co-organized by MATE and the Marine Technology Society's (MTS) ROV Committee, the competition challenges middle school through university students with underwater missions that are based on real workplace situations. From exploring the bowels of the "*Titanic*" to sampling organisms from methane seeps and inspecting oil pipelines, the competition involves budgeting, setting deadlines, documenting procedures and results, and producing deliverables on time—just like the real working world.

Working closely with technical professionals allows students to expand their knowledge and skills and helps them make the connection from school to careers.



Courtesy of Steve Van Meter

Cape Fear Community College's "*Sea Devil*," the grand prize winner of the 2001 national ROV competition recovers sunken treasure.



Courtesy of Peter Thain

Student Beckie Thain is underwater with her team's ROV at the 2003 National ROV Competition.

While sparking the interest of hundreds of students and educators, the competitions have also engaged the marine industry. Organizations ranging from large corporations to small businesses and private foundations support the competitions via funds, facilities, equipment, and professionals who judge the events and mentor the student teams. Working closely with technical professionals allows students to expand their knowledge and skills and helps them make the connection from school to careers. For the marine industry, the competition provides a way to heighten its visibility, support technology education, and, in turn, reap the rewards by way of students who are prepared to meet its work force needs.

In addition to the national event, the MATE Center partners with MTS and other professional societies, industry, colleges and universities, public aquaria, national marine sanctuaries, and NOAA's Office of Ocean Exploration, among others, to establish and coordinate regional competitions across the country. From New England to Hawaii, these regional ROV competitions are providing more and more students and educators with the opportunity to take part in these fun and exciting, real-world learning experiences.

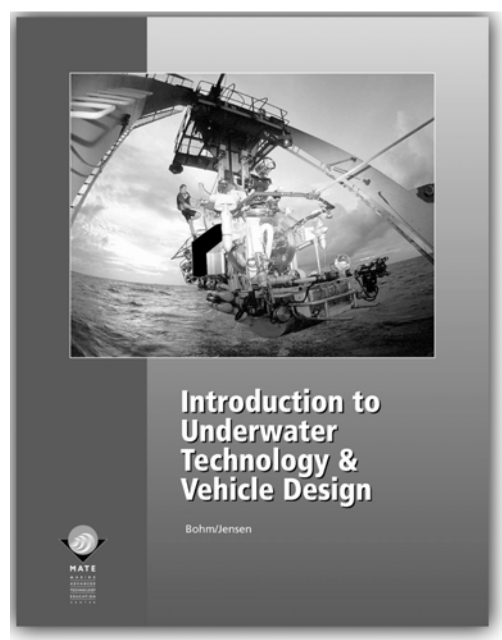
For more information, visit www.marinetech.org/rov_competition/index.php.

Underwater Technology Handbook

At last—a handbook that introduces students to underwater technology and provides the skills and information necessary to design and build an underwater vehicle!

Introduction to Underwater Vehicle Design is designed for advanced high school or college and university students but is also appropriate for do-it-yourselfers, hobbyists, and underwater technology enthusiasts. Each chapter includes "Stories from Real Life," which use real-world situations to set the stage for the science, math, physics, electronics, and engineering concepts that are addressed within the bulk of the chapter. The text also features complete plans for *SeaMATE*—an inexpensive, shallow-water ROV.

For information on prices and how to order, contact the MATE Center at info@marinetech.org.



ROV-Related Workshops for Faculty

The MATE Center and MATE partner institutions conduct a variety of professional development workshops for educators. Topics include marine technology, submersible technology, and GIS. For more information, visit www.marinetech.org/education/workshops.php.

Courtesy of the MATE Center

Summer Institute faculty gain experience with seafloor mapping technology from industry professionals.

ROV-Related Internships for College Students

The MATE Center's Technical Internship Program provides students with hands-on, real-world experiences that complement their academic learning and promote the development of technical, scientific, and critical thinking skills. The Center facilitates at-sea internships with the University-National Oceanographic Laboratory System (UNOLS) and other sea-going organizations. Visit www.marinetech.org/careers/internships.php for more information.

MATE Center Educational Partners

A number of MATE Center partner colleges and universities have programs that offer specialized courses that prepare students to work in the ROV industry. MATE partners that offer degrees or certificates related to ROV technology include:

- **Alvin Community College** (www.alvin.cc.tx.us): Marine Robotics Technology
- **Cape Fear Community College** (http://cfcc.net/programf.html): Marine Technology, Electrical Engineering Technology, Mechanical Engineering Technology
- **Monterey Peninsula College** (www.mpc.edu): Marine Science and Technology

Other MATE Partners that offer marine technology-related degrees and certificates include:

- **Brevard Community College** (www.brevard.cc.fl.us) see Electronic Engineering Technology (offer some ROV courses)
- **California Maritime Academy** (www.csum.edu) Marine Engineering Technology
- **Clatsop Community College** (www.clatsop.cc.or.us) Maritime Science
- **College of Oceaneering** (www.coo.edu) Commercial Diving
- **Florida Keys Community College** Diving Business and Technology and Marine Engineering Propulsion (www.fkcc.edu)
- **Hillsborough Community College** (www.hcc.cc.fl.us) Aquaculture
- **Honolulu Community College** (http://honolulu.hawaii.edu/) Marine Technologies: Boat Maintenance and Repair
- **Kingsborough Community College** (www.kbcc.cuny.edu) Maritime Technology
- **Lake Superior State University** (www.lssu.edu): Electrical Engineering (have ROV courses in the Engineering program)
- **Louisiana Technical College – Young Memorial Campus** (www.youngmemorial.com home.htm): Commercial Diving and Marine Operations

Courtesy of the MATE Center

A MATE Summer Institute geology field trip provides faculty with insight into modeling marine habitats using GIS.

- **Maine Maritime Academy** (www.mainemaritime.edu index.php) Marine Engineering
- **Oregon Coast Community College** (www.occc.cc.or.us) Aquarium Science
- **Prince William Sound Community College** (www.pwscc.edu) Oil Spill Response
- **Saddleback Community College** (www.saddleback.cc.ca.us) Aquarium and Aquaculture Science
- **Southern Maine Community College** (www.smtc.net) Applied Marine Biology and Oceanography

See www. marinetech.org/partnering/educational.php for a complete partner listing.

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Courtesy of Anne Hess

A MATE student intern aboard a research vessel prepares an oceanographic instrument for deployment.

Diving Deeper
(continued from page 15)

Professional Societies in Support of the ROV Industry

The Marine Technology Society (MTS) (www.mtsociety.org) and the MTS ROV Committee (www.rov.org) are sources of information about marine technology and ROVs. Both also offer scholarships for students (see www.mtsociety.org/education/student_scholarships.cfm).

The Association of Diving Contractors International (ADCI; www.adc-usa.org) works with the MTS ROV Committee and other organizations to establish standards and protocols for safe diving and ROV operations. The ADCI also provides student scholarships.

The ADCI and the MTS ROV Committee sponsor the annual Underwater Intervention Conference and Exhibition (www.underwaterintervention.com). This information-sharing event focuses on commercial diving, ROVs, AUVs, underwater operations, and all associated industries and technology. It includes technical sessions, panel discussions, and job fairs.

MTS and the Institute of Electrical and Electronics Engineers (IEEE) organize the annual Oceans Conference and Exhibition (www.mtsociety.org/conferences/index.cfm). Each year's theme addresses an exciting, relevant, and timely subject, such as issues affecting the global ocean. The event includes technical sessions, workshops, student poster sessions, job fairs, and much more.

The annual Offshore Technology Conference (OTC; www.otcnet.org) is the world's foremost event for the development of offshore resources in the fields of drilling, exploration, production, and environmental protection. Each year it has an overwhelming number of participants—more than 50,000 people!—who participate in technical sessions, tutorials, and get lost on the exhibit floor.

OceanCareers.com—a one-stop shop for ocean-related careers!

Through its partnership in the California Center for Ocean Sciences Education Excellence (CA COSEE[3]), the MATE Center created **OceanCareers.com**—a one-stop shop for ocean-related careers! Launched in June, the goal is for **OceanCareers.com** to be the preeminent web site for ocean career information, providing students and job-seekers with a centralized resource for information on ocean careers, such as:

- Ocean-related career opportunities
- Knowledge and skills required to enter ocean careers
- Educational institutions that provide ocean-related programs and degrees
- Industries and employers with ocean-related jobs

Why OceanCareers.com?

The MATE Center created **OceanCareers.com** for three primary reasons:

- *Lack of information.* The industry lacks a detailed, centralized information source on ocean-related careers. And because Department of Labor job classifications combine marine and land-based occupations, many occupations are not recognized as marine-related. As a result, many marine-related occupations lack visibility to those interested in marine careers—and new and emerging occupations have not yet been classified.
- *Changing technologies.* Comprehensive large-scale studies in areas such as marine fisheries and El Niño require multidisciplinary approaches, with technology playing a key role. Recent trends in ocean-related careers include the increased use of technologies such as remote sensing, computers and databases, microelectronics, and biotechnology. Many educational institutions are not able to keep up with the technology-based realities of today's work-force, and students need to be armed with the knowledge that will allow them to make better decisions about their ocean-related educational programs.
- *Economic consequences.* Approximately twenty percent of the U.S. economy relies on ocean-related activities; one in six jobs is ocean-related. An inadequately prepared workforce can profoundly impact the many sectors of the economy that rely on ocean-related occupations, such as national security and defense, transportation and commerce, energy and exploration activities, telecommunications, recreation and tourism, fisheries and aquaculture, search and recovery operations, nautical/underwater archeology, government assessment and regulation, scientific/medical research, and education.

Information Available on OceanCareers.com

OceanCareers.com addresses these challenges by bringing together six databases that provide detailed information about:

- *Occupations.* The web site provides descriptions of more than fifty ocean occupations, including skills and aptitudes, salaries, and demand, and relates them to Department of Labor workforce information where possible.
- *Educational Institutions.* **OceanCareers.com** describes ocean-related programs at more than 100 educational institutions.
- *Employers.* Included are nearly 10,000 ocean-related employers—including names, locations, and business descriptions.
- *Educational Competencies.* The website provides students and prospective employees with information on appropriate educational competencies in 24 different disciplinary areas.
- *Professional Societies.* The site lists more than 200 ocean-related societies that provide advice, access to mentors, current information on the field, and even scholarships.
- *Profiles.* **OceanCareers.com** provides profiles of employees, educational institutions and employers.

The MATE Center is testing **OceanCareers.com** with a variety of audiences and has included ample comment boxes throughout the site—so take a look and let us know what you think! **OceanCareers.com** is a long-term project that will continue to improve and expand, so be sure check back frequently.

—Deidre Sullivan, Curriculum and Industry Manager

[3]California COSEE is part of a National Science Foundation (NSF) network created to foster scientists' involvement in ocean science education. One of seven COSEE Centers nationwide, California COSEE represents a powerful collaboration among the Lawrence Hall of Science at UC Berkeley, the Marine Advanced Technology Education (MATE) Center at Monterey Peninsula College, Scripps Institution of Oceanography and the Birch Aquarium at Scripps, and California Sea Grant.