Trends in UUV Development

U.S. Navy Forcing the Envelope...Again; a Spectrum of Development Programs & Many Activities Addresses Multiple Systems, Components

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The inevitable tides of change have brought a set of new requirements to the U.S. Navy—transitioning missions concerned with a Cold War environment, where the development of deep-ocean ROVs was emphasized, to those where the major concerns revolve around the shallower littoral environment, mine warfare, and missions concerning potential conflicts in Third World countries.

Lead, Follow, or Get Out of The Way

This change did not come easily for the Navy's R&D centers. For over three decades, the U.S. Navy has been a world leader in the development of ROVs, driven initially by the requirement to recover ordnance or other material lost on the seafloor. Thus, driven by its own mission requirements, and with the necessary financial resources, the Navy spearheaded the development of advanced ROV systems. This was complimented by the infusion of funds from offshore oil companies in the 1980s, and the ROV industry came of age. Through technology transfer and Navy supported programs, the ROV technology was transferred to the commercial sector, where the ROVs evolved into powerful, highly efficient and capable work horses. Today's reliable ROVs, such as the Navy's CURV III, Oceaneering's MAGELLAN™, and Perry Tritech's TRITON® XL, routinely operate throughout the world's oceans to depths exceeding 20,000 feet.

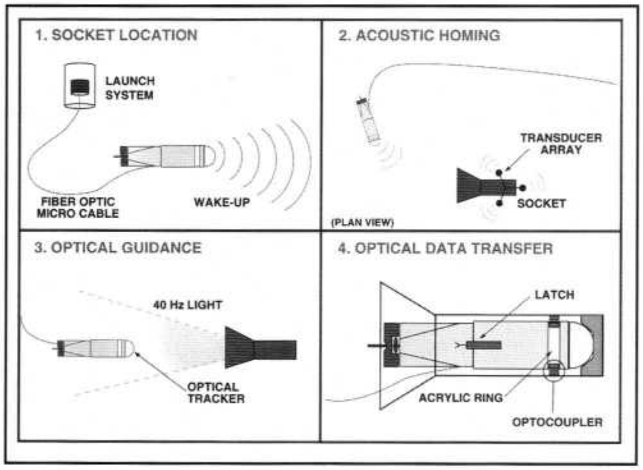
Thus, driven by its own success, the Navy changed from a leading ROV developer to an ROV leaser. Today, it has become more cost effective for the Navy to use commercial firms, such as Oceaneering Technology International (Upper Marlboro, Maryland), under contract to the Navy's Office of the Director of Ocean Engineering, Supervisor of Salvage and Diving, and lease the systems needed to perform work in the ocean when necessary. Whether a black-box recovery, or an insurance fraud investigation, the assets are now commercially available to do the job. The depths of the ocean can no longer be considered "out of sight, out of mind."

With that said, one might think that the U.S. Navy's undersea vehicle community has worked its way out of a job, however, that is far from the case. The Navy has embraced unmanned undersea vehicle technology as the

Long-Range Mine Reconaissance System Performance Targets

	Threshold	***Objective***
Sortie reach (miles)	75	120
Total area coverage (square miles)	400	650
Area coverage rate (square miles/day)	35	50
Minimum mine reconnaissance water depth (feet)	40	40
Maximum operating depth (feet)	1,500	1,500
Nominal endurance (hours)	40	62

Note: miles are nautical miles.



At lower left, Flying Plug being launched. After launch, it (1) acoustically locates the socket, (2) orients the socket by interrogating a triangulated array of transducers, (3) performs terminal homing on a chopped 40 Hz light source using an optical tracker in the vehicle's nose, and (4) autonomously docks with the socket where an LED transmits data through an acrylic ring in the vehicle's hull to a photodiode receiver.

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solution of the future, where heavy, tethered ROVs will give way to new systems, such as the Long-Term Mine Reconnaissance System (LMRS)—a submarine launched autonomous vehicle. Driven by new mission requirements, and with funding to back up its position, the Navy is once again taking the lead in developing technologically advanced systems that will eventually transition into the commercial sector, solving more than strategic problems.

Emerging Role of the UUV

Driven by the potential of hostilities with smaller countries that could wreak havoc through terrorism or unconventional warfare, the U.S. Navy began to rethink its at-sea strategy and littoral warfare now dominates. Missions that will require future military UUV systems include surveillance, intelligence collection, tactical oceanography, special warfare, counter-narcotics, and counter terrorism. However, the area of mine countermeasures (MCM) was identified as the most critical.

With instances such as mine warfare damage to two U.S. warships in the recent Gulf War, it became very clear to Navy planners that if future battles are to be fought along the world's coastlines, with mobility a key factor, then safe operating areas will need to be found or established. To achieve this, submarine launched UUVs will be required. This was recently established in the Navy's UUV program plan where clandestine MCM was given top priority. To meet that goal, several systems are planned for development by the Unmanned Undersea Vehicle Program Office—PMS403. The first two priorities are the development of the Near-Term Mine Reconnaissance System (NMRS) and LMRS (See *Sea Technology*, November 1997). Together, they are scheduled to nearly reach a $140 million combined budget for 1996-2001.

Near Term Mine Reconnaissance System (NMRS). The NMRS contract was awarded to Northrop Grumman Corp. [formerly Westinghouse Corporation's Oceanic Division (Annapolis, Maryland)]. The system is carried onboard a submarine, with the vehicles, operator consoles, tether, winches, and other system components housed like torpedoes on the standard storage racks. The vehicle is launched and recovered through the torpedo tube using a drogue that also provides a docking point to haul the vehicle back into the tube. The vehicle is battery operated, using silver-oxide batteries and communicates with the mother ship via an expendable fiber optic cable. The system will have the ability to return to the submarine for autonomous recovery should the communication link be broken. The 21-inch diameter, 206 inch long vehicle will carry a sensor suite made up of a forward-looking sonar for detection and classification of mine like objects on the seafloor and in the water column and a side-looking sonar for bottom target detection and classification. The initial operational capability (IOC) of the NMRS is planned for 1998.

Long-Term Mine Reconnaissance System. The LMRS, with an expected contract value worth nearly \$400 million over the next 20 years, will replace the interim NMRS. The NMRS will fill the need until the production of six LMRS systems meet a planned IOC of 2003. Unlike the NMRS, the LMRS will be fully autonomous, with either short-range underwater communication with the mother submarine or long-range RF communication on the surface. The vehicle concept will remain similar to the NMRS, with a full sensor suite to locate and classify mine like objects, but the operational requirements will be more stringent. The goal of the LMRS program is to develop a system that will meet the threshold requirements, and as much of the operational objectives that can be cost-effectively achieved. The thresholds and objectives are shown in the table.

Adding to the complexity of the ambitious LMRS are the high reliability criteria plus the required reduction in magnetic and acoustic signatures. The U.S. Navy is in the second phase of a three phase competitive contractual process to develop the LMRS systems. The two contractors, Northrop Grumman Corp. and Autonetics and Missile Systems Division of Rockwell International Corp. (acquired by Boeing Co. last year) have just begun the two-year, phase-two process of detailed design.

Lead Players

This short article cannot adequately describe all the UUV related work ongoing within the U.S. Navy, however, four of the most significant programs are:

Naval Undersea Warfare Center (NUWC) Programs. NUWC is developing two UUV test beds for evaluation of various payloads and advanced technologies, many of which will be directly applicable to programs such as the LMRS. The two vehicles are the Large-Diameter Unmanned Underwater Vehicle (LDUUV) and a 21-inch-diameter, torpedo-sized vehicle (21-UUV).

The LDUUV is an electrically powered, torpedo-shaped vehicle, 26.5 inches in diameter, and 300 inches long. It is fully autonomous, operates at speeds in the 4-to-12-knot range from depths ranging from 10 to 600 feet with an endurance of 30 nautical miles at 6 knots. Operational since 1993, the test bed is very quiet and thus capable of stealthy operation that allows testing of sonar systems, acoustic communication links, and other systems requiring quiet operating conditions.

The 21UUV testbed, currently under development, is a tactical sized UUV for the integration and test of advanced mine countermeasure sensors and payloads, advanced energy storage and propulsion systems, signature reduction systems, and non-traditional navigation systems. Active research programs at NUWC include:

- Thrust-vectored pump jet (TVPJ) with Applied Research Laboratory/Pennsylvania State University
- Acoustic communication system
- Intelligent mission controller with Texas A&M University
- Low-speed controller and hydrodynamic simulation
- Variable ballast system
- UUV motor system.

Office of Naval Research Programs. Among the many research programs of ONR is the Unmanned Undersea Vehicle Technology Program in the Engineering, Materials, and Physical Science & Technology Department. This technology program is targeting the areas of: endurance; energy and propulsion; sensors and signal processing; communications; mission management control; navigation; and vehicle design. The technology developed under the ONR program, which involves many of the Navy's centers and academic laboratories, will be tested on the NUWC LDUUV and 21UUV—with the ultimate application the LMRS.

Naval Oceanographic Office (NAVOCEANO) Programs. NAVOCEANO (John C. Stennis Space Center, Mississippi) the largest field component of the Naval Meteorology and Oceanography Command (COMNAVMETOCCOM), provides oceanographic support to the Department of Defense through a wide range of oceanographic modeling, prediction, and data collection techniques. NAVOCEANO has recently embarked on a program to field a variety of UUV systems to meet diverse military oceanographic survey requirements. One of NAVOCEANO's initial steps in establishing such a capability has been the acquisition of the autonomous vehicles developed by Charles Stark Draper Laboratory Inc. (Cambridge, Massachusetts) under contract to the Defense Advanced Research Projects Agency (DARPA). These 36 foot long (nominal), 44-inch diameter vehicles, will provide NAVOCEANO with the latest technology to support their mission of acquiring data on the world's oceans.

Space & Naval Warfare (SPAWAR) Systems Center Programs. The Navy continues to develop technology and systems for AUVs at the SPAWAR Systems Center San Diego (formerly the Naval Command, Control and Ocean Surveillance Center's Research, Development, Test and Evaluation Division—NRaD, a.k.a. NOSC), where the mainstays of command and control systems, fiber-optic and acoustic communication links, non-metallic materials, and general vehicle development continue. In addition, the center has three UUV testbeds: Free Swimmer II (FSII), the Advanced Unmanned Search System (AUSS), and the Flying Plug.

The FSII, a torpedo-sized UUV, can be used for autonomous vehicle research, or controlled through a fiber-optic microcable. The larger, 17 foot long, 30-inch diameter, AUSS vehicle is by far the most advanced full-ocean-depth search system in the world today. With its acoustic communication link, it has the ability to transmit real-time sidescan sonar data or CCD television pictures to the surface from depths to 20,000 feet. Due to its tetherless design, it can reduce the search time by an order of magnitude over conventional towed search systems. To date, AUSS (including its prototype version) has logged 134 dives, and is presently on standby for future R&D or operational tasks (See *Sea Technology,* December 1991).

The Flying Plug, which has far reaching applications for the Navy, has recently completed an ONR funded program. This small vehicle, after being launched from an air, surface, or subsurface platform, deploys a fiber-optic microcable communication link. The vehicle then docks with an underwater "socket," through a combination of acoustic and optical homing sensors, completing the high data-rate communication link between the platform and the underwater system, i.e.

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an underwater sensor network or surveillance system.

The Future

Change is inevitable. New military doctrines are shifting the Navy's focus from deep ocean missions using ROVs to the near shore environment and missions requiring autonomous UUVs. The missions of the Navy's R&D centers have been "purified" to eliminate duplication of effort. Funding is appearing to support the future integration of UUVs into the Navy's arsenal, and the technology base—especially that for autonomous systems—is maturing. Today, the maturity level of autonomous systems is similar to that of ROVs in the mid-1980s. Unlike the early ROVs, where offshore oil applications drove their acceptance, it will be the symbiotic relationship between the Navy's advanced developments and academia's cost-effective designs that will leverage UUV technology towards reality and acceptance.

Future UUVs, whether military, academic, or commercial, will be lost! When that single fact is accepted, and systems are cost effectively designed so that occasional loss is an acceptable risk, UUVs will come of age. Autonomous systems will be developed that routinely conduct intelligence, surveillance, and reconnaissance missions, and the world of the innerspace satellite network will begin. The U.S. Navy, through in-house programs, developmental contracts, support to academia, and technology transfer, will be there to help, once again forcing the envelope. /st/

Robert Wernli, a senior staff member of the SPAWAR Systems Center, has worked in the area of unmanned undersea vehicles for 25 years on U.S. Navy R&D programs. He has also been very active in the Marine Technology Society and IEEE OES. Wernli started the ROV conference series in MTS and chaired the conferences from 1983 to 1992 and was general chairman of Oceans 95 MTS/IEEE.