

COMMAND CHANGE

**Undersea robots
add capabilities**

Lockheed Martin's Marlin AUV has a recovery system that latches onto a cable for fast retrieval from the sea. The cable has a transponder that guides the robot toward it.

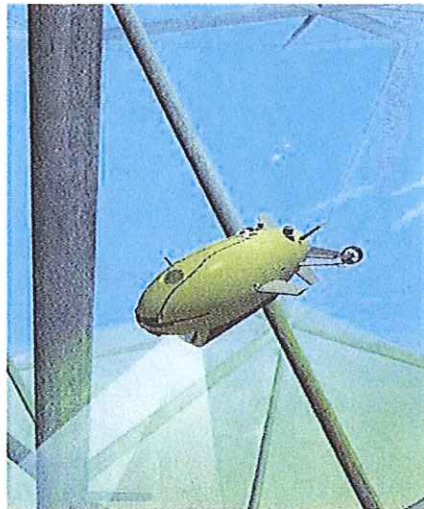
LOCKHEED MARTIN CONCEPTS

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Robotic vehicles deployed on land and in the air bring broad capabilities to the battlefield, substantially increasing activities ranging from intelligence, surveillance and reconnaissance (ISR) to explosives detection and disposal, perimeter security and attack. Land and air robots have long since changed battlefield tactics and, in the process, reduced casualties among forces that deploy them.

Developers of robotic vehicles for ocean and littoral use pursue similar benefits. While underwater platforms have been deployed for some time, work is underway to increase their performance in a number of areas, notably autonomous operations, multimission capabilities, speed and endurance. Underwater robots are not as advanced as land and air versions, but based on development programs that are underway and the needs expressed by maritime forces, more sophisticated platforms could be available in as little as five years for deep-diving, long-endurance and autonomous missions. Robotic vehicles, which are now chiefly used in passive operations—e.g., mapping and battlespace preparation, inspection, location and detection of underwater objects, mine countermeasures (MCM) and training—will be capable of more aggressive operations. Some say these could include tailing and attacking surface ships and submarines, a capability that could enable them to create buffer zones around ships, seaborne command centers and amphibious operations.

Unmanned underwater vehicles (UUV) and autonomous



A commercial version of the Marlin AUV will be demonstrated this year. The vehicle is designed for inspection of oil rigs (above), ships and other structures.

underwater vehicles (AUV) operate in a challenging environment: Underwater currents affect their speed and maneuverability; water salinity and temperature can affect communications; and even launch and retrieval may involve complicated maneuvers that in combat zones expose recovery teams to danger.

Many challenges can be overcome by increasing the autonomy and operational flexibility of UUVs, along with multimission capabilities. Objectives here include endurance of at least 30 days (24 hr. is generally the current limit for most UUVs), diving capabilities that exceed 2,500 ft., underwater speeds beyond the present top end of 8 kt., improved maneuverability and an energy-dense battery system to assure reliable, long-term power.

Improvements are especially important in communications. To overcome distance limitations in transmitting data or commands underwater, developers

are fine-tuning UUVs that can be programmed to conduct missions and return to a predetermined location for data retrieval or transmission, or descend to the bottom of the sea and "sleep" until activated for another operation.

To achieve operational flexibility, developers are incorporating highly integrated mission modules into the designs of their UUVs. These include high-resolution sensors for such functions as optical imaging, side-scan and conventional sonar, and onboard signal retrieval and processing. Using these techniques to provide multimission capabilities will also help drive down total ownership costs.

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A vital need is rapid access to data recorded by UUVs. Since a vehicle—especially an AUV—could pick up critical data while out of range of ship or land communications, techniques are being developed to rapidly exploit the information. One approach cited by Sven-Christian Hesse, head of UUV programs at Atlas Elektronik of Bremen, Germany, is improving automatic target-recognition algorithms for onboard processing. This would substantially reduce the time of post-mission analysis, he says.

Atlas is among companies working to broaden the capabilities of undersea vehicles. Along with sister businesses Atlas Elektronik U.K. and Atlas Maridan of Denmark, the company recently tested a synthetic aperture sonar called Vision600 (developed by Qinetiq) in its SeaOtter Mk. II, an AUV. Vision600 reportedly achieves resolution of 25 cm. (10 in.) across a 200-meter (656-ft.) swath of ocean. The sonar links to a positioning system in the AUV, interfaces with other onboard sensors and consumes little power. During the demonstration, the system was underslung on the bottom of the SeaOtter Mk. II, which traversed the survey area at 3 kt.

The SeaOtter Mk. II is one example of the evolving technology of AUVs. Based on the company's SeaOtter Mk. I, which is in service around the world, the Mk. II can be programmed for a mission or guided by radio beacon. It accommodates modular payloads relevant to general-purpose ocean and line surveying and to training in antisubmarine warfare. The vehicle is 3.45 meters long, 0.96 meters wide and 0.48 meters high. It weighs 1,000 kg. (2,200 lb.), carries a payload of 160 kg., and dives to 600 meters. Top speed is 4-5 kt., and endurance is 24 hr.

A model was on display at the Euronaval exposition in Paris in October. A company representative there said Atlas is developing a version that will be able to operate at depths of 4,000 meters. Initial demonstrations of this capability could come as soon as 2012.

MCM is an important role for UUVs. Most models are remotely operated and designed to detect and identify mines, then destroy them with an explosive charge. One company taking this a step further is BAE Systems, which propos-

Lockheed Martin's Remote Multimission Vehicle can be used for MCM and other missions.

SeaOtter Mk. II from Atlas Elektronik is an upgraded UUV that carries modular payloads.



The diversity of UUV designs is evident in the product lineup offered by Atlas Elektronik.

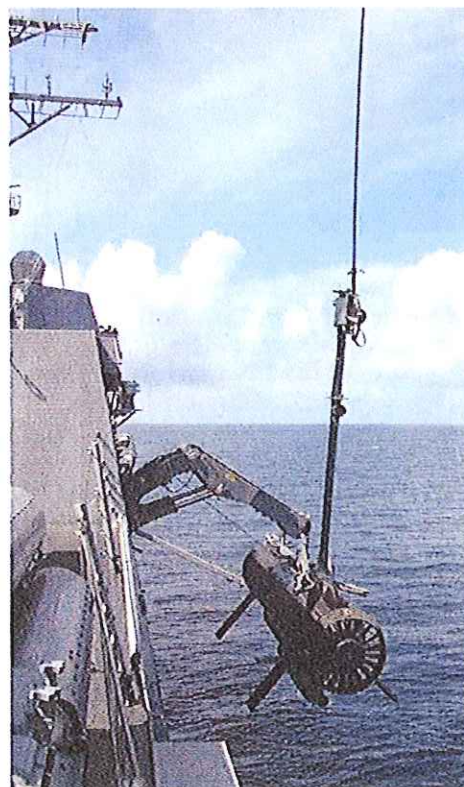
es loading single-shot mine-hunting or observation UUVs in a larger robotic vehicle called Talisman M. This vehicle would carry the UUVs into an area of interest, release them and, via remote operation, guide the vehicles to a target.

Talisman M is big—4.5 meters long, 2.5 meters wide and 1,200 kg. It has a top speed of 5 kt., and a carbon-fiber hull for stealth. The vehicle can launch four of the BAE Archerfish UUVs, the U.S. Navy's prime MCM weapon (which can be deployed at sea or by helicopter), or two of the company's recently developed Talisman L (littoral) UUVs. The L model is, at 1.4 meters long and 50-kg., highly maneuverable (it can turn within a radius of its length), and equipped with sensors for observation.

BAE sees Talisman M as a force multiplier—a compelling tactical use of UUVs. The company says it can transit 20 km. (12.5 mi.) underwater to access an area of interest, and then release UUVs. Talisman L can even carry an underslung Archerfish, which would be launched upon identification of a mine.

UUVs come in many sizes, but at least for MCM, there seems to be a lot of work underway in developing small, maneuverable vehicles that can be easily launched and controlled, and are effective enough to destroy the mines they encounter.

One example of this is K-Ster from



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ECA of La Garde, France, a UUV developed for detecting and destroying mines. The vehicle isn't new—it was commercialized in 2006—but its simplicity and effectiveness are attracting the attention of a number of navies, Valentin Hanns, export sales manager, told *DTI* at Euronaval. The wire-guided device weighs 50 kg., is equipped with a camera and sonar, and carries a 3-kg. shaped charge in a tiltable warhead. Once a mine is identified, K-Ster is maneuvered next to it and the warhead tilted for optimum placement of the explosive.

One-shot UUVs for MCM raise the question of how long it will be before naval forces deploy autonomous vehicles that hunt, detect, identify and attack targets. Rich Holmberg, vice president of missions and unmanned systems at Lockheed Martin, believes such a capability is probably in the cards for UUVs. "As the technology grows, along with the threats to our nation, I think offensive capabilities would be appropriate."

Lockheed is working on an AUV with a number of advanced performance features. Called Marlin, it demonstrates as much as any advanced platform where underwater robotics are going in terms of capabilities.

Marlin comes in two sizes—one is 10 ft. long and weighs 2,000 lb., and the extended-range (ER) model is 16 ft. long and weighs 3,500 lb. Both are 5 ft. wide. Military capabilities (there's also a commercial version) include ISR, radiofrequency interception and communication, sonar and optical surveys, minehunting and MCM.

Holmberg says that while Marlin operates autonomously, an operator can communicate with the vehicle via an acoustic modem to take control or transmit a new program for it to follow. The transmission range is only 1 km., however, so a shipboard operator would need to maneuver within this area to contact the AUV. Alternatively, Marlin can be programmed to return to a ship or a certain area and wait for further commands.

The AUV is powered by a lithium ion battery, which Holmberg says is reliable, energy-dense and, of course, rechargeable. It could also be run on primary batteries, lithium vinyl chloride, perhaps. This would not be rechargeable but would increase energy density by at least a factor of 3.

The Marlin as tested has 20 hr. of endurance. Holmberg says that with some fine-tuning, it could meet a challenge issued by the U.S. chief of naval operations for a 30-day AUV mission, which is probably where the use of primary batteries would be applied. Both versions of the Marlin operate at 1,000 ft., but work is underway to increase the depth range to 13,000 ft.

One notable point about the AUV, Holmberg says, is its



Talisman M from BAE can transport smaller UUVs for reconnaissance and minehunting missions.



Divers from the USS Dextrous, a Navy MCM vessel, recover UUVs in the Persian Gulf.

simple retrieval and docking system. Marlin uses an autonomous underwater homing and docking system, which cues the AUV acoustically. A cable with a transponder is lowered 20-30 ft. into the sea, where it pings the Marlin to return. A homing beacon on the AUV detects the signal and follows it to the source.

Once at the cable, Marlin deploys two guides that extend from the front and docking rings. As the AUV follows the acoustic signals to the transponder, the guides catch the cable and latch it through the docking rings, securing Marlin. The cable can then be pulled up and the AUV loaded onboard a ship.

Marlin is programmed to calculate the shortest route to the docking system. If it misses the cable because of a crosscurrent, algorithms in the AUV's software will reposition it and move it toward the cable again. The AUV has dual thrusters in the rear for propulsion and vertical thrusters in the body to hover. Holmberg says the AUV senses currents and "turns on a dime" when it comes to maneuvering for retrieval. An alternative system is being developed whereby Marlin would be recovered in a cradle on the seafloor.

Lockheed Martin designed the AUV with open architecture to accommodate different sensors and energy sources. This will improve versatility but may not affect the economics of operation. "I think the U.S. Navy would like to get to a common family of underwater vehicles to reduce ownership cost," Holmberg says. "But the mission spectrum [for AUVs] is so vast, I don't think any one vehicle will meet every mission requirement."

Some UUVs are designed for missions that can keep ships away from dangerous waters. Lockheed Martin's other major program is the Remote Multi-mission Vehicle (RMV), a semi-submersible, semi-autonomous platform that can be fitted with sensors for minehunting or equipped to tow sonar arrays and other threat-detection systems. The RMV can be used to protect ships. It can be deployed from any craft of opportunity, Holmberg says, and is the primary mine reconnaissance capability of the U.S. Navy's Littoral Combat Ship.

The RMV is 23 ft. long and 4 ft. in diameter. Because it is diesel-powered, it stays near the surface to maintain its air-breathing propulsion system. It tows an advanced variable-depth sensor for minehunting. The RMV has 24-hr. endurance, and reportedly searches an area five times faster and at 10% of the cost of a legacy system.

Importantly, it keeps ships and sailors out of harm's way. "The minehunting vehicle is cheaper to own than a 200-ft. MCM craft with 70-80 people on board," says Holmberg. ■