CHINA

New Robotic Vessel Extends Deep-Ocean Exploration

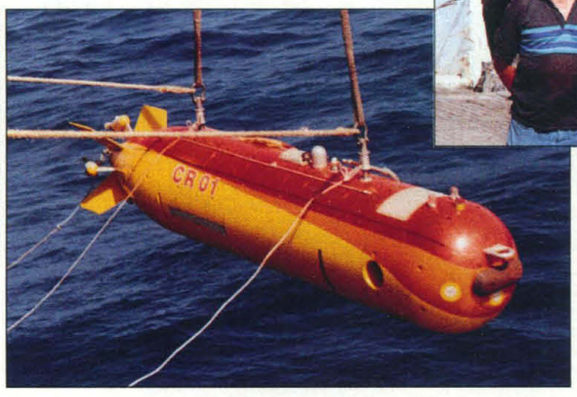
BEIJING—China has deployed a new and untethered robotic submarine that extends the reach of researchers and others interested in learning more about the deep ocean. In a series of dives earlier this year in the central Pacific, the autonomous underwater vehicle (AUV) CR-01 went down 6000 meters, matching the deepest levels reached by other submersibles. It can remain underwater for an extended period of time, maneuver to avoid obstacles, and take both still and video pictures.

The achievement puts China in the front ranks of countries—notably France, Russia, the United States, and Japan—with such a capability. And it may provide a boost for the entire field, which in the post–Cold War era has had to scramble for funding. "It's a significant accomplishment," says James Bales of the AUV lab at the Massachusetts Institute of Technology, which has a fleet of five smaller AUVs. "The fact that China is putting major resources into autonomous vehicles also validates what the rest of us have been doing."

Exploring the deep-ocean floor is a formidable technological challenge. Besides the great pressure and the difficulty in communicating through thousands of meters of seawater, navigating through unknown and irregular terrain is a treacherous business. But the potential rewards—both economic and scientific—are compelling. The vehicle can be used to get information on the topography and hydrology of the seabed, to explore mineral resources underwater, and to search for sunken objects. It is currently being used to explore deep-sea mineral deposits and is available for contract work. "It gives China the technological means for tapping ocean mineral resources," says the robot's designer, automatic control expert Feng Xisheng of the Shenyang Institute of Automation.

The torpedo-shaped AUV is 4.4 meters long, 0.8 meters in diameter, and weighs 1300 kilograms, making it significantly bigger and heavier than other deep-diving robots are. Its size allows for larger batteries, which means more staying power—up to 23 hours—and reduces the need for miniaturized sensors and other specialized equipment. Powered by a group of silver-zinc batteries with a total capacity of 4.8 kilowatt-hours, the vessel has a cruising speed of 2 knots, with bursts up to 2.7 knots.

To avoid collisions, the AUV uses five ranging sonars with a 60-meter range. It also uses one long-baseline acoustic positioning system for navigation. The system consists of three beacons placed on the seabed and separated by a distance of 3.6 kilometers, along with one subsystem installed on the support ship and one on the AUV. Each part of the system can send and receive signals, allowing controllers to pinpoint the robot relative to its support ship and to send commands for recovering the vehicle. This long-baseline system can cover an area of about 40 square kilometers; within this area, the system's positioning accuracy is 10 meters. In case of a breakdown, Feng says, the robot is capable of automatically resurfacing and raising the alarm signal by extending an emergency wireless antenna and flashing its lights.



SHENYANG INSTITUTE OF AUTOMATION

Frontier science. China's Feng Xisheng *(above right)* and Russia's Nicolai Rylov oversee the CR-01 on its 6000-meter Pacific dive.

The robot has no external devices to collect samples. To get information on metal-rich nodules that litter parts of the Pacific sea floor, explains sonar expert Zhu Weiqing, from the Beijing-based Institute of Acoustics under the Chinese Academy of Sciences, the robot takes photos (up to 3000 exposures) and video recordings with a camera that holds 4 hours of tape. It has two side-scanning sonars that can operate within a range of 350 meters on each side and one chirp sub-bottom profiler that can penetrate 50 meters into the seabed. Signals emitted by the side sonars help researchers analyze an area for any mineral deposits; sounds from the profiler provide information on the depth of those deposits.

The vehicle was put through its paces during a Chinese expedition to a region some 1350 kilometers southeast of Honolulu. CR-01 spent 8 hours on each of five dives, conducted between 21 May and 27 June, exploring an area the size of a large golf course from an altitude of between 3 and 5 meters above the sea floor.

The project, funded by the State Science and Technology Commission, began as an effort to design an AUV capable of diving to 1000 meters as part of China's high-level Project 863, begun in 1985. In 1992, the Chinese turned to Russia for help. "The Vladivostok-based Institute of Maritime Technology Problems had some technologies we badly needed, such as the long-baseline acoustic system and the airtight sealing technology," says Xu Fengan, an automatic control scientist and CR-01's deputy general designer. "More importantly, they have valuable operating experience under the water" with a variety of vessels, most recently the MT-88, also rated at 6000 meters. That knowledge, Xu says, was blended with Chinese expertise in automatic control technologies, propulsion and energy systems, and vehicle-recovery methods.

Mikhail Ageev, director of the Vladivostok institute, says he anticipates additional joint projects with China. The institute was also hired to help design and build a similar AUV for South Korea.

CR-01's first—and so far only—client is the China Ocean Mineral Resources R&D Association. Supervised by seven state departments, the association's main task is to explore and exploit mineral resources in an area of 75,000 square kilometers under the Pacific designated by the Deep-Seabed Authority, an international organization that oversees ocean-floor explorations.

CR-01 appears ready to play an important role in that exploration, and mineral association officials say they hope to acquire at least one more AUV, paid for by the state commission. The Shenyang Institute is also looking for outside support from other governments and private companies, including those in France, Sweden, Italy, and the United States.

–Li Hui

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