ROV/AUV Trends

Market and Technology

By Lukas Brun

The Duke University Center on Globalization, Governance and Competitiveness (CGGC) recently completed a study on ocean technologies, including remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), for a consortium led by Nova Scotia's Department of Economic and Rural Development and Tourism (ERDT). Excerpts from the report on the market and technology trends in ROVs and AUVs are provided in this article.

ROV market and technology trends

Global ROV vehicle sales in 2010 totaled approximately $850 million. In 2010, oil and gas purchased approximately 50% of ROVs, while ROV sales for defense & security and scientific research equaled 25% for each sector.

Market drivers for ROVs are offshore drilling, the security environment, and the need for ocean data. The prospect for offshore drilling varies by location, yet offshore exploration in Brazil, Nigeria, Indonesia, and the Gulf of Mexico are expected to be strong. In the security market, ROVs are routinely used for forward observation, reconnaissance, and mine counter-measures by the military. ROVs will increasingly be adopted by organizations charged with ocean rescue and port security seeking effective tools for scanning and observation, including hull inspection. The need for data on the oceans is driven by the need for creating detailed maps for navigation and minerals extraction, particularly in the Arctic.

The three market dynamics in the ROV market of particular note are 1) the growing market for mini and small ROVs driven, primarily, by their reduced cost and increased functionality; 2) the increasing number of sensors and robotics capable of being placed on vehicles; and 3) the reduction in cost of the platform relative to the cost of the instruments. The relative cost of instruments and platform is important to note because it indicates the maturation of the ROV technology. ROVs, although they remain highly sophisticated technology packages, have become adopted widely enough to expect continued cost reductions, or performance enhancements at the same cost.

Four technology trends in ROVs can be identified. The ROV industry is keenly aware of the need to simplify the interface between the ROV operator and the vehicle. Most ROVs in use have multiple screens for monitoring the ROV vehicle status (health), feeds from onboard cameras and video, robotic arm manipulation, and receiving feedback from data collection instruments. The trend is to simplify the interface by having information provided on one screen. The integration of multiple systems requires the development of software. ROV and instrument manufacturers are working to improve the integration of systems developed independently. This after-market integration between the platform and instrumentation is sub-optimal. In the future, functional integration will be incorpo-

	Remotely Operated Vehicles (ROVs)	Autonomous Underwater Vehicles (AUVs)
Global Vehicle Sales (2010)	~ 850 million (US$)	~ 200 million (US$)
Demand Drivers	• offshore oil • security environment • need for ocean data	• need for ocean data and mapping • increased functionality of AUVs • offshore oil (reducing ROV costs)
Market Dynamics	• market for mini and small ROVs • increasing number of sensors and robotics on vehicles • reducing operational costs	• increased comfort with autonomous vehicles for monitoring and patrol • market for versatile products suit able for tough, physical environments
Technology Trends	• simplified user-interface • high-definition (HD) camera & video • reduced vehicle size • tether-optional (hybrid) ROVs	• increased functionality • longer mission life • reduced power requirements • miniaturization

Source: Duke University Center on Globalization, Governance & Competitiveness (CGGC) rated into the design of ROVs and onboard systems.

The availability of relatively inexpensive High Definition (HD) camera and video has increased the demand for efficient data transmission from the ROV to the operator station. High definition allows better inspection of the underwater site due to improved quality of the image, better control of the vehicle, and allows for easy switching between video formats found in different parts of the world. The consequence is that the copper video transmission system used in most tethers must be replaced with fiber optic cable to accommodate the greater bandwidth required to transmit HD signals. Advances in fiber optic technology allow ROVs to communicate with the surface using millimeter-thin cables, allowing smaller diameters in the tether and reduced drag.

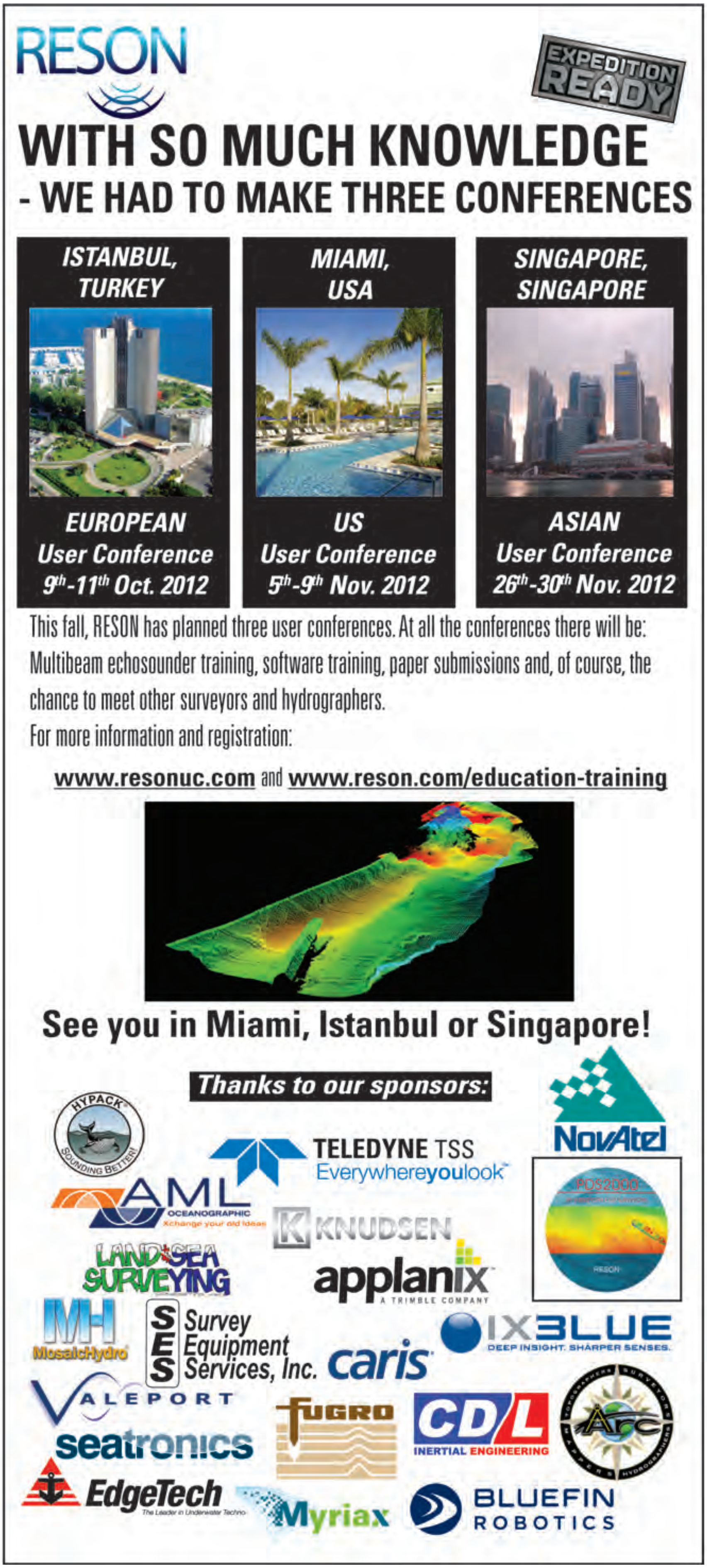
The size of the average ROV is decreasing due to technological developments in instrumentation. Smaller ROVs are preferred to large ROVs, keeping everything else constant, because of better maneuverability and lower deployment costs. Small ROVs deployed by one or two-man crews are less expensive to operate than vehicles deployed with large landing and recovery systems (LARS) requiring several operators. Maintenance costs are also significant drivers for reducing the size of ROVs, particularly in the scientific research market. In the past, large vehicles were needed to house the instruments needed to accomplish the dive mission; however, as a result of the reduced size of onboard instruments, cameras and robotic arms (often with improved performance) the size of the required vehicle has been reduced. The exception to this trend is in missions requiring the completion of heavy intervention tasks, as in offshore construction, or in missions where payload capacity is critical. Another driver of reduced weight is the result of technology improvements allowing greater propulsion power through a given diameter of wire. This has allowed for reduced weight in the entire ROV deployment system, including lighter landing and recovery systems. Improvements in compact buoyancy have also reduced the weight and size requirements for ROVs.

Hybrid ROVs (HROVs) are an interesting trend in the ROV market. Hybrid ROVs have tether-optional configurations in which the vehicle can conduct programmed missions free from the tether. The benefit of hybrid systems is increased maneuverability in locations where tethers would entangle or limit the ability to navigate around obstacles. Woods Hole's Nerus and Saab's Seaeye are examples of workclass HROVs. A number of manufacturers, including Seabotix, are making mini and small production HROV models. Canada's ISE has experimented with HROVs as a way to reduce monitoring costs. According to interviews conducted by CGGC, HROV configurations are expected to be an option increasingly offered by ROV manufacturers, particularly in the mini and small ROV markets.

AUV market and technology trends

The AUV market is smaller than the ROV market. According to industry interviews conducted by CGGC, the global annual expenditure on AUVs is roughly $200 million, dominated by U.S. manufacturers. Currently, the military/security market makes up approximately 50% of AUV sales. The scientific research market makes up approximately 30% of the AUV market. The oil and gas market makes up approximately 20% of AUV sales.

The market is expected to grow to $2.3 billion by 2019 (Westwood, 2010). Interviews with leading AUV manufacturers consider the 30% compounded annual growth rate implied by this forecast to be optimistic. However, the growth potential of AUVs is clearly large. Military and scientific research markets are expected to make up more than 75% of projected sales through 2019 (Westwood, 2010). AUVs increasingly will be used in the oil and gas market, primarily due to the cost of using ROVs. The increased functionality in AUVs and the demand for floating oil production systems and remote fields also are drivers for adopting AUVs.



The majority (~70%) of AUVs sold are rated for water depths less than 200m, illustrating the importance of small, light, shallow water AUVs for various end-markets. Of these shallow water AUVs, roughly 30% are rated for depths less than 30m. Unit sales forecasts through 2019 estimate that the majority of sales will occur in small AUV sales. However, large AUVs will dominate the projected $2.3 billion sales because of their high unit costs.

AUVs are still a relatively new ocean technology. The first recorded sale of an AUV occurred in 1985; 75% of existing AUVs were produced between 2001 and 2005. As newer technologies, the platform costs are greater than the instruments onboard. In contrast to ROVs, the AUV vehicle makes up the majority of the total cost of the vehicle. AUV platforms make-up, on average,66-75% of the cost (in comparison to 40% for ROVs), while instruments make-up 25-33% of AUVs. This of course depends on what instruments are included in the AUV. Some instruments (e.g., spectrometers, dissolved gas and nutrient sensors) are relatively expensive, while others (e.g., altimeters and pressure gauges) are inexpensive. The platform's share of the total AUV cost is expected to decrease as incremental innovations in the vehicle are implemented.

The technology trends in AUVs are increased functionality, longer mission life, reduced power requirements, and miniaturization. The trend in AUV technology is to increase their versatility from what essentially is an oceanographic data collection system to perform a greater variety of missions. AUVs are capable of mission lives up to a year, although this varies on the type of vehicle and amount of instrumentation onboard. Generally speaking, the greater the number of instruments onboard an AUV, the shorter its mission-life. AUV surveys in deep water (>3000 meters) are conducted two to three times faster than in towed systems because AUVs have higher cruising speeds, do not require repeated turns and passes over the same locations, and provide higher data quality because of the stability of the survey platform.

AUVs are currently being developed in the military market for locating and disabling mines. The University of Hawaii and the U.S. Navy's SAUVIM (Semi-Autonomous Underwater Vehicle for Intervention Missions) performed the first autonomous manipulation using feature based navigation in January, 2011

(MASE, 2011). Scripps Oceanographic Institute, the University of Washington, and the U.S. Navy developed the XRay Flying Wing prototype to track submarines and conduct remote sensing in shallow waters for up to 6 months.

A second trend is to increase the mission life of AUVs. Current AUVs can be deployed up to a year, after which batteries must be replaced and the vehicle reconditioned. The limitation on mission life is largely a power imposed constraint – the vehicle simply runs out of power to conduct its mission. Three developments have sought to address this limitation of AUVs. The first is the development of compact battery technology capable of storing more electricity. The second development is instrumentation and communication devices requiring less power. The third development is onboard power generation, either through the use of solar arrays kept above the ocean surface, or for gliders, through wave and bio-mimicking technology to power the vehicle.

A third trend is to reduce the power requirements for AUVs. Two power requirements exist for an AUV: forward propulsion and power for onboard instrumentation, guidance, computers, and communication devices. Forward propulsion for most AUVs is generated from power stored in onboard batteries. This limits the mission life of AUVs since physical limitations on the number and size of batteries carried onboard exist. The weight of batteries is a key drawback since they reduce the payload available for other instrumentation. Gliders have overcome some of these difficulties by using changes in the vehicle's buoyancy and onboard wings to propel the vehicle forward. Advances in mechanical design, particularly biomechanical engineering, may reduce or eliminate the need for stored onboard power in gliders in the near future. Researchers at the California Institute of Technology (US), Southampton (UK), Tokai University (Shizuoka, Japan), and the Delft University of Technology (Netherlands) have recently presented papers on biomechanical applications to AUVs. Most production glider models require stored power to bring the vehicle up at the end of its dive cycles. Onboard electronics are currently powered with onboard batteries or solar arrays. The use of solar arrays limits the depth the vehicle can dive; however.

The fourth major trend is miniaturization of onboard instruments and vehicles. The application of nanotechnology to robotics and electronic equipment holds tremendous potential to develop small, highly sophisticated underwater vehicles. While the promise of nanotechnology continues to develop, AUVs have continued along the same path as ROVs to become smaller while simultaneously adding capabilities.

About the Author

Lukas Brun is a senior research analyst at the Duke University Center on Globalization, Governance & Competitiveness (CGGC), and author of the ROV chapter in the Nova Scotia Ocean Technology report from which excerpts were taken for this article. The full report is available free of charge at http://www.cggc.duke.edu/pdfs/2012-03-05_Nova%20Scotia%20OTReport.pdf