MARINE TECHNOLOGY REPORTER

July/August 2022
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POWER PLAY

AUV fuel sources continue to diversify

CTO In Focus
Shepard Smith, XOcean

XLUUV
Build it & they will Buy

ROVs & Hybrids
Send ROVer Over

Leveraging USVs for
Port & Harbor Security

Volume 65 Number 5

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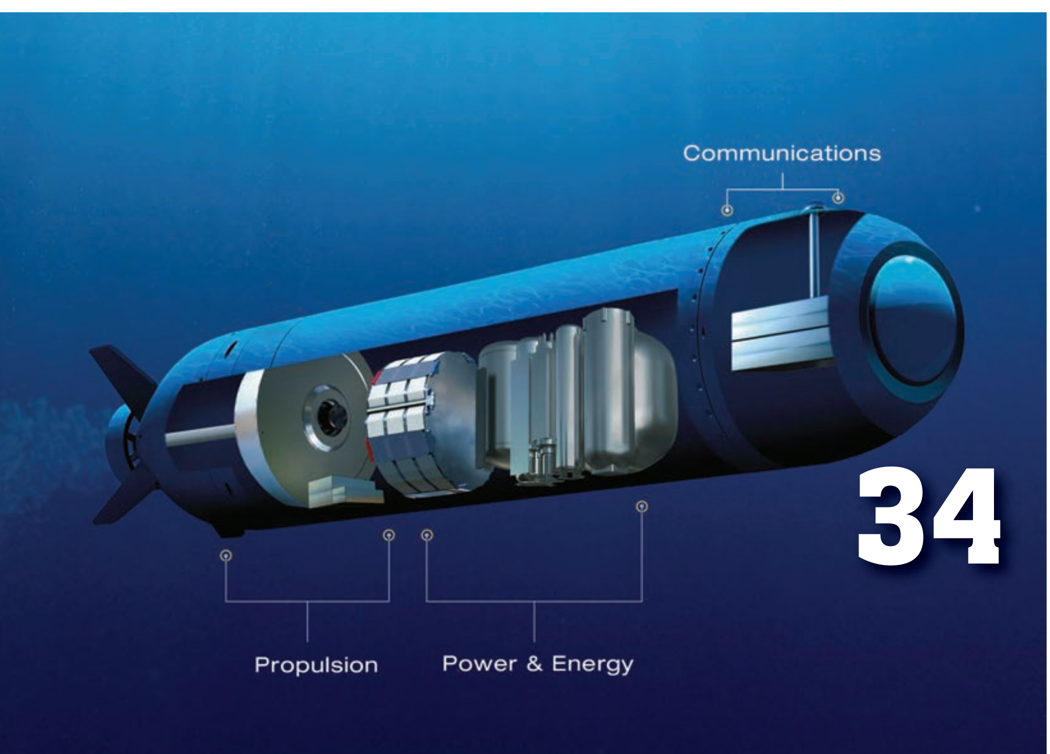
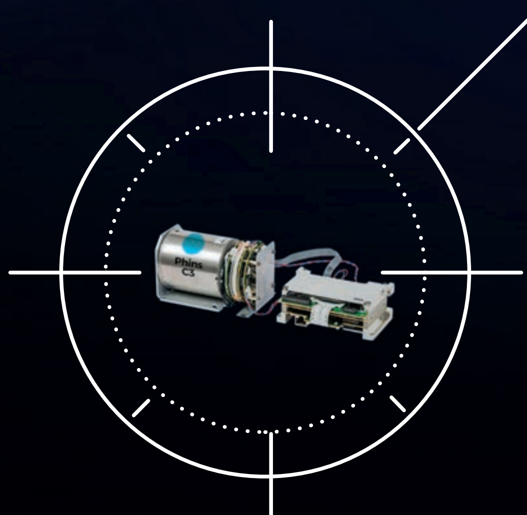


GA EMS

On the Cover

Kraken's SeaPower batteries fitted into Ocean Infinity's AUVs.
Image courtesy Kraken



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Editorial

In some respects, procurement of editorial stories for our pages, print and electronic, is analogous to fishing: we throw out a lot of lines, never really knowing what we might catch.

My interview with **Shepard Smith**, ex-NOAA and new CTO of XOcean, in my humble opinion was a solid "keeper." Before we met on Zoom for our recent interview, I did not know Shep Smith, but I'm sure at conferences and exhibitions our paths had crossed. I won't spoil the punch line here, as our 6 page feature on Smith and XOcean starts on page 28, but what I found was someone with an enviable depth and breadth of experience and knowledge courtesy of his nearly three decades at NOAA, finishing up as the Director of the Office of Coast Survey and the U.S. National Hydrographer. But the story on Smith goes deeper, as he reflects on his recently completed 2000 mile trek along the Appalachian Trail, affording him the time to reflect not only on his "next chapter", but also to gain some tools that will inevitably aid him in his new position.

In this edition **Elaine Maslin** (again) does what she does best: taking a deep dive into a technical topic, in this case a looking inside the future of power for autonomous vessels. The subsea space is clearly the leader when it comes to autonomy under (and in fact on) the water, and as this technological evolution proceeds at speed, another transcendent trend is decarbonization and the push toward net zero.

Where years ago "being green" was more marketing slogan than corporate mandate, the trends towards cleaner, greener operations of size and shape of vessels at sea is being driven simultaneously by government and corporate mandate. Read up on some of the latest trends in the fueling and propulsion of AUVs starting on page 34.

Gregory R. Trauthwein
Associate Publisher & Editor

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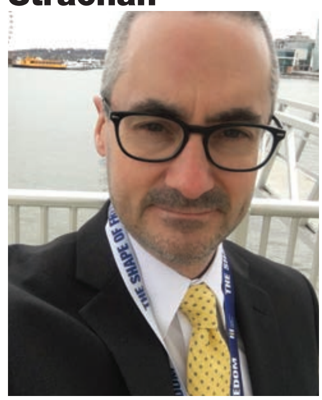

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XLUUV: If You Build It, They Will Buy

Anduril Industries

Industry sees emerging opportunity in large, extra-large AUVs

By David R. Strachan, Defense Analyst and Founder, Strikepod Systems

In August, 2021, after years of delays, cost overruns, and rising tensions, the Australian government canceled a A$90 billion order with France's Naval Group for 12 conventionally powered submarines intended to replace the Royal Australian Navy (RAN)'s aging fleet of six Collins-class attack subs. Overnight, the future of the RAN's undersea warfare capability was cast into uncertainty. The very next month, however, the United States and the United Kingdom announced a plan to help Australia fill the void, offering to assist in the design, development, and construction of a new fleet of now nuclear powered submarines. While the move was hailed by many as cunning geostrategy, the devil is in the details.

Given Australia's lack of experience in nuclear power production or nuclear submarine construction, and that the new class of attack sub would have to be designed largely from scratch, the full realization of this trilateral security pact, dubbed AUKUS, is still many years, if not decades, away. Meanwhile, China's regional expansion continues unabated - most recently with an infrastructure partnership with the island archipelago of Vanuatu, just 1200 miles off Australia's east coast. "The security challenges in the Indo-Pacific region have grown significantly," said Australian Prime Minister Scott Morrison. "Military modernization is occurring at an unprecedented rate and capabilities are rapidly advancing and their reach expanding. The technological edge enjoyed by Australia and our partners is narrowing." The sense of urgency is clear. But with only a small fleet of aging attack subs, how can the RAN augment its undersea defenses in order to secure its maritime interests?

Enter Anduril Industries, a U.S. defense technology company and developer of autonomous systems, who, in May, announced a partnership with the RAN to deliver three XL-AUV (extra large autonomous underwater vehicles) by 2023. Anduril's focus has been air and force protection systems, but earlier this year the company moved into the undersea domain with its acquisition of Dive Technologies, the Quincy, Massachusetts developer of the Dive-LD, a 5.8-meter, 2720 kg large displacement unmanned underwater vehicle (LDUUV). Founded by former Bluefin Robotics engineers, Dive pioneered the use of additive manufacturing (3D printing) to fabricate the LD's outer hull, as well as its internal components and substructures. With the Dive acquisition, Anduril is now uniquely positioned to offer the RAN a near-term undersea warfare solution by combining the Dive-LD's manufacturing methods with Anduril's advanced technologies. "There is a clear need for an XL-AUV built in Australia, for Australia," said Palmer Luckey, Anduril Founder. "The XL-AUV will harness the latest developments in autonomy, edge computing, sensor fusion, propulsion, and robotics to bring advanced capability to the Royal Australian Navy."

Since the Anduril announcement, similar industry partnerships have emerged, heralding what could be a trend toward turnkey, commercial off the shelf (COTS) solutions for defense-related large and extra large UUVs. In addition to the Anduril partnership, the RAN, through Australian defense cooperative research center Trusted Autonomous Systems, is tapping British Columbia-based Cellula Robotics to develop the SeaWolf XLUUV. Cellula is the developer of the Solus family of AUVs, which includes the Solus-LR, a hydrogen

Cellula Robotics

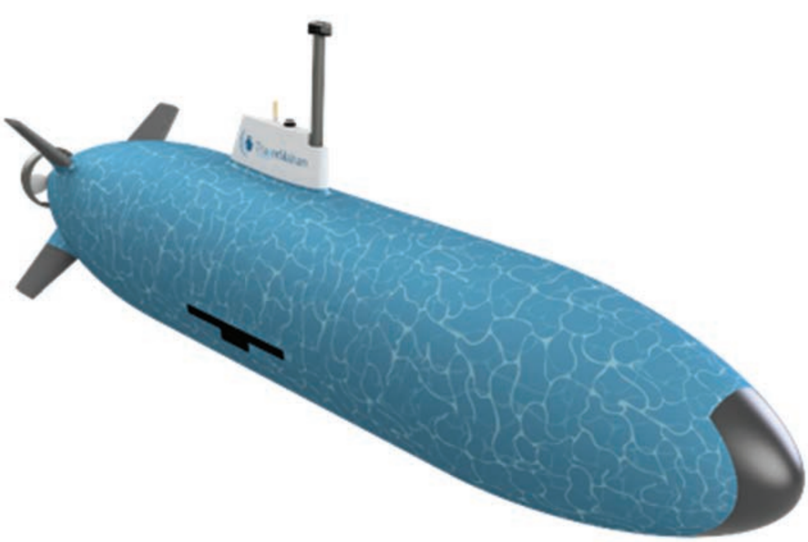
fuel-cell powered XLUUV with a range in excess of 2000km. The 12 meter technology demonstrator, to be rolled out in late 2022, or early 2023, will have a range of over 5000 km, and will include contributions from Australian sub-contractors Mission Systems, Ocean Wave Consulting, East Consulting Services, as well as renowned Australian marine robotics engineer Ron Allum whose company, Ron Allum Deepsea Services, will assist in the integration of power and propulsion systems. And in the large displacement UUV (LDUUV) space, UK submersible builder MSubs is teaming up with U.S.-based maritime surveillance company ThayerMahan for the development of Minke, an advanced, multi-mission vehicle with a depth rating of 1500 meters. “We will use Minke in commercial work in the near term and expand to government work when the Navy’s LDUUV program is re-started,” said ThayerMahan CEO Mike Connor. “The fundamental design will scale to extra-large vehicles (XLUUV) when the defense market is ready for that capability.”

Meanwhile, goernment-driven XLUUV programs inch forward. Under development since 2017, the U.S. Navy’s Orca XLUUV Test Asset was christened in April of this year, and will put the platform through its paces while five contracted vehicles continue production. And in addition to its partnership with Thayer Mahan, since 2019, Msubs has been working closely with the U.K. Royal Navy on its XLUUV program, Manta, providing a test platform based on its existing 9-meter S201 submersible.

But the future of U.S. Navy’s LDUUV program, Snakehead, just months after christening its prototype, is now in doubt. Budget pressures, and a “misalignment of … design and procurement efforts with submarine hosting interfaces [drydeck shelters]” have forced the Navy to reconsider its commitment to the program. As a result, Msubs/Thayer Mahan, as well as Anduril and Cellula Robotics, would be well positioned to benefit should the Navy pursue a COTS LDUUV procurement

While small and medium COTS AUVs have been in use by navies for several years, given the cost and complexity of larger displacement AUVs, their development has been driven primarily by traditional government R&D efforts. The Orca, for example, is essentially a miniature diesel electric submarine, with a varied mission set that includes autonomous payload delivery, such as sea mines, as well as anti-submarine warfare (ASW). But even for well-established submarine powers, indigenous R&D can be challenging and isn’t always an option. Should the Australian model prove successful, other regional maritime powers who find themselves behind the technology curve and in immediate need of a low cost, credible ASW capability may seek out similar partnerships. Much as cruise missiles, and now drones, have enabled cash-strapped nations to acquire their own “poor man’s air force,” so too could COTS LD and XL-AUVs engender a similar trend with unmanned submersibles.

To be sure, LD and XL AUVs are largely uproven as undersea warfare platforms, and it remains to be seen how they will ultimately be integrated into naval operations. But as great power competition continues to intensify, along with the budgetary strain of high-value, high-dollar manned platforms, the demand for an affordable alternative will grow. And companies like Anduril, Cellula Robotics, Msubs, and ThayerMahan will be standing by to offer innovative solutions.



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The boat is crossing multiple times three large bridges including one made of steel.

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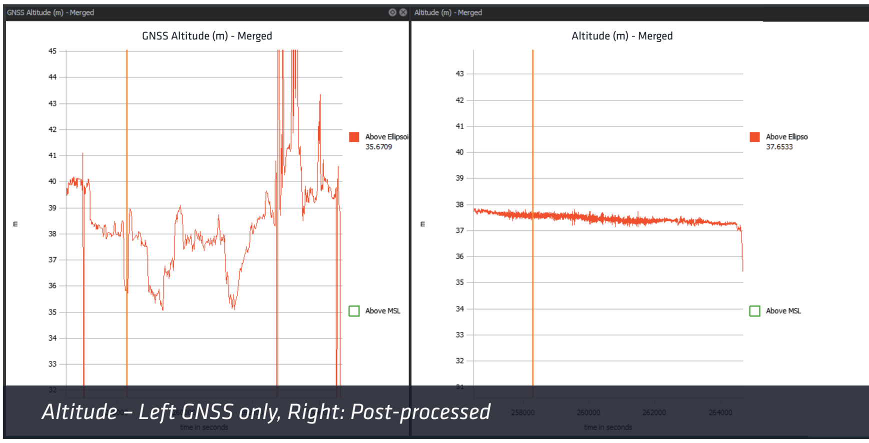

Altitude – Left GNSS only, Right: Post-processed

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Many thanks to Hydro Systems Development (HSD Japan) for their kind collaboration.

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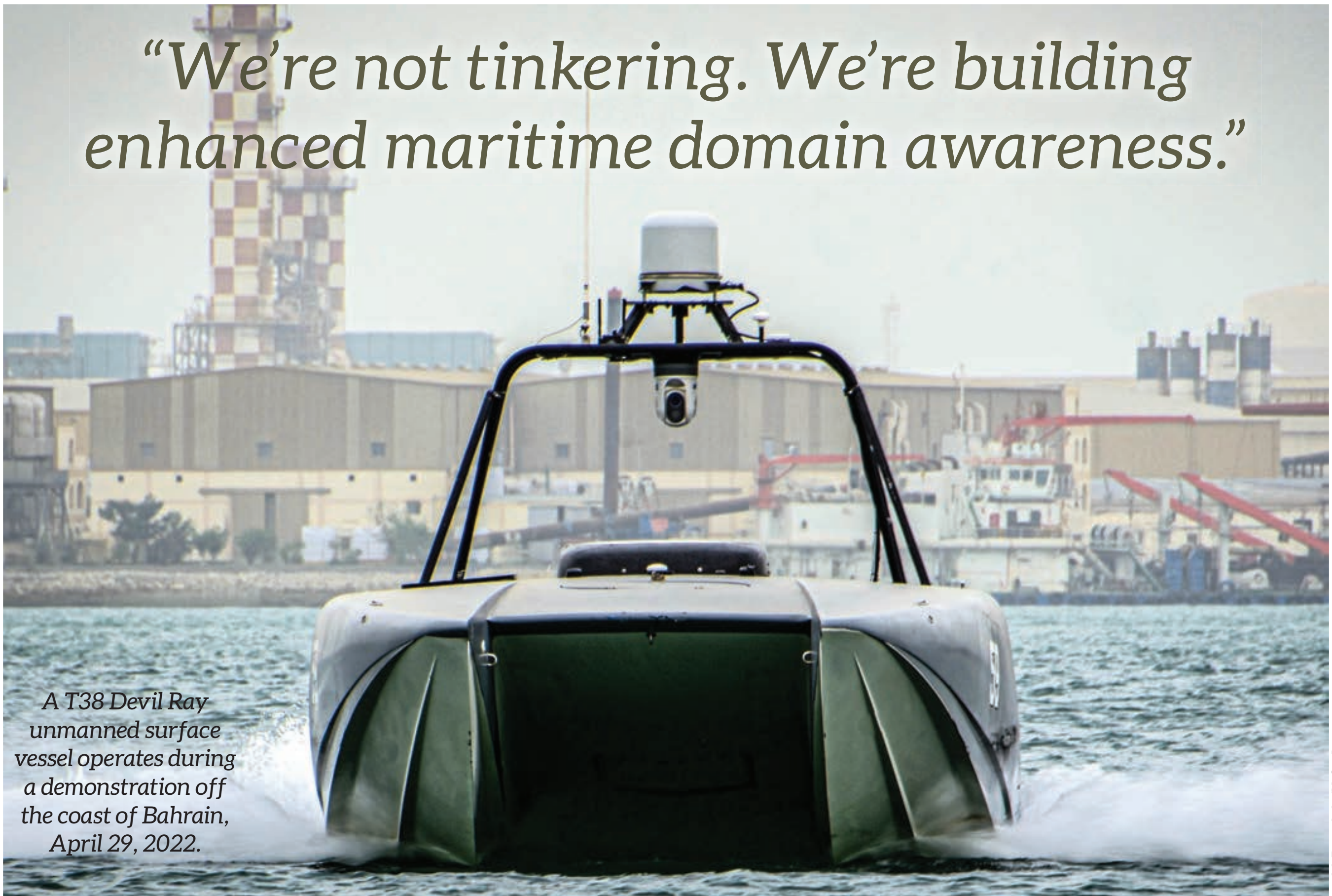

A T38 Devil Ray unmanned surface vessel operates during a demonstration off the coast of Bahrain, April 29, 2022.

David Resnick/U.S. Army

Navy establishing unmanned surface vessel fleet for persistent ISR in Middle East

By Edward Lundquist

The U.S. Navy's Task Force 59, based in Bahrain as part of the U.S. Naval Forces Central Command (NAVCENT) and U.S. Fifth Fleet, is advancing the operational employment and integration of unmanned systems and artificial intelligence in fleet operations.

According to Vice Adm. Brad Cooper, the fleet commander, unmanned systems and artificial intelligence are helping to accelerate innovation, especially in such a vast area of responsibility (AOR).

"It's 5,000 miles from the Suez Canal all the way around the Arabian Peninsula and up to the North Arabian Gulf — and perhaps too large an area to cover with manned vessels. Using emerging technologies, last year we seized on an opportunity to put more eyes out on the water by fielding unmanned systems. In September, we stood up Task Force 59 as an unmanned systems and artificial intelligence task force. Unmanned systems and artificial intelligence go together; this is an important point. There's not one without the other."

Cooper said TF 59 has established operating hubs in Bahrain and Jordan, and is coming up on 15,000 hours of operating time for the unmanned surface vessels. "We are on a path to build the world's first international unmanned surface vessel fleet. We have two different types of platforms. One of them provides a persistent ISR capability, and the other has a high-speed sprint capability. In the case of the persistent ISR, we

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U.S. Navy photo by Mass Communication Specialist 2nd Class Dawson Roth

NAVAL SUPPORT ACTIVITY BAHRAIN (Sept. 9, 2021) Vice Adm. Brad Cooper, left, commander of U.S. Naval Forces Central Command, U.S. 5th Fleet and Combined Maritime Forces, shakes hands with Capt. Michael D. Brasseur, the first commodore of Task Force (TF 59) during a commissioning ceremony for TF 59 onboard Naval Support Activity Bahrain, Sept. 9. TF 59 is the first U.S. Navy task force of its kind, designed to rapidly integrate unmanned systems and artificial intelligence with maritime operations in the U.S. 5th Fleet area of operations.

have several unmanned vessels underway in regional waters that have been out there for 140 days, which is incredible. The goal is to work with our partners and grow the USV capability by the summer of 2023 to a point where we have 100 USVs operating around the theater. Our partners see the opportunity here and they are very committed to moving forward."

"Earlier this year we conducted the world's largest unmanned maritime exercise to date," said Cooper. "It involved 10 nations bringing more than 80 unmanned platforms together."

Capt. Michael Brasseur is the TF 59 commander. "We are focused on the rapid delivery of unmanned systems and artificial intelligence into fleet operations, to enhance maritime domain awareness."

The task force works closely with members of Navy's re-

Photo by Petty Officer 3rd Class Dawson Roth U.S. Naval Forces Central Command / U.S. 5th Fleet search and development enterprise, industry, academia and other experts to provide operator feedback and help drive the innovation process forward.

CTF 59 works with the Office of Naval Research and the science and technology (S&T) enterprise, but Brasseur said his focus is in the here and now. "We're tracking what they're doing," Brasseur said. "But, we're in a different space. We're working with high TRL (technology readiness level) systems."

"We're very much focused on the commercial dual-use side of unmanned and AI," said Ens. Schuyler Moore, CTF 59's director of strategic plans. "We understand that there are very important research projects that have longer term delivery paths that are currently ongoing in the Navy and DOD. But what we're looking at is solutions that are available right now, that have already been matured in the commercial space."

PARTNERSHIPS

Cooper said the concept of CTF 59 was a two-page white paper a year ago. "Now we're fielding USVs from the Red Sea to the Arabian Gulf. We expect to continue expanding these efforts, with our partners leading the way. They understand there is tremendous opportunity in putting more eyes out on the water through unmanned systems and artificial intelligence. They can put however many platforms they want out there, and with AI, they process and identify things they need to pay attention to. Our role is to provide an operational construct and scheme of maneuver. It's up to them which platforms they choose."

Brasseur said CTF 59 is working on the platforms, sensors, and the network to connect them. "The final piece is the artificial intelligence that will help us sift through all of that sensor data and help us to see what's outside of the normal pattern of life. That will also help us to deploy our manned assets more precisely."

"This is where the magic happens because we are the problem holders. We're bringing together the solution providers with the problem holders, and we can quickly determine if the system or the AI can help us solve our problems. We're based forward and in a challenging, hot, dusty, and salty environment," Brasseur said. "We have real world operators using the systems in actual situations continuously. It's a tough proving ground for any kit.

"We're not tinkering," Brasseur said. "We're trying to build enhanced maritime domain awareness."

Marine Minerals – a new opportunity for Subsea Oil and Gas Technology

By Tore Halvorsen, CTO at Loke Marine Minerals

2023 could be a significant year for subsea mining, both in Norway and internationally. Norway's environmental impact assessment for marine mining is ongoing, and the opening of the first Norwegian area for marine mining licenses is due to be approved while the International Seabed Authority (ISA), which has the authority over licenses in international waters, is due to approve legislation for marine mining exploitation internationally.

Critical minerals for the green transition have large remaining reserves under water. As an example, 96% of the world's remaining cobalt reserves are under water. Subsea mining can directly impact the green transition, Underwater Technology Conference (UTC) keynote speaker Tore Halvorsen says. But it needs knowledge from the oil and gas industry to make it happen and Norway could lead that drive, both in terms of technology but also licensing and regulation, he will tell UTC, during June 14-18.

Tore Halvorsen, previously SVP Subsea Systems at TechnipFMC, is CTO at Loke Marine Minerals, which was founded in 2019, with TechnipFMC and Wilhelmsen as technology partners and investors. It's targeting the Norwegian Exclusive Economic Zone and international waters.

"The green transition is fully dependant on critical minerals, and marine mining will not happen without the knowledge we are sitting on as an oil and gas industry," he says. "I think Norway can play a very important role in this. Norway could become a dominant technology player and operator in marine minerals because of the heritage from oil and gas.

Image courtesy LOKEmm.com

"There are two main triggers for a significant jump in the interest for marine minerals.

One is that Norway is planning to approve the opening of an area for licensing for marine minerals. The other is that the ISA is due to approve legislation for marine mining exploitation in 2023.

"The Security of Supply for critical minerals is increasing significantly. Both the geopolitical situation and the fact that very few countries are controlling both extraction and processing of critical minerals is a growing concern for many industrial countries who are highly dependant on these critical minerals.

"Remaining reserves of critical minerals like Cobalt, Manganese, Nickel and Copper can to a large extent be found under water. Up to 96% of the world's remaining cobalt reserves are under water. For Manganese and Nickel, the situation is similar, with 75-85% of the remaining reserves under water.

"Norway can play a vital role in developing marine mining as a new industry. The ISA see Norway as having demonstrated the ability to produce oil and gas with a high safety level, high environmental focus. Norway's legislation for Marine Mining is to a large degree built on oil and gas legislation. Norway is already engaged by ISA to help develop the international legislation for marine mining.

"In addition, Norway's strong expertise in deepwater oil and gas technology can directly be used and built on to develop a new industry around marine mining, with similar export opportunities as for the oil and gas sector.

"The environmental aspect of marine mining will be a main focus area to ensure we fully understand the impact of marine mining prior to startup. Norway has a long tradition in both baselining, impact assessment and environmental monitoring from the oil and gas sector and a lot of work has already been done regarding marine minerals both by universities and NPD.

Autonaut Put to the Test

'AutoNaut completes a 16-week, 4,000-mile mission gathering PAM, ADCP, CTD, and wave data on the Atlantic continental shelf break.'

AutoNaut

*By **Mike Poole**, Director and Project Manager, AutoNaut*

AutoNaut 'Oban' arrives quietly into Penzance after waiting out Storm Arwen off Mount's Bay. The 115-day voyage covered 4,000 nautical miles gathering data on the Atlantic shelf break from the Hebrides to Cornwall.

A proving trial for 'AutoNaut for Extreme Environments' in autumn 2021 saw the 5m uncrewed surface vessel (USV) spend 16 weeks at sea and cover over 4,000 nautical miles on the continental shelf break in the Atlantic. Data gathered by PAM, ADCP, CTD, and wave sensors was distributed free to partners. Data analysis continues in 2022. Preliminary results include what is believed to be the first acoustic detection of a Kogia pygmy or dwarf sperm whale in UK waters.

This was a great result for the new Seiche light weight hydrophone array designed for USV deployment. It is fitted to a fin under the keel, rather than requiring a towed array of hydrophones. The new system registered 23 acoustic encounters with dolphin species and 21 encounters with harbor porpoise, during transits through the Sea of the Hebrides and Stanton Bank Special Areas of Conservation (SAC).

AutoNaut has a unique wave propulsion system using just pitch and roll, which means the boat itself has a quiet sound profile and provides a 360° sound picture because there is no propeller noise. Earlier sound surveys in the Gulf of Mexico and off Sao Tome demonstrated that cetaceans do not swim away or stop vocalizing. For a PAM baseline survey this is excellent.

A 25m-long towed thin-line PAM array is also used, but as the new high latitude AutoNaut is designed for the roughest places in the world, such as the Southern Ocean in winter, capsize and pitchpoling is expected. A long, towed array might get tangled, and it causes more drag.

The success of this 115-day mission was tempered by a fault that developed in the charge control system between PV panels and a bank of new lithium batteries, reducing hotel power. As a result, the original plan had to be rerouted and less data was collected. This issue was quickly solved after the operation completed.

The long mission in the Atlantic proved the robustness of the AutoNaut wave-propulsion system, and demonstrated new developments to scientific and commercial stakeholders, one of the objectives of the project. With no fuel and no mothership required, AutoNaut offers a long endurance ocean going platform that is zero carbon.

The aim of the 'AutoNaut for Extreme Environments' project, funded by Innovate UK, is to develop the wave propelled USV to be capable of operating at high latitude, eventually in winter. The initial three-year project was interrupted by Covid 19. IUK funded this extension proving trial in 2021. It was also impacted by Covid, starting three months later in the year, by which time winter was approaching, and without additional the battery power that had been planned.

Technology challenges for high latitude operations include anti-icing, the detection and avoidance of small ice in the waves, ice abrasion, materials combinations suitable for extreme cold, and providing 'hotel' power when it is dark for command, control and communications, as well as sensors and other electronics.

The AutoNaut wave propulsion system, which works much like a penguin's wings but with no muscle required, does not produce electrical or other power. But it is inherently very simple, robust and quiet, and therefore suitable for extreme environments where it is dangerous to send ships. PV panels on deck are normally used to provide hotel power. For long endurance at high latitude in winter another power solution is required. This is being explored further.

In addition to these novel technological challenges the boat itself was 'hardened' to be capable of surviving repeated capsize and pitchpoling in the famously rough Southern Ocean. Destructive drop and ice-impact tests were carried out in phase one to test newly designed rudder, struts, foils, fixing inserts, hatches, and hull parts. The 4,000 nautical mile voyage validated these improvements.

In the initial project the University of East Anglia used its ‘sea-ice chamber’ facility to test all aspects of anti-icing and the effects of extreme cold and ice abrasion on build materials and PV panels. This proving trial showed the anti-icing solution remains effectively hydrophobic after 115 days at sea. It had already had a year of environmental exposure ashore.

In phase one a method to detect small ice in big waves was identified. Work continues ashore with IR video and machine learning to inform the existing collision avoidance system.

Also in Phase 1, University of Exeter developed a pendulum motion energy harvester. This was not installed for the extension proving trial as Covid had prevented its further development. Other ways of providing hotel power such as a fuel cell were tested, and overheated in phase one, as well as state-of-the-art batteries.

In this extension trial a further reduction in available hotel power was caused by a low ‘bridge’ fitted instead of the usual sprung mast, carrying antenna, AIS, weather station, radar transponder and nav light. The thinking had been that in Southern Ocean storm seas the USV would be repeatedly capsized and pitchpoled, making a mast more vulnerable to breakage.

On this proving voyage the AutoNaut was capsized in storms several times, and the bridge was undamaged. However, in the low winter light the bridge shaded the PV panels and cut power input, and its low profile also reduced the range of AIS, radar transponder and nav light. Short sprung masts will do a better job in future.

As well as successfully verifying the technological solutions developed in phase one, the extension trial was designed to demonstrate AutoNaut’s new potential to external stakeholders.

Enter SAMS

The Scottish Association for Marine Science (SAMS) partnered and helped to develop the science program. Other stakeholders became associated in the data collection program as the project developed and the route changed. These included the Irish Marine Institute, Galway Marine Institute of Technology, OSNAP and iFADO partners, NOC, CEFAS, University of Exeter, and the UK Met Office. The data collected are made freely available to all partners.

The sensor fit for this deployment was loaned to AutoNaut, for which we are grateful. It comprised:

- ***Nortek*** *Signature500 ADCP, fitted through the hull*
- ***Seiche*** *PAM, fitted to a small fin below the hull rather than as a towed array*
- ***Aanderaa / Xylem*** *Motus wave sensor, fitted internally*
- ***SBE*** *49s CTD, loaned by UEA, fitted externally to the hull (depth not used)*
- ***AirMar*** *weather station, fitted to low bridge*

The original route plan was to be a 90-day deployment from

SAMS in Oban, following the Extended Ellett Line out to Rockall and then north towards Iceland, before transiting west some way towards Greenland, with return to Oban.

This changed as the start was delayed from May to August due to Covid impacting supply and resources. Also obtaining diplomatic clearance to collect data in the EEZ of other nations normally takes six months, and conditions were attached.

The plan then developed to follow the Ellett line to Rockall collecting data for comparison with underwater gliders and moored subsurface sensors, and then head west to the mid-Atlantic ridge where the OSNAP project (Overturning in the North Atlantic Program) has a further array of moored sensors. This mission would provide a rare opportunity to obtain contemporaneous comparable data from the surface, as well as most of the sub-surface water column. The route also had the advantage of avoiding all EEZs, and remaining at a lower latitude with more sunlight later in the year than Iceland and Greenland.

Photo: AutoNaut; Inset: GoogleMaps

On August 4, AutoNaut was towed into the Firth of Lorne by SAMS support vessel Seol Mara. All systems and sensors were working well. A watch of remote operators, largely based in Cornwall, guided the vessel via satellite, passing lighthouses, islands and the CEFAS Blackstones Wavebuoy, out into the open sea.

AutoNaut can steer a track between waypoints within a few meters of the line. A feature that was used to good effect in getting safely offshore, and later in completing repeated precise ‘hour-glass’ transects over moored acoustic sensors.

After two days an intermittent fault showed that charge from one of the PV panels was not getting through a complex charge control system to new Li batteries. Over some days this became a permanent fault. It later transpired that charge from all of the PV panels was reduced. A new configuration has since been tested satisfactorily.

The plan to run the different sensors at specific locations evolved as the voyage developed. In part due to the weather dependent schedules for SAMS and Irish partner glider deployments and moorings recovery and maintenance, and also due to the proximity of the Irish EEZ. AutoNaut only got consent to enter the EEZ as she started the first 30-km hourglass transects over Stanton Bank, right on the EEZ line. AutoNaut is grateful to the Irish Government and UK Foreign and Commonwealth Office for expediting this consent.

From Stanton the route proceeded north to S1, and another series of precise hourglass transects over an acoustic mooring, and then further north to OSNAP mooring RTEB1, on the shelf break to the Rockall Trough. At this point the lack of hotel power was becoming acute. AutoNaut was put into a holding position while the batteries slowly recharged, and clouds endlessly covered the sun.

An interrupted series of ADCP transects was completed at mooring RTEB1E, which is equipped with subsurface CTDs and current profilers. Those data are now being analyzed. The concept was for AutoNaut to collect contemporaneous surface data on currents, contributing to the study of the sub-polar meridional overturning current, which plays a significant role in Europe's weather. While it is not yet known if the datasets will be exploitable scientifically due to interruptions for recharging, they will provide valuable technical information and will allow further system improvements (for example in terms of sensor mounting, navigation system integration, operational best practices).

The decision was made to head south to obtain longer daylight and higher angles of sunlight. As AutoNaut made her way towards Ireland a replacement power management controller became available on loan from University of East Anglia's AutoNaut 'Caravela' (in for repair after being damaged in a shipping container after a successful deployment from Barbados). AutoNaut Oban was brought into Blacksod in NW Ireland, the PMC swapped out, and the boat charged up and redeployed. Data was downloaded and distributed to partners, allowing some analysis to get started early.

From Blacksod the opportunity was taken to go out 200 nm to the Irish Met Office buoy M6 on the shelf break, with a plan to zig zag down the shelf break running ADCP and PAM transects. Also, at M6 it was possible to collect wave data in a box around the buoy, to facilitate comparison of met-buoy and USV data. This could provide met offices with a zero-carbon option for collecting such data in future. Later analysis showed these wave data compare well.

Lack of hotel power, even with three PV panels working, limited the ADCP and PAM data gathering that was possible on the zig zag of transects heading south down the shelf break. The intention had been to finish by reaching out to the PAP-SO mooring in the abyssal plain, but when the batteries showed 0% it was decided to recover.

To be safe, a seagoing tug was hired from Southern Ireland, successfully recovering the AutoNaut in 4-5m waves. The USV was recharged on the journey back to Ireland while the office wrestled with Brexit import / export complications and the possibility the boat might be stuck in customs for months. It was decided to get the tug to relaunch close to the M3 Met Office buoy. With full batteries, a transect close to the M3 buoy was run with the wave sensor switched on.

Calculations indicated AutoNaut 'Oban' should make it back to Penzance in Cornwall with 10% battery in reserve. As she did, waiting offshore from St. Michael's Mount until Storm Arwen blew through, and then quietly entering the bay for pickup within a mile of the harbor wall, as if nothing had happened.

Data gathered has been distributed to partners and is being analyzed, completing the extension project in March 2022.

Lessons Learned

- The boat itself performed beautifully and arrived without a barnacle.
- The charging system produced a problem for the first time. Li batteries take more care to set up than the lead gel batteries we used to use as ballast.
- For high latitude work, and more power-hungry sensors, this confirmed we require an additional way to provide hotel power, preferably by harvesting energy on the fly.
- The sensors performed as designed. On first examination all data looks good. The wave data compares well with the M6 met buoy data, offering a possible zero-carbon option for future metrology; the PAM fin analysis showed effective baseline detections at the higher frequencies; ADCP and CTD data is good, and analysis will show whether this is a worthwhile way to collect surface data relevant to ocean currents and climate changes in future.
- Remote Operators (pilots, who can be based anywhere in the world with an internet connection) must be given a clear brief on how a particular boat is wired up. In this case the GNSS was wired in with the CTD rather than the ADCP, for which the GNSS data is required. Normally this would not matter, but when the CTD was cycled to save power that section of ADCP data was degraded too.
- 'External stakeholders' were wonderfully helpful.
- This was also a lesson in 'extreme piloting'. Remote operators found that when AutoNaut was hundreds of miles offshore they could switch off the rudder to save power and the USV would take up a course relative to the wind and waves. This could be used to advantage to reduce the requirement for hotel power. They also learned to use the heading to maximize the PV charge and prevent shadowing on the rare occasions when the sun chose to smile.

Seaeye Falcon underwater robot being deployed for inspection of the abandoned platform to become an artificial reef.

All photos courtesy EQS

FROM RIG TO REEF

Turning an oil platform in Angola into an artificial reef

Having reached the end of its service lifecycle, the Safueito Field had its Cessation of Production (CoP) in 2003 while its production well was plugged and abandoned (P&A) in 2006.

Part of the facilities will now become an artificial reef.

This project is comprised of several phases. EQS (Environmental Quality Services) is proud to have been selected by one of the most important oil and gas companies operating in Angola to lead the initial phases of the project that constitutes the first decommissioning of a platform in the African continent. It is worth noting that this activity is undertaken under the auspices of The Ministry of Mineral Resources, Oil and Gas of Angola.

EQS helps offshore energy clients navigate the complex environmental regulatory landscape including compliance, HSE subjects, and business liabilities.

In compliance with industry standards the top side is to be prepared, fitted and dismantled and taken ashore. The jacket is to be toppled and laid on its side on the seabed ready to become an artificial reef.

The overall facilities consist of an unmanned platform, a production well with its protection dome, two pipelines (4" and 8") and an umbilical.

The first phase started in 2021 by EQS, has been to collect a vast amount of baseline data concerning the condition of the infrastructure, the equipment and surrounding maritime environment.

Best Reef Location

The mission has involved a multi-disciplinary team from different companies and sectors of activity, including marine biology, hydrographic surveys, quality inspectors and personnel specialized in survey equipment such as a drone and a Saab Seaeye Falcon underwater robot.

EQS selected the Seaeye Falcon as it can handle an array of cameras, sensors, tooling and complex data gathering systems that can be easily reconfigured by the Falcon's iCON™ intelligent module-focused distributed control architecture.

Along with its camera configuration, the Falcon has been fitted with an Imagenex 881A digital multi-frequency profiling sonar.

Hydrography and Bathymetry

The objectives of the survey were to map all the underwater components, including checking the wellhead and pipelines.

The hydrography and bathymetry work included the use of three pieces of equipment: multibeam, IMU (Inertial Motion Unit) and SV (Sound Velocity) Sounder which were deployed in the vessel's moonpool structure.

General Condition & Surrounding Maritime Environment

Inspection of the platform's integrity was an important objective, mainly due to the fact it has been abandoned for several years and exposed to the mercy of the maritime environment.

Before sending personnel to the platform, it was inspected by EQS using a drone to survey the immediate area and the platform's general condition including the surrounding maritime environment.

The tripod and jacket were successfully inspected using the Seaeye Falcon. The mud mats, piles, riser and pipeline could not be inspected due to significant sedimentation. There is already significant marine growth throughout the structure and marine life is abundant.

Sampling activities

One of the objectives of this first phase was to determine the area baseline environmental condition, so water and sediment samples were taken in several stations and at different depths.

The plan called for five sampling stations around the plat-


The abandoned platform.


EQS team viewing video images from the Seaeye Falcon of the marine growth and marine animal activity at the platform.

form, the wellhead and at the artificial marine reef construction site pre-determined location.

The water samples were analyzed for pH, temperature, electrical conductivity, salinity (sodium chloride), dissolved oxygen, turbidity, radioactivity (mSv), chlorophyll, suspended matter, total hydrocarbons (TOC and TIC), chemical oxygen demand (COD), total dissolved solids, phenols, cyanides and nutrients (Ammonia, Nitrates, Total Nitrogen, Orthophosphates, Total Phosphorus). Niskin bottles were used for water collection.

Seabed sediment samples were taken using a Smith-McIntyre Grab sampler, which allowed the collection of a representative sample of the surveyed area.

The sampling activity also focused on the collection of biological matter, namely zooplankton, phytoplankton, and benthos collected using a WP-2 net.

Conclusions

The pending issues and evidence resulting from the first phase of technical and operational monitoring of the decommissioning of the Safueiro field will be addressed under the new plan already developed by EQS.

New planning is in place to continue works of the second phase, which will include the correction of some findings identified in the first phase, NORM assessment, clearing an area of fish nets, restoring platform signalling and marking, positioning of signal buoys and confirmation of pipeline locations.

The third and last phase of the decommissioning will consist of equipment removal and structural cutting of the topside.

Once the decommissioning has been completed, a series of surveys will be scheduled to monitor the evolution of marine growth on the newly created artificial reef.

SEND ROVER OVER

An illustration of the Isurus ROV monitoring an offshore wind cable lay operation.

By Celia Konowe

June 8, 2022, marked this year's United Nations (UN) World Ocean Day—as well as 30 years since the idea was proposed and 14 since being adopted officially by the UN. This year's hybrid conference highlighted the theme, "Revitalization: Collective Action for the Ocean," inspired by a global urgency to create a new, healthier coexistence. Earth's oceans are reaching a tipping point and as time passes, so do opportunities to understand the deep blue sea and mitigate the effects of centuries of misuse. The pressure of time, though, is not lost on those enamored by and dependent on the ocean; as such, research, expeditions, policy and technology have all advanced notably in recent years.

One challenge facing a healthy and plentiful oceanic future is the undeniable anthropogenic influence on the climate. Consumption, from natural resources to consumer goods, has left the planet dependent on dirty processes and commodities, as well as weighed down by mountains of lingering trash. Potential solutions for environmental crises across the board are not new, yet more needs to be done and quicker. Given that humans leave their mark wherever they go, how can positive change be implemented for the oceans need without further disturbance? The world of remotely operated and autonomous underwater vehicles (ROVs and AUVs, respectively) may yield some ideas.

FAN OF OFFSHORE WIND

Oceaneering is a Texas-based provider of engineered products and services for industries on land, in the air and in the sea. Its Subsea Robotics Program features multiple ROVs, including Isurus, a work-class vehicle for offshore wind. Isurus is designed to complete tasks in regions specific to offshore renewables, where water is shallower and currents are stronger. "Traditional work-class ROV systems were designed for deep-water environments and for operating more powerful tooling," explains Nick Rouge, Subsea Robotics program manager. "These systems struggle to maintain position in tidal currents that exceed 1-1.5 knots. Working with our clients, we identified that a hydrodynamic form factor for a work-class ROV could significantly increase its speed in water and enable projects to continue in currents exceeding 2.5 knots."

Isurus takes inspiration from Oceaneering's more traditional Magnum ROV, using its powerplant and propulsion as a base. Isurus' frame, foam block and body skins were then modified to increase hydrodynamic qualities. Additionally, Rouge shared, "We have implemented multiple high-resolution sonar systems on the Isurus to provide the required visibility to continue operations in the turbid water that is generally encountered in shallow, near-shore environments." Thanks to its design, the ROV can operate six hours longer than a traditional vehicle when tidal currents get too powerful.

Five Isurus systems operate around the world, performing tasks such as monopile installation, inter array and export cable installation, inspection and maintenance for offshore windfarms, and supporting tidal energy project installation. The ROV can reach 3000m deep, has two manipulators and is capable of operating heavy tooling. "This will become even more important as offshore wind moves further offshore with floating wind projects," Rouge said. "Isurus will be able to install and maintain the cables and mooring systems for floating wind, even in regions with strong tidal or oceanic currents."

FROM OCEAN TO CLOUD

Beyond offshore energy applications, traditional subsea and surface vessels are beginning to fall short for ocean data collection, too. Specifically, manned vehicles are being replaced by ROVs and AUVs that reduce the need for an onboard support crew—surveyors, scientists, operators, technicians—and minimize risk of anthropogenic impacts. Terradepth, another Texas-based company, is using unmanned submersibles to capture and expand sea imagery through data collection.

Ken Childress, Terradepth's chief strategy officer, shared the inspiration and technology behind their Autonomous Hybrid Vehicles (AxV), a pair of identical vessels that are capable of operating at the water's surface and underwater at the same time. "From the very beginning, what was driving the development of the AxV system was the need to augment or replace the high capital and operational costs of traditional, manned surface vessels that support deep-sea survey operations," explained Childress, citing the expense of an on-board crew. "The logical approach was to advance large-scale ocean survey using long-range, high-energy autonomous vehicle systems capable of many weeks of at-sea operations.

There are two primary features that distinguish the AxV, Childress pointed out. "First, the ability of the system to produce energy on board by air-breathing power generation while at the surface. The produced energy is stored in a battery system capable of powering the submerged operation of the vehicle and its sensor payload. Second is an on-board data network that processes various types of sensor data into readable formats and can transmit small 'snippets' of collected data to on-shore operations for validation and immediate use."

Terradepth's goal with the AxV is to collect data from the ocean and its contents using a single design vehicle. It can autonomously navigate and survey making decisions about

Terradepth Engineering team working on the recharge module of their long endurance AxV platform.

Terradepth

safety, route, data collection and data quality, plus respond to unforeseen circumstances and return to the recovery location. With the ability to integrate and power a wide array of sensors, the AxV can also collect data on and below the ocean's surface while recording accurate location information. It can operate at sea for up to 30 days at a time and perform surveys at depths of 3000m or more.

Data collection goes beyond the AxV, however, and extends to Absolute Ocean (AO), Terradepth's cloud-based, browser-accessible ocean data management platform. "Ocean geospatial data consists of high-resolution sonar imagery, bathymetric point clouds and other seafloor survey data. As these datasets are large and of disparate, incompatible file formats, managing them effectively has been difficult," Childress pointed out. To date, there has not been a comprehensive system to store, analyze and collaborate with this data. AO offers an intuitive, immersive interface for the visualization of vast high-resolution geospatial datasets and provides access to users across the enterprise.

AO can be leveraged to manage existing publicly available or customer-owned datasets, while concurrently accessing data provided by Terradepth on a subscription basis. The hope is to make interaction with vast quantities of ocean data as easy as using Google Earth to search, view and navigate ocean mapping data and related information, Childress explained.

FIN-TASTIC

As companies like Terradepth seek to better understand Earth's oceans, others are trying to actively fix problems decades in the making. Plastic pollution, in all its complexities and unknown impacts, remains a vexing problem. While governments and other organizations around the world have begun to limit plastic production, consumption and improper disposal, the problem compounds. Dutch company RanMarine has given the job of cleaning oceans and waterways to one of nature's most cunning predators—the shark.

The WasteShark, often referred to as a "Roomba for the water," is an active cleaning system that removes trash, debris and biomass by scooping up waste from the surface for onshore processing and disposal. "The idea behind it came to me back in 2011 when I was watching men in my hometown in South Africa clean plastics from water using a net and a large boat," said Founder and CEO Richard Hardiman. "I decided to find a better, cheaper way to do the job while making it easier for the water management team and operators to do their job. At that time, the technology wasn't as easy to implement on a small vessel, but I was able to create a small prototype in my garage and test it in my swimming pool."

There are two versions of the WasteShark, one manually remote controlled and another fully autonomous. The former requires an operator onshore to steer the vessel and employs LiDAR as the "eyes and ears on board," while the latter allows clients to program the vehicle through RanMarine's cloud platform. The WasteShark collects biomass and plastics in a basket framed between the two catamaran hulls, while even smaller mesh baskets can be added to collect and strain microalgae or microplastic particles. The vessel can operate for six to ten hours depending on manual/autonomous function, plus weather and water conditions.

"All our WasteSharks come with data collecting capabilities,

A WasteShark clearing biomass from canals in Schiedam.

RanMarine

both manual and autonomous," Hardiman added. "Sensors mounted onboard send the data captured back to our web portal for customers to analyze.

The WasteShark allows for different environmental sensors such as dissolved oxygen, chlorophyll, pH, nitrogen, salinity, conductivity and temperature, all coupled with the ability to match each data point to GPS and a timestamp." WasteSharks currently operates waterways in Australia, South Korea, Singapore, the U.S., Ireland, Denmark, Romania and South Africa.

A PUSH OF A BUTTON

Aside from ROVs and AUVs being technologically intriguing and inspiring, they've also become increasingly necessary in the race against time to re-establish fragile marine ecosystems, understand complex processes and reverse decades of damage, especially without further destructiveness. "Sadly, we shouldn't need this kind of technology deployed in our world at all, but it is needed," Hardiman lamented. "We like to believe that using robots and autonomous solutions helps reduce the impact of plastic waste and harmful algae on our fragile water environments in a very non-intrusive way."

The need to understand the deep blue sea holds even more importance in the face of the climate crisis as humanity struggles to protect the global environment: "The oceans are the lungs of the earth and understanding them requires the gathering of as much data as is practical," Childress said. "Autonomous vehicles, operated independent of large support vessels, can accelerate the acquisition of that data while reducing the industry carbon footprint by more than an order of magnitude."

The solution? Collective action on a grand scale, as pointed out on World Ocean Day. More specifically? Robots. What once seemed to be the hallmark of any futuristic, out-of-this-world movie has become a reality—and an effective one at that.

"Humans have done the damage, but robots are perhaps one of the solutions to mitigate and restore that impact on our planet," Hardiman said. "With many systems working in unison across the planet, we will be able to tap into vast resource data that can inform us to make better decisions in the future." As made clear on June 8, there's no lack of passion towards ocean revitalization—but this battle may be one fought by humans and robots alike.

All photos courtesy XOcean

"Stop, Listen & Think"

CTO in Focus:

One-on-One with Shepard Smith, XOcean

*From his nearly three-decade career at NOAA to hiking the Appalachian Trail, **Shepard "Shep" Smith** brings a broad base of experience and expertise to his new post as Chief Technology Officer of XOcean. We checked in with Smith for his insights on technical drivers in the ocean exploration space, as well as what to expect from XOcean in the coming years.*

By Greg Trauthwein

Shep, to start us off, please give an overview of your 28-year career at NOAA.

I was with the Commissioned Officer Corp part of NOAA. I started off in the hydrographic program assigned to the NOAA Ship Rainier up in Alaska, and we surveyed using survey launches and single beam echo sounders, as well as a 'brand new' technology – GPS – around the unexplored areas off the coast of Alaska. The next 10 to 15 years of my NOAA career was technology focused, working on integrating new technology, bringing in GIS and multibeam and database-based systems in through grided bathymetry to speed up our workflows. I also got into the charting side; and I was the chief of our charting division. I finished my career as the Director of the Office of Coast Survey and the U.S. National Hydrographer. Some of my most memorable times were the 10 years that I spent at sea, including four years as the commanding officer of the NOAA Ship Thomas Jefferson. But through it all, I was driving toward bringing new technology to improve the science and art of hydrography at sea.

Before we dive into your new role at XOcean, I'd like to get a little background on the ocean exploration market, as you see it. What technologies do you count as to have the single biggest influence on studying the oceans more efficiently, more safely, and why?

I'm going to date myself, but GPS was not widely available when I first started. We take it for granted now that we can position our sensors accurately. That used to be the biggest difficulty, and frankly, the biggest barrier of entry for people who could otherwise be helping with observations at sea. It's only been recently where you can readily combine an echo sounder and a GPS unit and get the first cut of bathymetry from almost any platform, clearly for multibeam work and more careful work. It goes up in complexity from there, but that really has opened the doors to a much broader participation from a wide variety of players and as well as the crowdsource bathymetry market.

As far as the exploration side, I'll focus on the mapping side of exploration, which is usually the first cut. First you see what's generally there, and then you start doing additional sampling with an ROV or AUV on features of particular interest. Toward the end of my time with NOAA, Dr. Alan Leonardi and I chaired what was called the National Ocean Mapping Exploration and Characterization Council, a high-level administration led project to integrate ocean mapping and exploration programs across the government to get toward the really big goal of mapping and exploring all the U.S. waters.

First we looked at what we had, then we looked at the level of effort it would take to map all U.S. waters. As your readers know, the deeper water for surface level multibeam scales resolutions goes a lot faster than the shallower water. The coverage is proportional to depth, so when you get into less than 40-50 meters of water, the pace slows down a lot.

At 200 meters and deeper, we had the technology we needed: crewed ship based multibeams. We just needed to get coordinated and get it done.

When you get into 250 meters and shallower, the level of effort goes through the roof, and we declined to even publish what we thought it would cost given current technology, because it wouldn't have made it through the vetting process within the government. You can't say numbers like that. So we said: "Well, we can get the deeper water done with current technology but we really need to lean in on improving the technology to get the shallower water mapped more efficiently."

So we spent a lot of time thinking about what that technology would look like. And, lo and behold, what it looks like is where I have now landed: where uncrewed systems can operate around the clock, often in conditions and with endurances that crewed vessels cannot be operated, with tiny frac-

tion of the environmental footprint. So the piece of work that I left undone at NOAA was "How can we get this done efficiently?" So that's really been one of my missions here at XOcean.

You might have already answered this, but what attracted you to this position with this company at this time?

Well, I mentioned the focus on being able to efficiently map shallower waters faster and cheaper in order to be able to open up new applications. The other thing is I had spent a lot of time hiking, and we're going to talk about that later, and thinking about what I wanted to do with the next phase of my career. I wanted to do something important that would have an impact on the earth. And there were really two crises that I had focused on. One of them is the climate crisis, and clearly, we need to spend a great deal of effort decarbonizing the maritime sector. And I thought that the platform that XOcean had already developed had the potential to revolutionize the way we do science at sea.

I'm a big fan of a lot of the uncrewed systems manufacturers and operators in the world, because those classes of vessels will be able to change the way we do science at sea; but we can't do it at the cost of further carbon contributions to the atmosphere. I spent about 10 years at sea, and we used about 1,000 gallons of fuel a day, with an average of about a hundred days a year sea. It's about four pounds of carbon per gallon, which comes out to 40 million pounds of carbon emitted from the ships I was on. [By comparison] it would take about 2000 years for XOcean's entire fleet to emit that much.

Well we cover the maritime, subsea and offshore energy industry closely, and it appears that all have transcended 'being green' beyond the marketing slogan only.

Both the maritime sector and the offshore energy sector are really taking this seriously. A lot of the companies that used to be oil and gas companies are now putting most of their effort into offshore wind and they're watching the carbon content, not only of their own activities, but the results of their activities and those that are contracted to them to help them. So companies like XOcean, with tiny carbon footprints, are attractive to those folks. The maritime sector is 3% of the carbon load on the earth, and that's not small potatoes.

XOcean is certainly no stranger to this audience, but for those not in the know, can you give us a brief overview of the company and the technologies that it offers?

XOcean designs, builds and operates a fleet of uncrewed surface vessels for a variety of science and engineering applications at sea. We deliver the data. So we don't sell our boats, we have only one customer for our boats and that's ourselves. We then contract with somebody to do work, to provide the platform and the sensors to be able to allow them to collect their data. A lot of it has been seabed mapping, multibeam and sub bottom profiling, a little bit of fisheries work [among others].

One big benefit is there's no personnel offshore, so we have no problem hiring as many super qualified people as we want right now. There are loads of people that have offshore experience that, for one reason or another, don't find that going offshore again works with their lives anymore. We offer a huge lifestyle benefit.

So we're able to recruit hydrographers, pilots and surveyors to work for us.

We talked about the low environmental impact, and not just the carbon, as we're no discharge by design. We can operate for as long as we want inside no-discharge zones, which is a real problem for the research fleet, particularly in parts of the U.S.

To date we have about 40,000 operational hours and we've learned a lot in those 40,000 hours. All of those lessons learned have plowed back into our technology, back into our operations, and this isn't a 'new' company anymore. We have a lot of operations, talent and experience baked into what we do.

[Our vessels are) small and light, and as a result we have this logistical nimbleness. We can deploy from a normal boat ramp and refuel at a service station, an advantage as road fuel is cleaner than marine fuel. And our survey system is all cloud based; all processing is done in the cloud, and we don't own a single server anywhere. So our surveyors can be working around the clock, we can put a lot of people on a project to get it done quickly and use all the benefits of cloud resource.

The job is still relatively new to you but stepping into the job day one, can you discuss what your priorities would be for the coming 12 to 24 months?

We're a fast-growing company, building a new boat a month right now and we expect demand to be increasing such that we'll need to do that more or less indefinitely. The other parts of the expansion [include modifications and integration of different sensors and systems to ensure] we can meet most demands from our clients. And we're looking at global expansion, too. Right now, we do most of our construction and maintenance in Greenore, Ireland, just north of Dublin. But when we start to have a significant [globally distributed] fleet, we want to be able to do [regular maintenance, upgrades and replacements] locally, so we're putting together a quality control maintenance system that goes with a global fleet.

You've had a long career and I'm sure along the way there have been many that have helped you. Can you discuss your most influential mentor?

I'm going to call out one guy, and it's hard for me because he passed away last year. Rick Brennan was like a professional brother to me. He and I were more or less the same sort of seniority coming up all the way through NOAA and we had this way of clicking, a shorthand communication, knowing how the other was reacting to a situation without any real verbal clues. Rick had talents, particularly with people. I never have been the master with people that Rick was, and he could take a vision and inspire people with it.

He had set up some really visionary ways of integrating the ocean mapping program at NOAA, not only across NOAA so that the work we are doing for safety and navigation could also work for habitat and in fisheries, but also outside of NOAA so that we could do joint projects with the USGS and [others], to be able to learn from each other and do joint projects and really take this vision to reality of getting this done. Rick, himself, had

so many mentees. I'm honored to claim that for myself as well.

I understand that you recently took some time to hike the 2000-mile plus Appalachian Trail. Can you share insights on the experience, why you decided to make the trek, what you got out of it and what you learned about yourself along the way?

I left a week after I retired from NOAA and started in Harpers Ferry, West Virginia, which is about the halfway point and hiked north from there up to Mount Katahdin in Maine and then, flipped back down to Harpers Ferry and finished southbound. So I just followed Spring all the way up, and then flipped back down and followed the Fall all the way down into the south.

It's sort of a whole lifestyle, homeless by choice, and you don't have a lot of the amenities. My pack was pretty light, a 30-pound pack, but after climbing mountains with it, you really take a harder look at [your gear and ask] "Do I really need this? I haven't used it in a week. I think I could probably get by without it." So I kept dropping weight and simplifying.

I think that process was valuable, to really think about what's important.

At NOAA I had a lot of people working for me, and I was a little bit of a public figure in my own little world. But once I got out of the trail, I didn't have any of that. So it was fun to start over [and ask]: "Who am I in this world?"

So I am a recovering scientist, and I did a little project along the way, where I recorded a sound clip every hour at the top of the hour, a 15-second sound clip, which I then analyzed for the different frequency components and mapped it up in a GIS with the help of some great folks. And that was a really neat opportunity every hour, to just stop, listen and think. [Another great part is] there are people out there of all ages, really well integrated. The 60-year-olds were hanging out with the 22-year-olds, and it was just everybody doing this thing in a very supportive environment.

The DIVE LD UUV comes with Kraken's SeaPower batteries.

Image courtesy Kraken

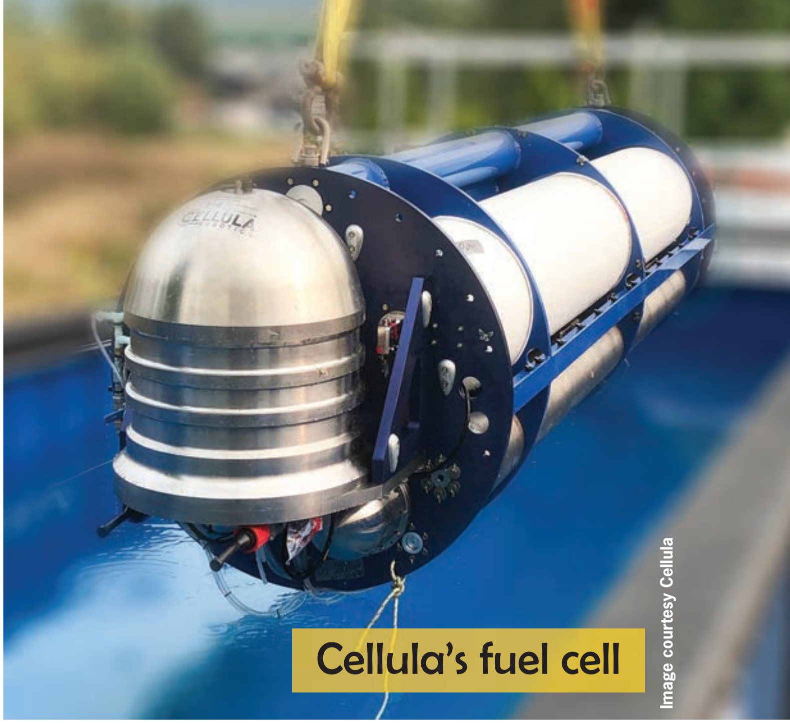
POWERING UP FOR ENDURANCE

Choice of power source for vehicles is isn't always straight forward. While electric vehicles are dominating growth in the domestic transport market, as an alternative to fossil fuel, hydrogen fuel-cell based vehicles are also out there, albeit in smaller numbers and broadly focused towards heavy duty vehicles. Power density, range, the ability to refuel and the cost and ease of access to fuel sources (as well as their climate impact) are all factors at play. Most of these factors are also at play in the autonomous underwater vehicle (AUV) space, especially for larger vehicles targeted at 1,000 km plus excursions.

By Elaine Maslin

It's a sector now dominated by lithium batteries. But as various players, including navies, look to increase endurance even further, fuel cells are also, once again, being considered. The choices might seem straight forward, but there are trade-offs, even between types of lithium battery. Choice of lithium (primary, secondary, pressure tolerant or not) or fuel cell depends on the size of AUV and your concept of operation.

"The easiest thing you could probably do in the whole world is plug in an AUV and recharge its batteries," says AUV Product Manager at Cellula Robotics. However, that means it's not working. In the commercial domain, where operations are conducted from a costly survey vessel, it's worth paying for swappable secondary cell batteries, to get vehicles straight back in the water, he says. But for long-range XLUUV type vehicles, more likely deployed from shore, where vessel time is less critical, that's not such an issue. Today, a primary cell lithium battery could get you close to 2,000 km on the AUV clock, as the UK's National Oceanography Centre recently proved with its ALR4. But fuel cells capable of 5,000 km trips are also looking attractive to some.



Cellula's fuel cell
Image courtesy Cellula

Cellula's Solur-LR UUV
Image courtesy Cellula

A bit of history

Back in the 1980s and early 1990s, lead acid, nickel cadmium and silver zinc batteries technologies were used for underwater vehicles. Using silver-zinc secondary cells, International Submarine Engineering's Theseus AUV achieved 60 hours endurance, under the Canadian defense Spinnaker project to lay fibre optic listening cables. But these batteries were either low energy (nickel-cadmium/lead-acid) or high cost and short cycle life (silver-zinc), so a hunt was on for alternatives.

Over in Norway, the Norwegian Defence Research Establishment (FFI) developed a magnesium/dissolved oxygen "seawater battery" for AUVs that enabled 1,000 miles at 4 knots. But it didn't have enough power for sensors. So, FFI developed a new concept, an 'aluminium-hydrogen peroxide' semi-fuel cell which used hydrogen peroxide with potassium hydroxide and aluminium rods. Initially, it enabled 36-hour dives.

At the time, the offshore industry was exploring deeper waters in excess of 1,500m, then 2,500m. Operators wanted a more accurate survey method than deep tow for these depths. C&C Technologies, now part of Oceaneering, decided to invest in AUVs to do the job. After considering developing its own, the company went out to the market with key attributes: 3,000m depth rating, really accurate navigation and 48-hour run-time, says Jami Cheramie, who was part of C&C from its early days and is now Subsea Robotic Product Manager – Survey at Oceaneering.


A Kongsberg semi-fuel cell in one of C&C's Hugins
Image courtesy Jami Cheramie

Hugin 2's fuel cell

Kongsberg, which commercialized FFI's aluminium-hydrogen peroxide semi-fuel cell technology into its Hugin 2, met their requirements (the Hugin 1 had 3 kWh of nickel-cadmium batteries*), upping the capacity to 48 kWh. In one of the first missions, it completed a planned three-year mapping undertaking in the Gulf of Mexico in just eight months.

"That capacity was way larger than anything else anyone could give us," recalls Cheramie. "It let us run a 48-hour dive without thinking about it." By 2005/6, using a slightly bigger vehicle, C&C was getting 78hr kWh capacity. But it came at a cost. "The logistics around hydrogen peroxide and potassium hydroxide were a problem. They're dangerous and, evidently, can be used in making crystal meth, which could add to the logistics problems."

Around the same time, lithium-ion batteries were commercialized. They didn't offer the same energy density – the same volumetric space as a 72 kWh semi fuel cell could only fit 24 kWh of lithium batteries, says Cheramie. But they were easier to use, so were soon widely adopted. Over the years, their chemistry has also improved. "We've gone from 6 kWh per pack to 8, to 12 today. So we can now carry about 72 kWh (6 x 12 kWh)," he says. "Lithium has caught up with what we were doing in 2005 and most (commercial) AUVs are now lithium based."

SeaPower

Most of the lithium battery cells actually come from the same handful of producers. What's different is how they're packaged. Some manufacturers keep their batteries housed in a watertight cannister and others have made pressure tolerant batteries. For smaller, shallower water vehicles, the latter make more sense and vice-versa.

Kraken Robotics has been doing the latter since about 2017, when it got involved in developing lithium batteries for AUVs. The 18650 lithium cells which have traditionally been used

Kraken's SeaPower batteries fitted into Ocean Infinity's AUVs

Image courtesy Kraken

in subsea vehicles (also laptops) aren't pressure tolerant, said Jeffrey Bartkowski, Director of Business Development, Kraken Sonar Systems, so require pressure housings to be used underwater. "They are small batteries, so require many connections to build capacity and therefore potentially have more places for things to go wrong," he says. "They're packed so tightly in the pressure housing to increase density that if one touches off, propagation is difficult to stop. Pressure housings require a relief valve, but if the relief valve doesn't work then you have a bomb."

Kraken's SeaPower batteries use larger pouch cells, which are pressure tolerant, and a silicone gel encapsulation technology, which eliminates the need for a pressure housing or oil compensators, reducing size, weight and cost.

"We're building batteries of 15-27 kWh ranges. Other pressure housing batteries would typically be 3, 4, maybe 10 kWh each and you would have to start stacking those up to get the capacities required." That makes sense for deep water AUVs. Pressure housing batteries make sense for lighter weight, shallow water AUVs, as below 1,000m, a pressure housing battery is probably more energy dense, says Bartkowski. However, somewhere between 1,000-3,000m, pressure tolerant batteries become more efficient.

"Typically for a larger diameter UUVs, such as DIVE LD, we'll put six batteries in and that will provide up to 1,000 km range (confirm)," he says. "We're on Anduril (Dive Technologies), Teledyne Gavia Sea Raptor, and others platforms we can't mention.

"With Kraken SeaPower batteries, we've been able to provide 80 kWh in the same volume as the manufacturer originally provided ~50 kWh as standard in a 6,000m-rated vehicle," he adds. "We turned their two-day vehicle into a four-day vehicle, just by doing things a bit differently, while cutting down on the number of connections," says Bartkowski. "The name of the game is energy density. In deep water it can take up to five hours to get down to the bottom and around the same to get back up, you'd rather be recovering your vehicle, and charging your batteries, every four or more days, than every two."

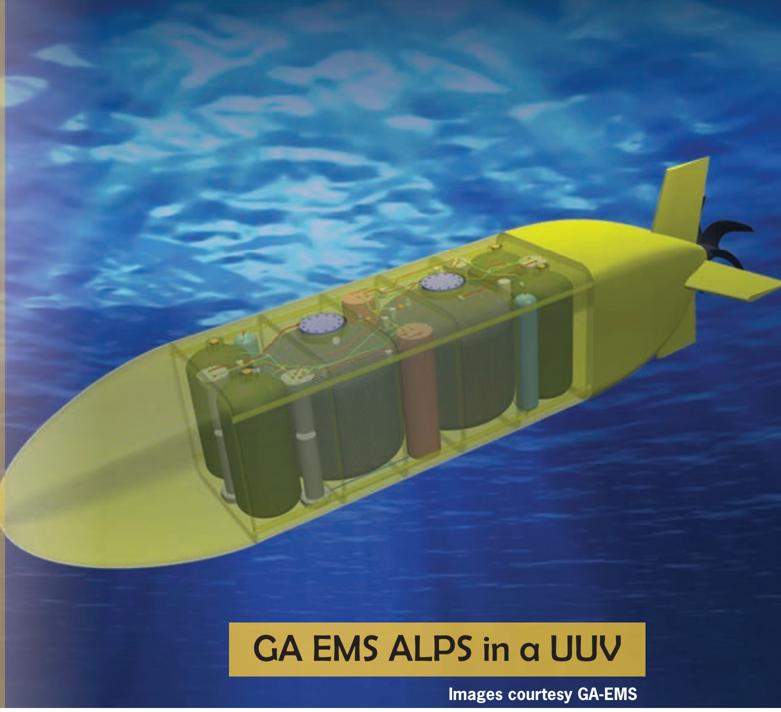
LiFT off

General Atomics Electromagnetic Systems (GA-EMS)'s offering is a Lithium-ion Fault Tolerant (LiFT) battery system that's scalable from 1 kWh to more than 500 kWh. These have been used in manned and unmanned undersea applications, says Rolf Ziesing, GA-EMS vice president of maritime programs. They were being targeted at the US Navy's Snakehead LDUUV, that's aimed at increasing endurance and range, with deployment from submarines. Driving LiFT are certain navy safety requirements that the energy system has to pass before it's considered authorised for use onboard a submarine, says Ziesing.

That's because lithium-ion hasn't been that welcome by the US navy due to an incident with a US seal delivery vehicle, which means even to today, lithium-ion batteries aren't allowed on navy ships without special permission and not at all

“Our approach is to have a safe Li-Ion battery format that would satisfy the most stringent safety requirements associated with hosting on other vehicles.”

Rolf Ziesing,
GA-EMS Vice President of Maritime Programs



GA EMS ALPS in a UUV

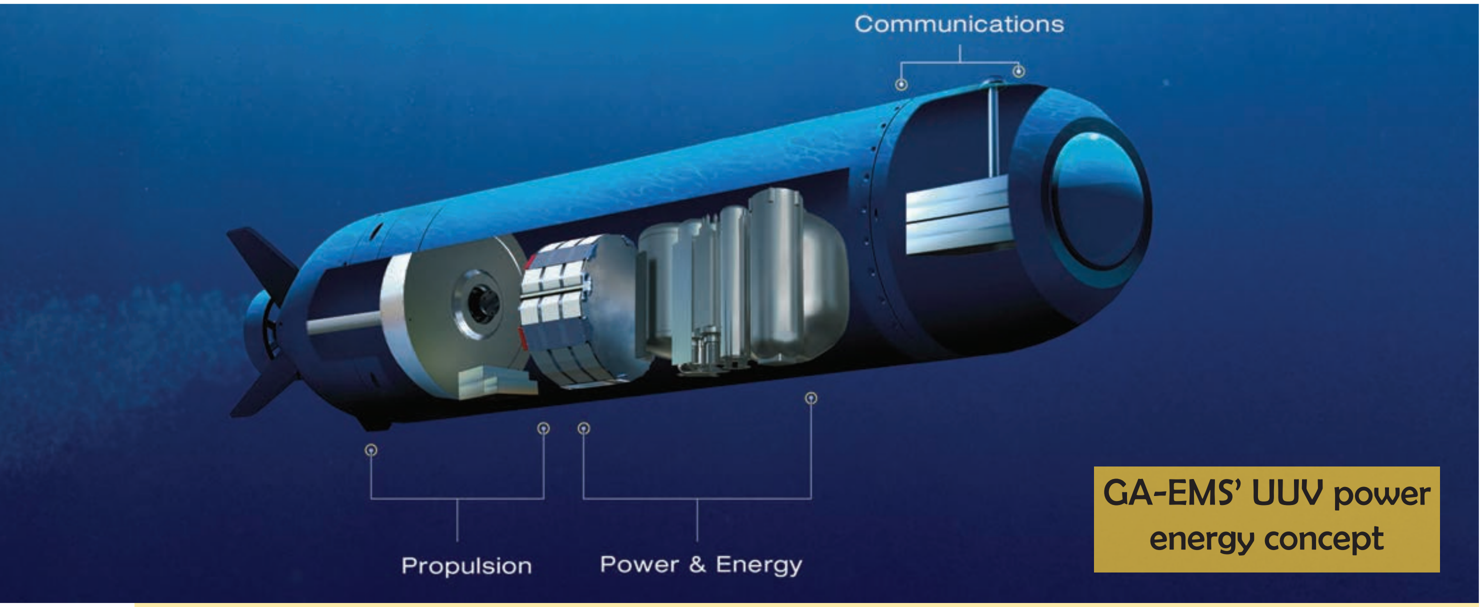
Images courtesy GA-EMS

on submarines, says Cheramie.

“Our approach is to have a safe Li-Ion battery format that would satisfy the most stringent safety requirements associated with hosting on other vehicles,” says Ziesing. “We use well characterised small format commercial cells with a layer of defence from the physical design to prevent a cascading thermal runaway failure, as well as the software to monitor the battery and ensure it always stays within a safe operating region from a thermal stand point. If there were a thermal excursion, it’s been demonstrated that the LiFT architecture can tolerate any single cell runaway event without resulting in a cascading failure. Also, using small format batteries and connecting them together, provides a lot of flexibility in terms of size and format and that has some versatility from a space usage, voltage and current (options).”

To get more power from lithium-ion today is a trade-off. Vehicles have to be bigger or battery chemistries have to be riskier. It’s about how daring you want to be, says Cheramie. Some lithium chemistries can offer higher energy density than what is commonly used today, but there are trade-offs, says Bartkowski. “The higher densities can be a little more volatile or have reduced charging cycles so may not be the best choice for subsea vehicles. Lithium batteries can be dangerous and charging on surface ships in close quarters is always a concern. Here, pressure tolerant batteries, which do not require pressure housings, can provide a much less energetic release of gases, and therefore safer mode of failure. The certification programs to bring lithium batteries on board US Navy ships are some of the most stringent in the world.”

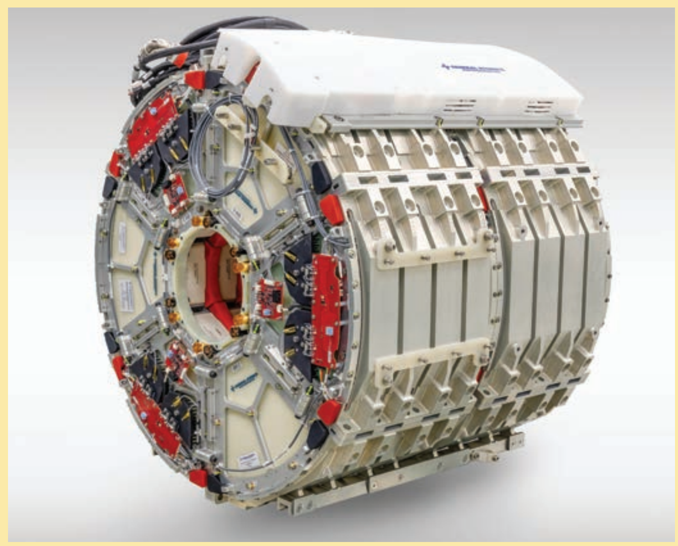
There are also challenges around procuring lithium battery cells. AUV consumers are small fry compared with electric vehicle manufacturers, so lead times can be a struggle for the industry, Bartkowski says. At the same time, cell technology, and therefore AUV batteries have benefitted greatly from developments for automotive and other commercial applications. “If they weren’t



GA-EMS' UUV power energy concept

Images courtesy GA-EMS

A HYBRID POWER SYSTEM



General Atomics LiFT Battery Modules

Another technology GA-EMS is working on is the Aluminium Power System (ALPS). "We don't make or design fuel cells, we design and make power and energy systems and look for the best fuel cell out there for the application," says Ziesing. "Aluminum has a lot of stored energy, but it's inert. We make a special aluminium alloy that allows the aluminium to dissolve in contact with water and that interaction creates hydrogen. So it's a very efficient abundant source of hydrogen. And that's really where it plays into the fuel cell energy system concept. "We have different system approaches: one approach creates high pressure hydrogen gas that can be bottled and stored. Another approach creates low pressure hydrogen on demand as the fuel cells needs it. It's a chemical reaction, so it can be turned on and off.

"In a large UUV, our approach involves the ALPS at the front end to make hydrogen to power fuel cells which would work a hydrogen-electric plant in association with LiFT batteries. The batteries could be used for larger electrical loads, like operating propulsion motors, and then use the fuel cell to recharge the battery system, so it's an air independent electrical unit. We've demonstrated meaningful durations simulating what a conceptual large UUV operation might be, on the order of many weeks, where the platform is going through different power cycles."

GA trialled the ALPS in 2019, providing hydrogen and oxygen to a Teledyne Energy Systems fuel cell which provided electricity to an ROV.

"Our objective is a hybrid electric plant that will increase power energy capability by factor of 10," says Ziesing. "So a substantial increase. Used in conjunction with other technology such as a buoyancy engine, we are designing a large UUV that will operate submerged in excess of a month and with thousands of miles of range. Our objective is to enable large UUVs with very extended submerged operations.

"Full lithium won't give you the endurance that you would get with a hybrid system. You could operate straight from the fuel cells but the hybrid system is something we're looking at. If you look at some of the larger UUVs, their power systems consist of batteries and a conventional diesel generator to recharge the batteries. The difficulty is you need air and to get air you need to surface and lose your stealth." Last year, the firm won a contract for the US navy's LD UUV (Snakehead) program, comprising motors and power systems. Snakehead seeks to launch LD UUVs from submarines, but the program has stumbled over submarine hosting interfaces.

continuing to pour money into development, we would never have access to such high capacity cells," he says.

Primary cells can also give more capacity, but have the downside that they can't be recharged. It was primary cells that the National Oceanography Centre (NOC) used on a recent trial of its Autosub Long Range 4, proving 1,700km excursion capability out of the UK, operating over five days down to 1,000km, using 74 kWh primary Lithium thionyl chloride batteries.

But there is also still more to come from Lithium, says Ziesing. "There are new advances looking at how to improve the efficiency of a lithium battery. GA-EMS is developing nano technology for anodes and cathodes in the battery, with nano size particles you can increase the surface area, and increase the efficiency and capacity in the same form factor," he says. Beyond that, non lithium batteries, such as solid state batteries, are being explored, but are further out in the development phase.

However, Bartkowski doesn't see anything replacing lithium in the near future. "I've not seen a technology that's viable to replace lithium in the next 10 years," he says.

The return of the fuel cell

There are hybrid systems that use diesel generators and batteries are used on submarines and XLUUVs, such as the 15.5 m-long Echo Voyager, allowing 6,500 nautical mile range. But for the not quite as large AUVs and where stealth is required, this isn't feasible, so fuel cells, hydrogen in particular, are becoming attractive again.

The US' Office of Naval Research (ONR) has been working actively on the idea since 2011. Spain's JALVASUB Engineering is promoting its HYCOGEN system, while Germany's thyssenkrupp Marine Systems has also developed a fuel cell, based on systems used for submarines, for its Modifiable Underwater Mothership project.

Fuels cells are attractive due their higher energy density per unit weight, says Johnson. "Once you get to medium sized and large sized AUVs, a hydrogen fuel cell is going to be significantly more efficient in terms of how much energy you can cram into the same amount of space. For the same size vehicle you can go 30-50% further with hydrogen than a battery powered vehicle. That's the big advantage and there's a lot of work being done in improving on those numbers."

Fuel cells today are often based on proton exchange membrane (PEM) technology, which transforms the chemical energy liberated during the electrochemical reaction of hydrogen and oxygen to electrical energy, as opposed to the direct combustion of hydrogen and oxygen gases to produce thermal energy. These fuel cells work by feeding hydrogen and oxygen to a polymer membrane electrolyte and platinum-based electrodes, generating electrical energy, as well as producing heat and water as by-product.

Their attraction is that the energy density of the hydrogen storage media is

Image courtesy Cellula Robotics

"Our objectives are to get to run 24 hours fully fuel cell powered mission this summer and then in the fall 1,000km mission and so forth."

Alex Johnson,
AUV Product Manager at Cellula Robotics

Image courtesy Infinity

"Our fuel cell designs are different from surface or air breathing designs in that we work on pure hydrogen and oxygen and we manage a key part of the fuel cell technology, water removal, by passive means, so there's no noise in pumping water around and no additional systems designed to circulate the oxygen."

Bill Smith,
Founder and CEO at
Infinity Fuel Cell and Hydrogen

Image courtesy Infinity

much higher than batteries. But the requirement for the fuel cell itself usually limits them to larger UUVs. For use in space or underwater, where there's not direct access to air, handling the feedstock and by-products are some of the main challenges. Broadly, they're also more complex than batteries.

"If you're looking to go less than 1,000km range, it probably doesn't make the most sense to use a hydrogen fuel cell," says Johnson. "It really shines above the 1,000km range, giving a more efficient vehicle that's more cost effective and capable than it's battery version. There are lot of AUVs that do battery operation under 1,000km quite well. So if it's a 5-6 m-long vehicle or less, it's probably not a hydrogen vehicle. For over 5-6m and 90cm diameter a fuel cell makes a lot of sense."

Johnson says Cellula's hydrogen powered Solus LR is 30% smaller than the Hugin Endurance, but both are targeting 2,000km endurance. Cellula's SeaWolf project, with the Australian navy (also called Solus XR), is even bigger (12m-long) and with more oxygen and hydrogen, to target 5,000km. "It's quite an arms race as far as 'can we go further using one technology'," says Johnson.

Cellula has been performed endurance pool tests on its fuel cell earlier this year, and it ran without issues for more than three days, says Johnson. "We're right now integrating it into the AUV to do more at-sea testing," he says. "Our objectives are to get to run 24 hours fully fuel cell powered mission this summer and then in the fall 1,000km mission and so forth."

Space – and beyond

Connecticut, based Infinity Fuel Cell and Hydrogen has been working on ONR funded programs since 2012. This has included a program with General Atomics, advancing the ALPS. Infinity's founder Bill Smith has been working on fuel cell related programs since the 1980s, including various NASA programs.

"Our fuel cell designs are different from surface or air breathing designs in that we work on pure hydrogen and oxygen and we manage a key part of the fuel cell technology, water removal, by passive means, so there's no noise in pumping water around and no additional systems designed to circulate the oxygen," he says.

"Removal of cathode water is a key issue. In conventional hydrogen air fuelled cells, you blow air through the cathode as water is produced and that removes the water through entrainment. In other hydrogen-oxygen fuel cells you circulate oxygen through the cathode, remove the water by entrainment and you separate the water from the oxygen with a separate device which might be a centrifugal separator. Those systems are more complex and noisier and that's of interest in many cases. Our system manages to remove that cathode product water by maintaining a pressure differential between the oxygen and the water collection chamber across a membrane that allows water to pass through, but resists gas passing through, in some cases up to 30 to 50 psi differential pressure, because of the pore structure inside of the material. We were able to develop that technology with NASA's help and bring it forward from a technology idea to prototypes now working to transition to products in the field soon.

"Passive water removal is the core technology and it works very well for a long period of time, it works at low power, at very high power. We've been able to operate some systems at up to 2 amps per cm squared. We still rely on active cooling systems, so we're not completely passive, but we're without having rotating gas circulation and phase separation equipment."

There are a number of considerations around fuel cells. FFI says some of the challenges are around hydrogen and oxygen storage or generation, buoyancy and trim of the vehicle, ambient conditions and other challenges that stem from operation of fuel cells in a sealed container. Like any other vehicle, there's also a cost associated with going to greater depths, where there aren't commercially available tanks, which increases the cost of engineering.

"Some of the biggest challenges are around building the infrastructure to provide fuelling for the vehicle and making sure that you have the access to hydrogen and oxygen and the pumps and whole infrastructure associated with that," says Johnson. "There are also challenges associated with ground transportation and generally people's comfort levels with hydrogen. Those are the biggest challenges we face, because it's new and different and there's perceived risk."

Ultimately, there are trade-offs with all options. Some are more brutal than others. "Fuel cells are like being in a car crash," says Cheramie. "They're more likely to happen, but you're probably not going to die. With lithium, if there's an incident it's like being plane crash. It's going to be catastrophic. That's the trade off," says Cheramie.

So, if not batteries or fuel cells, what else is there? Some suggest looking to the source Google uses for satellites; radon. Nuclear beryllium reactors was also raised – and there's a nuclear reactor on the MARS Rover. But what if you lose a UUV with nuclear on it? That's maybe for another day (or decade).

**"The alkaline aluminium/hydrogen peroxide power source in the Hugin II unmanned underwater vehicle", Øistein Hasvold), Kjell Havard Johansen, Ole Mollestad, Sissel Forseth, Nils Størkersen, Journal of Power Sources 80 _1999. 254–260.*

C-Innovation Charts its Growth Path

All photos courtesy C-I

Maintaining corporate equilibrium through business cycles is a challenge for all, but companies serving the offshore oil and gas business navigate a particularly treacherous path with many volatile and swift price swings. While C-Innovation LLC (C-I) is a relatively new company, it has deep roots as an affiliate of traditional offshore energy powerhouse Edison Chouest Offshore (ECO) and its family of companies.

Founded in 2007, on the steps of a global economic crisis, C-I has not simply maintained a steady course, it has enjoyed enviable growth in those 15 years, enduring several market booms and busts along the way.

Today the company employs more than 650 with a stable of 57 ROVs – the largest owner and operator of Schilling Robotics ROV systems in the world, with a plan to grow its business and global footprint with the addition of AUV, offshore survey, pipeline and well intervention services. The addition of these services has steadily expanded C-I's footprint on the oil and gas industry. "The past 15 years has seen multiple ROV companies come and go, while C-I has continued to grow and expand," said Bourque. The company's ROV fleet are exclusively Schilling Robotics work class ROVs, with the majority of the fleet in the 200-250hp range.

Building the Schilling Robotics ROV Fleet

According to Bourque, C-I started and remained with the Schil-

As C-Innovation celebrates 15 years in business, we caught up with ***Richard Bourque, COO,*** *to discuss how the company went from three ROVs and 25 people in 2007 to 57 ROVs and more than 650 people – with an office in Brazil and a substantial operation in Guyana – in just 15 years.*

By Greg Trauthwein

Schilling ROVs for a simple reason: "they were the most technologically advanced ROVs on the market, with a lot of enhancements and efficiencies. They're easier to operate, easier to repair, and easier to spend a long time on the bottom. We have some systems, they'll spend 40 days on the bottom, never coming up."

Bourque said overall the Schilling ROV is built to work, and while he and his team have monitored all of the new technologies and 'bells and whistles' that have come along – from automated manipulators to resident systems to remote operations to autonomous systems – "we haven't implemented a lot of it; we just gradually grow with what we have … a more user friendly system."

While the machines are dependable and user-friendly, Bourque credits his team of ROV operators as "the most advanced Schilling operators anywhere." Opting to center its ROV offering on one brand from the outset help to establish and build that team.

"Not a lot of people had Schilling Robotics experience, so we took it upon ourselves to create a training program that was very intuitive to help the team move along through the process," said Bourque. "The Schilling systems are intuitive themselves, so it was more about exposing good operators to the technology and then training them on how the system works, how to repair them."

According to Bourque, the training program progressed so well that Schilling sent some of their own people to participate

"We looked at the downturn as an opportunity for us to grow, and during that time we started our survey services, we started our pipeline remediation services, we started IMR work, and we started well intervention work."

Richard Bourque, COO, C-Innovation

in the program, too. "They built them, but once we had a few years under our belt of actually putting them into service, we knew a lot more about what they could do and what kind of adjustments could be made to make them better."

Survival is a Marathon, not a Sprint

Any growth story in any industry is impressive, but with C-I steadily growing in the offshore energy sector – one of the most volatile industries around – serves as a testament to solid corporate planning and guidance.

"We're a small, privately owned organization, and we have a small team of really smart people," said Bourque. "I think what makes us good, and what makes us constantly expand, is that we move quickly. We're not burdened with heading in a specific direction; we react to client's requirements. We look to the areas in the market that we could make better, as opposed to just trying to get bigger doing the same thing. We try to advance ourselves by doing different things."

In 2014/2015, when the oil and gas market started its steep and prolonged slump, the C-I team was driven by market conditions to adjust the way in which it earned money.

"(The downturn) hit fast, but we didn't want to stagnate, we didn't want to merge, we had no desire to do anything besides control our destiny," said Bourque. So C-I took inventory of its people, it's experience and its equipment and found new ways to deploy itself anew.

"We looked at the downturn as an opportunity for us to grow, and during that time we started our survey services, we started our pipeline remediation services, we started IMR work, and we started well intervention work," said Bourque. "We acquired a subsea engineering company, and in short we did everything to build ourselves bigger and better."

Adding AUVs to the Mix

With the price of oil booming again premised on strong global demand following two years of COVID lockdowns and more recently, geopolitical imbalance following Russia's invasion of Ukraine, Bourque sees plenty of opportunity ahead, particularly in its well intervention service and growth overall internationally, particularly in Guyana and Brazil.

Most recently C-I expanded with an offering of AUVs following a request from the market. "Kind of like we did with Schilling on ROVs, we're standardizing on Kongsberg for AUVs," and today C-I runs Kongsberg Hugin AUVs, two 4500-meter units and two 6,000-meter units, with "an additional whole Hugin or two in spare parts" to keep C-I's 24/7 operational philosophy a reality.

While the AUV fleet represents a sizable investment, Bourque doesn't see the fleet or its capabilities growing rapidly in the future, unless strong client demand or market conditions dictate.

All photos courtesy C-I

LEVERAGING UNMANNED SURFACE VESSELS TO ENHANCE THE EFFECTIVENESS OF PORT AND HARBOR SECURITY

USVs can be a powerful force multiplier in keeping up with security operations in ports and harbors.

*By **George Galdorisi**, Director of Strategic Assessments for the Naval Information Warfare Center Pacific*

All photos: Jack Rowley

When most people think of globalization, they immediately think of the international trade that has lifted hundreds of millions out of poverty over the past few decades. As a former active-duty U.S. naval officer, that is where my focus has been for most of my professional life—on the high seas. That changed in August 2020 when deadly explosions rocked the harbor in Beirut, Lebanon. However, lost among the headlines that dominated the international news for weeks, was the importance of ports and harbors to the global commerce that is the lifeblood of the economy of virtually every nation.

The critical nodes that support trade are the world's harbors. From Shanghai, to Rotterdam, to Los Angeles, to Hong Kong, to Shenzhen and to other mega-ports, as well as hundreds smaller ports, ports and harbors are critical to world prosperity. A catastrophic event could close one of these ports for an indefinite time and spill an enormous amount of pollution into the oceans.

Faced with this challenge, port authorities must ensure security twenty-four hours a day, every day. This task includes continuous inspection of port assets, threat detection and security response, ongoing surveys to ensure navigable waterways, hull inspections, and a wide-range of other missions.

The magnitude of providing comprehensive security for an average size port – let alone some of the world's mega-ports – can sometimes lure port authorities into wishing away the challenge. But in an increasingly dangerous world, ports that can be attacked via land or sea present an inviting and vulnerable target.

Today's "State of the Art" for Port Security

Today's port and harbor security measures in most ports involve monitoring the video provided by cameras throughout the port, as well as patrolling the ports' expanse of water with a fleet of manned vessels. This methodology stresses the ability of port authorities to provide around-the-clock security.

Cameras seem to offer an effective solution, but several people must monitor the video for the cameras to have any effectiveness. With some ports maintaining scores of cameras, this entails having a command center and enough watch-standers to monitor all of the cameras twenty-four hours a day.

The use of manned craft to patrol a harbor of any size comes with its own issues. Manned vessel operations are expensive, are often limited by weather and water conditions, and physically stress port professionals. For most ports, multiple manned vessels are needed to guarantee sufficient revisit.

Given the manifest challenges of providing adequate – let alone comprehensive – security for ports with current state-of-the-art systems and capabilities, it is little wonder that port officials are searching for technology solutions that will enable them to provide better security, at lower costs.

Port of Los Angeles: A Mega-Port with a Mega-Challenge

The Port of Los Angeles (POLA) is the busiest port in the United States. This mega-port comprises 43 miles of waterfront, 42 square miles of water, 26 passenger and cargo terminals and 86 ship-to-shore container cranes. POLA handled over ten million twenty-foot equivalent units (TEUs) of cargo last year.

Current capabilities to secure the Port of Los Angeles involve monitoring the video provided by five hundred cameras throughout the port, as well as patrolling the ports' expanse of water with a fleet of manned vessels. This methodology is increasingly expensive and does not provide comprehensive security. For these reasons, Port of Los Angeles officials had a mandate from a number of stakeholders to explore the

All photos: Jack Rowley

possibility of using unmanned surface vehicles to enhance the security of the port.

To search for a solution, the port invited Maritime Tactical Systems Inc. (MARTAC) to visit and demonstrate the capabilities of their MANTAS unmanned surface vehicle. One of the primary reasons that the Port of Los Angeles requested the MANTAS system demonstration was the fact that MANTAS had performed well in a port security evaluation conducted by the U.S. Army. Three MANTAS T-series vessels were part of the Army's Mobile Ocean Terminal Concept Demonstration in Concord, CA.

MANTAS is a high-performance USV built on a catamaran-style hull, and comes in a number of variants ranging in size from six-foot to 50-foot. The POLA demonstration was conducted with a 12-foot MANTAS (T12). MANTAS can be equipped with a wide variety of above-surface sensors and below-surface, as well as other devices such as chem/bio/nuclear sensors, water quality monitors, and above/below surface environmental sensors.

MARTAC representatives provided a comprehensive briefing on MANTAS capabilities, examined the span of POLA authorities' operations, and provided a remote demonstration where POLA officials controlled MANTAS operating off the eastern coast of Florida. The demonstration provided POLA stakeholders with an understanding of how a USV could enhance port security.

POLA officials and the U.S. Coast Guard asked MARTAC Inc. to consider providing larger USVs for the port and harbor security role, since a larger unmanned maritime vessel could carry more sensors and stay underway for a longer period. MARTAC engineers did just that, and a 38-foot, T38 Devil Ray, was built and was demonstrated during a number of U.S. Navy exercises, as well as during a port and harbor security demonstration for the Port of Tampa.

Enhancing the Effectiveness of Port and Harbor Security

The enhanced port and harbor security methodology described in this article has not been evaluated previously, and there is a reason. The technology to provide reliable, adaptable and affordable USV support to augment manned capabilities and expand the reach of port security officials at facilities such as the Port of Los Angeles and Port of Tampa simply did not exist just a few years ago. But that has now changed.

This technology is available today with commercial off-the-shelf unmanned surface vessels, and these can be employed to

All photos: Jack Rowley

increase the effectiveness of port protection. Given the enormous personnel costs associated with monitoring cameras and patrolling with manned vehicles, this innovative solution designed to supplement current capabilities will drive down life cycle costs.

This POLA demonstration and subsequent Port of Tampa validation certified that commercial-off-the-shelf unmanned surface vehicles can ably conduct a comprehensive security inspection of a mega-port. As the world continues to come to grips with the human and economic impact of the Beirut harbor disaster, all nations would be well-served to leverage emerging technology to enhance the security of the ports and harbors that make the global economy hum.

About the Author

George Galdorisi is Director of Strategic Assessments for the Naval Information Warfare Center Pacific. He enjoys writing, especially speculative fiction about the future of warfare. He is the author of fifteen books, including four New York Times bestsellers.

Hybrid Research Vessel

Snow & Company in Seattle, Wash., started construction on a 15m hybrid, Incat Crowther-designed catamaran research vessel for operation by the Pacific Northwest National Laboratory. The vessel's 28 sq. m. main deck is equipped with an A-Frame, boom crane and movable davit in addition to access to a foldable swim platform, extracting maximum functionality from the space. A set of stairs offer direct access from the main deck to the upper deck and flybridge, which affords excellent all-round visibility. The vessel can support the research of six scientists in a tailored layout containing multiple research workstations and convertible sleeping arrangements, providing PNNL a capable platform to efficiently carry out their research. It will be powered by an advanced parallel hybrid-electric propulsion system, consisting of two Volvo Penta D8-510 main engines, capable of producing 374kW each, supplemented by two Danfoss Editron EM-PMI375-T200-2600 motor-generators. Power is stored using a Spear Trident battery system.

Glosten Designed RV for KAUST

King Abdullah University of Science and Technology (KAUST) selected Glosten to design a new ship for Red Sea research. The new oceanographic research vessel (RV) will replace the existing RV Thuwal, designed to bring advanced research capabilities for work in both shallow reef and deep-water environments with a reconfigurable deck for multipurpose jobs and equipment and weather hardy traits for managing the unique conditions of the Red Sea. The existing ship for KAUST is nearly 22-years-old, originally designed as a fishing vessel for navigating the coastal waters of Australia. This ship has served KAUST scientists for as many as 220 days at sea per year since 2013. However, the retrofitted 34.7-meter long Thuwal is limited in the tasks and sea conditions it can manage, and as KAUST expands its research ambitions for studying the Red Sea, a robust vessel with optimal functionality is required. The Glosten-designed ship will offer custom designed features to meet a broad range of oceanographic missions, including seawater, sediment, and biological sampling to the full depth of the Red Sea, approximately 3000 meters.

At 50m long, the vessel will be significantly larger and offer a greater range of operational capabilities. The deck will be designed to deploy heavy equipment and sophisticated instrumentation for multiple disciplines, including geoscience, bioscience, marine science, and oceanographic research interests. The RV will be equipped with an advanced positioning system to enable deployment of long-duration remote and autonomous vehicles as well as geoscience sampling systems.

SEA-KIT: New H-class USV for Ocean Survey

SEA-KIT International unveiled a new USV design that focuses on hydrography and environmental data collection. The SEA-KIT H-class USV, with its retractable gondola and dual sensor deployment options, is a configurable design based on data and feedback collected from its X-class USVs.

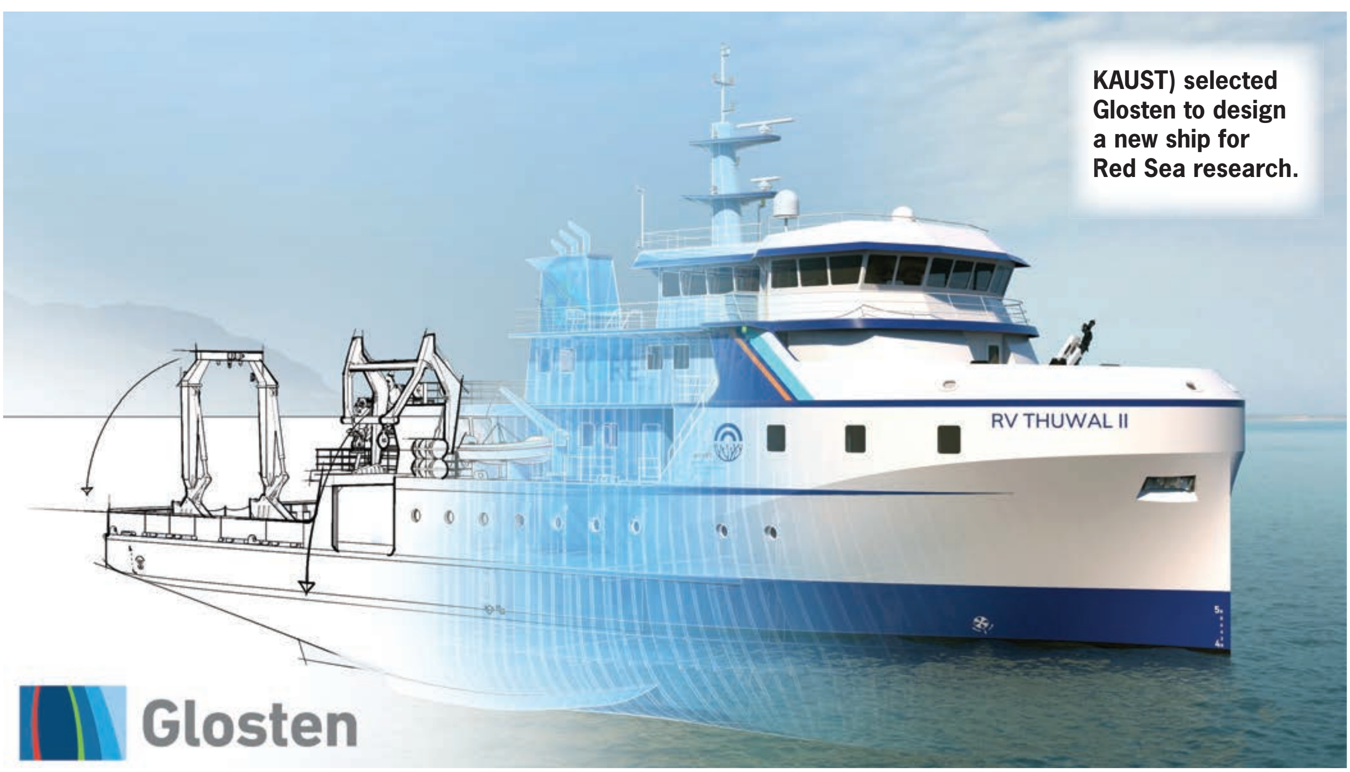
The H-class features a composite hull to enable greater

Snow & Company in Seattle has started building this Incat Crowther design hybrid research vessel.

Incat Crowther

Did you know?
The name “Argus” comes from Greek mythology, “a giant with a hundred eyes.”

Image Courtesy Argeo



KAUST) selected Glosten to design a new ship for Red Sea research.

Image Courtesy of Glosten

range and endurance, as well as active stabilizers to minimize roll. The new design has 12m and 15m variants, with the 12m version transportable in a standard shipping container for rapid, low-cost deployment.

Both variants can be davit launched.

The H-class USV can accommodate a range of sensors as well as deploy a tow cage, SVP, MAPR, CTD and side scan sonar for deep-water and nearshore bathymetric and hydrographic survey missions. The vessel includes a Multibeam Echo Sounder (MBES), station holding and winch-deployed sensor payloads for versatile ocean survey capability.

SEA-KIT's H-class USV is designed to MCA Category 0 for extended, over-the-horizon capability and will hold Unmanned Marine Systems (UMS) certification from Lloyd's Register as well as Lloyd's Register approval for design and hull construction.

Argeo Argus Launched

Argeo launched its first uncrewed, remotely supervised survey and inspection vehicle dubbed Argeo Argus. The Argus USV (Uncrewed Surface Vehicle) will conduct mapping and inspection services using robotics and autonomous ocean space technology for offshore and energy projects in water depths from 2 to 200 meters.

"Investments in the offshore energy sector are growing at a massive rate. The Argeo Argus is a major breakthrough in commercial uncrewed solutions for the offshore energy sector," said Trond Crantz, CEO, Argeo. "We believe Argeo Argus is the perfect match for developers in this market segment. The demand for mapping & inspection services is increasing and we expect that offshore wind will be an important business segment for years to come."

Argeo, and many others across the offshore energy sector, are banking on continued vibrant activity and outlook for the offshore wind market. "Yearly global spending on offshore wind will double to more than $100 billion in 2030. The demand for accurate mapping the oceans, will increase rapidly. Argeo Argus uses state-of-the-art sensors and robotics which gives the best possible data resolution in the market today," said Crantz.

Argeo Argus is a multi-purpose uncrewed vehicle for offshore and coastal applications, designed to offer a stable, low emission hybrid platform equipped with advanced navigation, supervision, and hydrographic and geophysical technology.

It was built at Maritime Robotics in Trondheim, Norway, in close collaboration with Argeo. Argeo currently owns and operates four AUV's, two Hugin AUV's (Autonomous Underwater Vehicle) and two Sea Raptor AUV's.

SEA-KIT unveiled a new USV design that focuses on hydrography and environmental data collection.

Image Courtesy SEA-KIT International

The Quest to the after effects of the Tonga Eruption

Tonga Eruption Discoveries

A remote underwater glider used to gather data from the water column surrounding the underwater volcano.

New findings from the record-breaking Tongan volcanic eruption are "surprising and unexpected," according to scientists from New Zealand's National Institute for Water and Atmospheric Research (NIWA).

NIWA's research vessel, RV Tangaroa, recently returned from a month-long expedition as part of the Nippon Foundation-funded Tonga Eruption Seabed Mapping Project (TESMaP), where scientists were studying the effects of January's eruption of Hunga Tonga–Hunga Ha'apai (HT – HH).

Due to the power of the explosion, researchers expected to find dramatic changes to the volcano, but instead found it largely intact.

The research is also supported by The Nippon Foundation-GEBCO Seabed 2030 Project which aims to map the world's ocean floor by 2030. NIWA mapped 22,000 sq. km of the surrounding seafloor, which showed changes covering an area of 8,000 sq. km.

NIWA scientists recorded up to seven cubic kilometres of displaced material, but there is likely more yet to be seen. Tonga's domestic internet cable that was broken and cut off communication is buried under 30m of ash and sediment.

The voyage leader, NIWA marine geologist Kevin Mackay, says that he was completely taken aback by what they first saw. "With an explosion that violent – the biggest ever recorded – you would expect that the whole volcano would have been obliterated, but it wasn't. While the volcano appeared intact, the seafloor showed some dramatic effects from the eruption. There is fine sandy mud and deep ash ripples as far as 50 km away from the volcano, with gouged valleys and huge piles of sediment."

The team also studied impacts on the ecosystem. The volcano is devoid of biology, but remarkably there are features as close as 15 km away that still have abundant and diverse populations of fish and other animals. Scientists speculate that they escaped impact by being out of the eruption flow's pathway, or far enough away to avoid thick ash fall.

NIWA also tested the water column for physical and chemical characteristics, including temperature, nutrients, and oxygen concentration.

Preliminary data shows that the water column is still recovering, and some airborne ash is yet to completely settle on the seafloor. There is also evidence that the volcano may still be erupting, with a dense ash layer found in the upper water column near the volcano.

NIWA biogeochemist Dr. Sarah Seabrook says the persistence of ash they saw in the water column has a myriad of impacts on the ocean ecosystem. "In the immediate aftermath of an eruption, volcanic ash fertilises microscopic ocean algae thanks to the ash's concentration of nutrients and trace metals - in this case, there was a bloom of life so big that we could

Left: Biochemist Dr. Sarah Seabrook.

Right: Voyage leader and marine geologist Kevin Mackay.

Photo credit: NIWA-Nippon Foundation TESMaP / Rebekah Parsons-King

Photo credit: NIWA-Nippon Foundation TESMaP / Rebekah Parsons-King

see it from space.

"However, the unexpected persistence of the ash in the water column is creating prolonged impacts. For example, spikes in volcanic ash were coupled to the appearance of oxygen minimum zones – where oxygen levels in the water are at their lowest – which could have implications for important services provided by the ocean, such as food production and carbon sequestration."

Scientists also collected hundreds of samples during their mission, including seabed cores, various corals and 250 kilograms of rock, some of which were newly formed from the eruption.

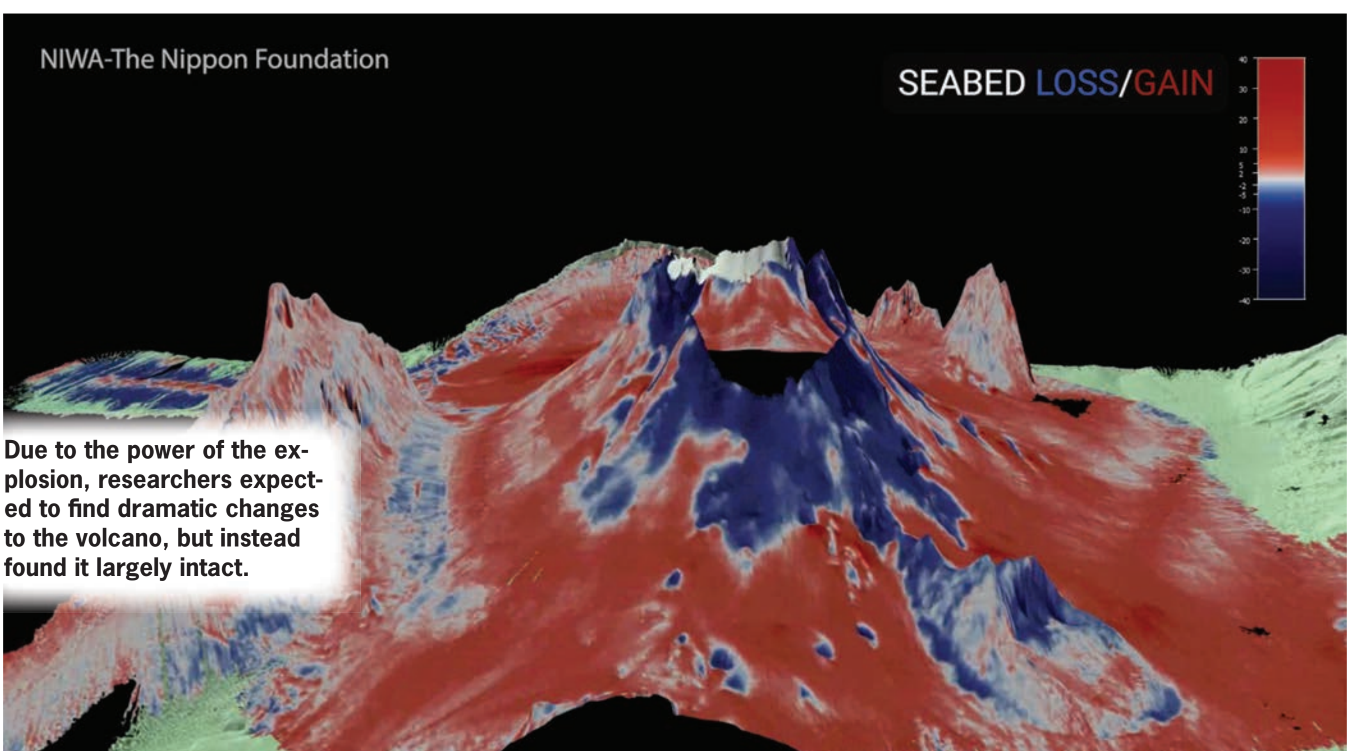
Fisheries are a vital part of Tonga's economy and subsistence, with species such as snapper and tuna being key to the region. There has been a reduction in some of Tonga's fleet, with many boats damaged in the tsunami which followed the eruption. Rebuilding the fleet is the highest priority and it will be a while before it is fully understood how fisheries have been impacted.

The mission has also given important insight into the fate of the broken domestic internet cable, with strong indications that this will need to be fully replaced.

The Nippon Foundation's Executive Director Mitsuyuki Unno said "This project is being conducted in the hope that understanding the effects of the volcanic eruption will contribute to the recovery of Tonga, where the sea is an important resource, and to the disaster preparedness of many countries, including Japan."

The second part of the TESMaP mission will see the caldera mapped by a SEA-KIT International uncrewed surface vessel (USV). The caldera was unable to be surveyed during NIWA's voyage because of safety reasons.

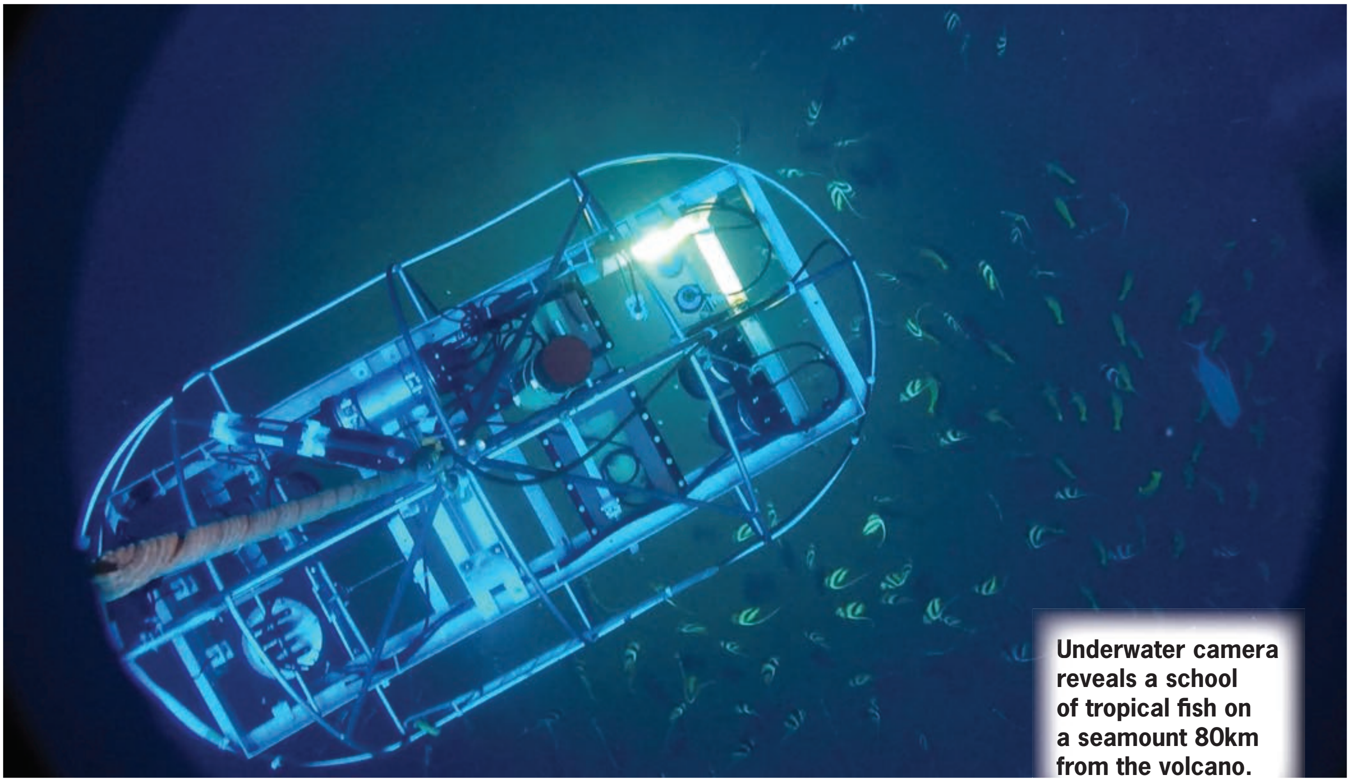
The unmanned part of the research mission to study the caldera is expected to be completed in mid-July.



Due to the power of the explosion, researchers expected to find dramatic changes to the volcano, but instead found it largely intact.

Photo credit: NIWA-Nippon Foundation TESMaP / Rebekah Parsons-King

The Quest to the after effects of the Tonga Eruption



Underwater camera reveals a school of tropical fish on a seamount 80km from the volcano.

Photo credit: NIWA-Nippon Foundation TESMaP / Rebekah Parsons-King

Researchers collect water samples from the CTD.

Photo credit: NIWA-Nippon Foundation TESMaP / Rebekah Parsons-King

MARINE TECHNOLOGY REPORTER

2022 Editorial Calendar

January/February 2022

Underwater Vehicle Annual

- Underwater Defense
- Manipulator Arms and Tools
- Autonomous Navigation GNSS MEMS
- Unmanned Vehicle Propulsion
- IMR: Offshore Inspection, Maintenance & Repair

Event Distribution:
Subsea Expo
February 22-24 Aberdeen, Scotland

Digital Edition

MTR E-Magazine Edition: Oceanographic

Special Report on Coastal Zone Management

March/April 2022

Oceanographic Instrumentation & Sensors

- Fiber Optic Cables, Connectors & Slip Rings
- Buoyancy Technology
- Environmental Testing Equipment
- Underwater Communications
- Underwater Battery Technology

Event Distribution:
Oceanology International:
March 15-17, London, UK
IPF:
April 26-28, Atlantic City, NJ

May/June 2022

Offshore Energy: O&G & Renewables

- Hydrographic Survey Sonar
- Sonar, Telemetry & Data Processing Software
- USV, ROV & AUV Platforms
- GPS, Gyro Compasses & MEMS Motion Tracking
- Interconnect: Underwater Cables & Connectors

Event Distribution:
OTC:
May 2-5, Houston, TX

July/August 2022

Autonomous Vehicle Operations

- ROV Technology: Work Class to Micro Systems
- Thruster Tech: Underwater Propulsion
- Underwater Tools & Manipulators
- Scientific Deck Machinery

Event Distribution:
MATE ROV Competition:
July 2022

Digital Edition

MTR E-Magazine Edition: Hydrographic

Special Report on Offshore Wind Field Surveys

September/October 2022

MTR100: Focus on 100 Leading Companies, People and Innovations in the Subsea Space

Event Distribution:
Oceans 2022:
October 17-21, Hampton Roads, VA

November 2022

Ocean Observation: Gliders, Buoys & Sub-Surface Networks

- Acoustic Doppler Sonar Technologies ADCPs and DVLs
- Instrumentation: Profilers, Samplers & Sediment Corers
- Fresh Water Monitoring & Sensors
- Seafloor Mapping
- Geospatial Software Systems for Hydrography
- Underwater Imaging: Lights, Cameras, Lasers & Multibeam Sonars

Digital Edition

MTR E-Magazine Edition: Subsea Vehicles

Special Report on Autonomous Defense Vehicles

Tech Files

Innovative new products, technologies and concepts

Armach Hull Services Robot

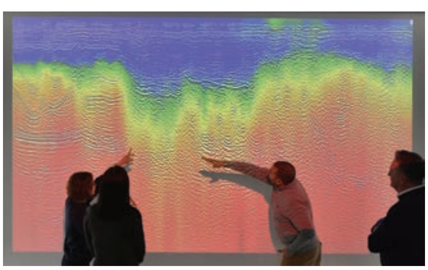
Armach Robotics, a spin-off company from Greensea, has unveiled its first post-prototype Hull Service Robot (HSR).The HSR is man-portable at under 66 lbs (30kgs) and around 34 inches (86cm) long. For the HSR Armach designed and is producing the electro-mechanical drive and cleaning components in-house because it needed not only high power-density and unique packaging but also precision control and feedback. This bespoke approach pays dividends when it comes to in-water usability and control, along with the quality of the hull data fed back.

Deepwater Hydrate Detection

TSC Subsea's ART vPush is designed to provide hydrate detection. The tool uses TSC Subsea's ART technology on a moving platform to rapidly assess pipeline contents over complete pipe runs. Data is collected in real time and processed with several algorithms to monitor signals from the far end side of the pipeline which detect if hydrate is present. Typically deployed via ROV manipulator, it can also be fitted directly onto an ROV and has a depth rating of 3,000 m. Common applications include detection of, or screening for, hydrate in subsea pipelines and wall thickness measurements on subsea pipeline.

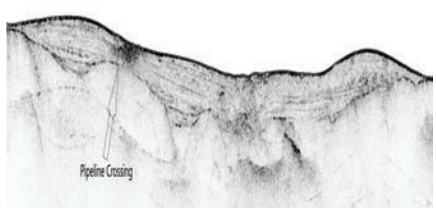
WolfFish

Arctic Rays LLC has unveiled its most powerful continuous LED light yet: WolfFish. The multichannel, ultra-high-output LED torch light sets a new bar for the compnay with configurable combinations of colors for specialized uses as well as the one-two-punch of wide-flood and focused-beam light, all in a single 6,000-meter-rated housing. According to the company, early adopters are finding WolfFish's dynamic abilities can suit a variety of missions, from blue-chip film making to heavy ROV and everything in between.



Seismic Data Processing

STRYDE has launched its new fast-track seismic data processing service for high-density surveys. In addition to offering its disruptive nodal technology to acquire seismic safely and affordably, STRYDE complements its solution with data processing of high-density datasets acquired from nodal technology to further cement its position as the go-to provider of affordable land seismic equipment and services for the energy market and beyond.

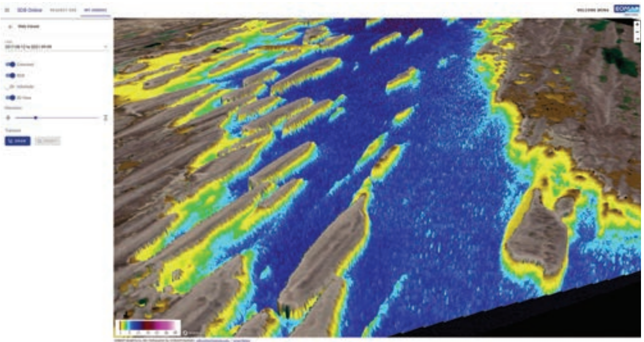


Sub-Bottom Pipeline Survey

EdgeTech added a new feature to the 2050-DSS combined sub-bottom profiling and side scan sonar system: a new Pipeline Survey Mode with the ability to select a smaller hydrophone sub-array enabling a larger fore-aft beamwidth and faster transmission rate. The 2050-DSS systems use a flat multi-channel Polyvinylidene Fluoride (PVDF) hydrophone array. The 2050-DSS also boast a tri-frequency side scan sonar, where any two frequencies can be operated simultaneously. The towfish can be fitted with either a 120, 410 & 850 kHz or a 230, 540 & 850 kHz arrays along with a 2-16 kHz sub-bottom projector..

T500 Thruster

Blue Robotics announced the T500 Thruster., an underwater thruster that produces 16 kgf (35.5 lb) of thrust and can be used on remotely operated underwater vehicles (ROVs), unmanned surface vessels (USV), unmanned underwater vehicles (UUVs), and human-carrying vehicles like kayaks and stand-up paddleboards. The T500 Thruster uses the same patented flooded brushless motor design that enables the T200 with newly added performance improvements and ruggedness. Blue Robotics is initially offering the T500 Thruster through limited pre-orders with shipments expected to start in July 2022 at a price of $690 each.



3D visualization by SDB-Online of coastal area in northern Canada - © EOMAP

Shallow Water Survey from Space

SDB-Online is the new cloud-based WebApp to create high-resolution bathymetric grids for shallow waters. This builds on EOMAP's experience in Satellite-Derived Bathymetry (SDB). With SDB-Online, coastal engineers, surveyors, modellers or scientists can create high-res bathymetry grids 24/7, from the comfort of their desks. "Experts managing or studying coastal shallow waters will experience an incredible time and information gain: Within minutes they can trigger automated processing routines and receive high-res bathymetry data for their projects", said Mona Reithmeier, SDB-Online manager and SDB expert at EOMAP. EOMAP's SDB allows users to calculate water depth data by inverting sunlight's way through atmosphere and water, harnessing multispectral satellite imagery. On SDB-Online, this complex process is now running automatically – basically in four steps: Once the user has accessed SDB-Online via their browser, they define an area of interest anywhere on Earth using the map. A – manual or AI trained – image selection process starts and is linked to satellite data archives of the European Space Agency (ESA). Following that, the physics based SDB analysis creates the gridded bathymetry surface that align with ISO and OGC standards. As an option, QAQC processes by EOMAP's data analysts or seafloor classification can be added.

Mona Reithmeier, SDB-Online Manager, EO Data Analyst, EOMAP.

Balmoral Group

Sir James S Milne

Balmoral Group's Milne Receives Knighthood

Jim Milne, chairman and managing director of Balmoral Group, is now officially Sir James S Milne CBE, DL, DHC, Hon DBA, Hon FRIAS, was awarded the honor of Knight Bachelor in the Queen's Birthday 2022 Honors List for services to business and charity. "For as long as I can remember I have strived to be the best I can be and, I think, have encouraged others to do and think the same way," said Milne. "I am very fortunate in that I have been surrounded by a loving family all my life and they have given me the strength and freedom to pursue my commercial, charitable and personal dreams." Sir James is often quoted as saying that he hasn't come a long way in life, as his company's corporate headquarters are located less than a mile from where he was born and brought up on the family farm, just outside Aberdeen city at that time.

Like all business people, he has experienced numerous highs and lows, both on a commercial and personal level and, somehow, has always bounced back. "You can draw your own conclusions from this", he says. "You might think I'm either a genius, completely mad or, perhaps more realistically, somewhere in the middle."

He is a firm believer that the way to get on in life is to take calculated risks, make mistakes and learn from them - and admits to making quite a few in his time.

Sir James continued: "I do believe, however, that I was a born entrepreneur; growing lettuce and mushrooms; buying, renovating and selling cars while at school before acquiring an 84 x 21ft ex-RAF hut from Kinloss to start up my first glassfibre manufacturing operation on the family Home Farm of Tullos."

Nowadays, Balmoral Group operates from a 45 acre site in Aberdeen and has engineering and manufacturing facilities in Newcastle, South Yorkshire and South Wales, all run by dedicated and committed individuals which he feels is so important.

Sir James is joint founder and chairman of Friends of ANCHOR, a charity established in 1997 that supports Aberdeen's cancer and haematology care unit, as well as financing many groundbreaking research programmes.

"I am very proud of the charitable work that I have been fortunate enough to be involved in around the world. This is not something that I normally comment on but I have to mention Friends of ANCHOR.

"Since 1997 Balmoral has funded all the fundraising team and administrative costs of Friends of ANCHOR. The charity, in its 25th year, is on course to reach a record project target of £2m that will help make the difference in Aberdeen's new cancer care centre due to open in 2023. This is an absolutely fantastic effort by the FoA team and their volunteers."

He will turn 82 years of age this year so it's been quite a journey for the boy that left school at 14 with no qualifications and the youngest of nine of a family.

Greensea

Greensea Names Allen VP Ops

Ashtead Technology

Greensea Names Allen VP Ops

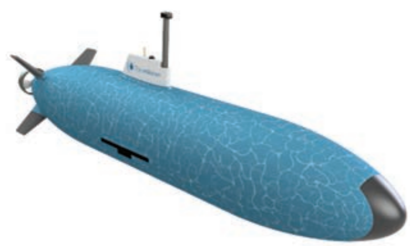
Scantrol

Greensea Names Allen VP Ops

Greensea, announces the promotion of Chelsea Allen to Vice President of Operations in response to the company's ongoing growth and subsequent strategic management and operational needs. Allen joined the company in 2018 as Production Manager and quickly became a key member of the Greensea team before being appointed to her new role. She has been instrumental in positioning Greensea to become one of the leaders in ocean robotics by providing program management to Ocean Infinity's Armada fleet and overseeing production of the RNAV2 diver navigation systems. As VP Operations, she is responsible for software and hardware production teams as well as the quality and documentation teams which represents more than 50% of Greensea's workforce.

Ashtead Appoints Middleton

Ashtead Technology appointed Phil Middleton as Survey and Robotics Director. Middleton brings a wealth of experience to the role having held various senior positions in the subsea technology sector, most recently with MacArtney Group where he was UK Managing Director. Prior to that, Phil was Group Managing Director at Seatronics, a post he held for over five years during his 17 years with the business.



ThayerMahan

MSubs Ltd underwater vehicles & equipment

MSUBS, ThayerMahan Team on 'Minke' LDUUV Development

MSUBS, a UK builder of manned submersibles, unmanned submersibles, and unmanned surface vessels and ThayerMahan, a U.S. builder and operator of remote and autonomous undersea systems and sensors, will team on project; a large diameter unmanned underwater vehicle with multiple capabilities to support customers in government, industry, and academia.

XOCEAN Acqires Geomara

XOCEAN completed the acquisition of Geomara, a specialist hydrographic survey company, as part of its strategic global growth plan. For more than 15 years, Geomara has been providing expert advice and services to a large variety of clients across the marine industry including Renewable Energy developers. Having tripled its revenue for two consecutive years, XOCEAN is developing a reputation within the ocean data market, and is accelerating this growth as the business scales. The company has tripled its headcount to 150 over the past 12 months and plans to grow it further to 300 over the next 18 months.

The company uses its proprietary marine robotic technology to collect ocean data sustainably across a range of industries including Offshore Wind.

Scantrol AHC for Electric Winches

Scantrol AS announced a new cooperation with C-LARs LLC, a Texas based manufacturing company, for the supply of control systems including Active Heave Compensation (AHC). Scantrol is an independent supplier of monitoring and control systems for the marine business. C-LARs, LLC is an ISO-9001:2015 certified manufacturer of custom engineered industrial equipment that serves a global client base, including aerospace, oceanographic, military, government, and commercial users.

Healthy planet needs 'ocean action' from Asian and Pacific countries

By Armida Salsiah Alisjahbana

As the Second Global Ocean Conference opened recently in Lisbon, governments in Asia and the Pacific must seize the opportunity to enhance cooperation and solidarity to address a host of challenges that endanger what is a lifeline for millions of people in the region.

If done right ocean action will also be climate action but this will require working in concert on a few fronts.

First, we must invest in and support science and technology to produce key solutions. Strengthening science-policy interfaces to bridge practitioners and policymakers contributes to a sound understanding of ocean-climate synergies, thereby enabling better policy design, an important priority of the Indonesian Presidency of the G20 process. Additionally policy support tools can assist governments in identifying and prioritizing actions through policy and SDG tracking and scenarios development.

We must also make the invisible visible through ocean data: just three of ten targets for the goal on life below water are measurable in Asia and the Pacific. Better data is the foundation of better policies and collective action. The Global Ocean Accounts Partnership (GOAP) is an innovative multi-stakeholder collective established to enable countries and other stakeholders to go beyond GDP and to measure and manage progress towards ocean sustainable development.

Solutions for low-carbon maritime transport are also a key part of the transition to decarbonization by the middle of the century. Countries in Asia and the Pacific recognized this when adopting a new Regional Action Programme last December, putting more emphasis on such concrete steps as innovative shipping technologies, cooperation on green shipping corridors and more efficient use of existing port infrastructure and facilities to make this ambition a reality.

Finally, aligning finance with our ocean, climate and broader SDG aspirations provides a crucial foundation for all of our action. Blue bonds are an attractive instrument both for governments interested in raising funds for ocean conservation and for investors interested in contributing to sustainable development in addition to obtaining a return for their investment.

These actions and others are steps towards ensuring the viability of several of the region's key ocean-based economic sectors, such as seaborne trade, tourism and fisheries. An estimated 50 to 80 per cent of all life on Earth is found under the ocean surface. Seven of every 10 fish caught around the globe comes from Pacific waters. And we know that the oceans and coasts are also vital allies in the fight against climate change, with coastal systems such as mangroves, salt marshes and seagrass meadows at the frontline of climate change, absorbing carbon at rates of up to 50 times those of the same area of tropical forest.

But the health of the oceans in Asia and the Pacific is in serious decline: rampant pollution, destructive and illegal fishing practices, inadequate marine governance and continued urbanization along coastlines have destroyed 40 per cent of the coral reefs and approximately 60 per cent of the coastal mangroves, while fish stocks continue to decline and consumption patterns remain unsustainable.

These and other pressures exacerbate climate-induced ocean acidification and warming and weaken the capacity of oceans to mitigate the impacts of climate change. Global climate change is also contributing to sea-level rise, which affects coastal and island communities severely, resulting in greater disaster risk, internal displacement and international migration.

To promote concerted action, ESCAP, in collaboration with partner UN agencies, provides a regional platform in support of SDG14, aligned within the framework of the UN Decade of Ocean Science for Sustainable Development (2021-2030). Through four editions so far of the Asia-Pacific Day for the Ocean, we also support countries in identifying and putting in place solutions and accelerated actions through regional dialogue and cooperation.

It is abundantly clear there can be no healthy planet without a healthy ocean. Our leaders meeting in Lisbon must step up efforts to protect the ocean and its precious resources and to build sustainable blue economies.

Armida Salsiah Alisjahbana is an Under-Secretary-General of the United Nations and Executive Secretary of the Economic and Social Commission for Asia and the Pacific (ESCAP)

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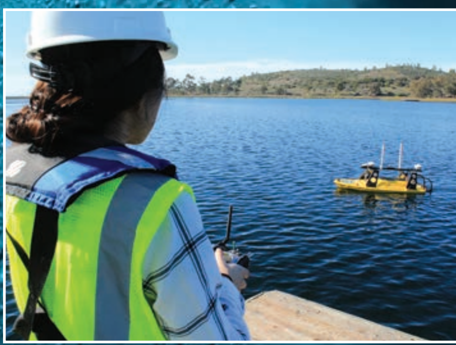
Work Hard, Have Fun, Change the World.

– Douglas Webb, Founder of Webb Research



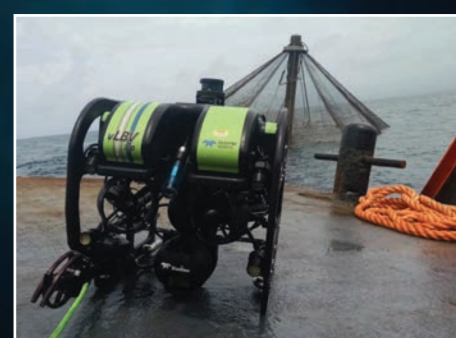
Z-Boat 1800 USV

Q-Boat 1250 Remote Trimaran

SeaRaptor AUV

Slocum Glider

Osprey AUV



vLBV ROV

Around the clock and around the globe, Teledyne is aiding researchers, commercial companies, and militaries to get the job done. We manufacture the equipment that helps customers make new discoveries, map underwater terrain, characterize the oceans and inland waterways, and deliver data from the abyssal zone to data centers around the globe. Let's put our technology to work for you today. Contact us at: info@teledynemarine.com.

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