MARINE TECHNOLOGY REPORTER

May 2020

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Subsea Defense

Advancing Autonomy

Interview
Duane Fotheringham, President, Unmanned Systems, HII

The Hybrid Survey USV

A New Look @ Pipeline Inspection

Volume 63 Number 4

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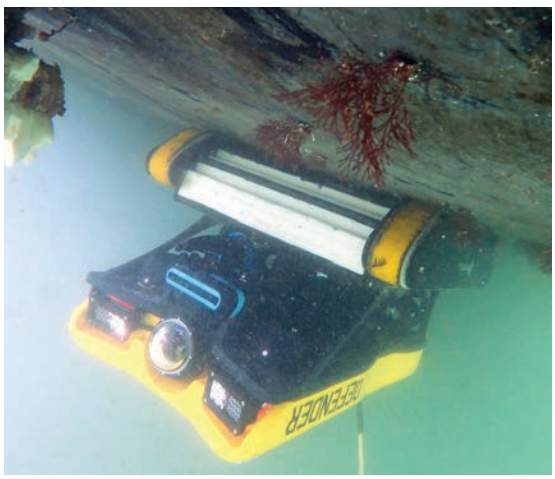

New Greensea crawler technology shown with the VideoRay ROV supports UWILD and EOD hull inspections.

GREENSEA

May 2020
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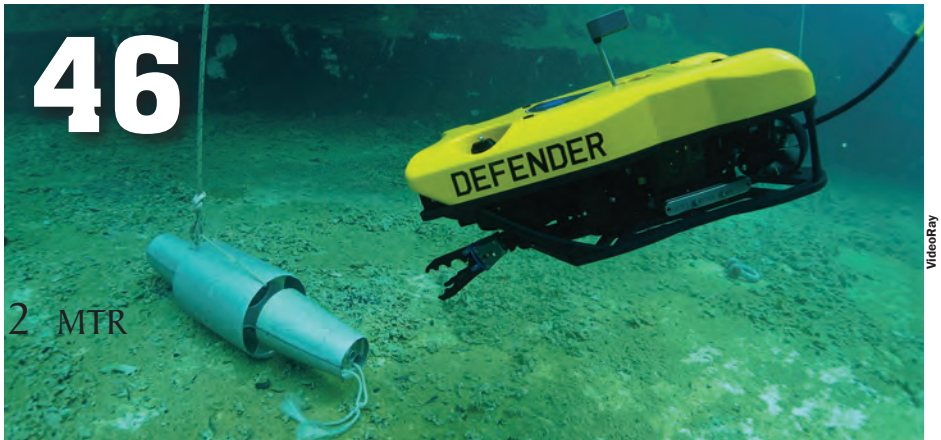

VideoRay

On the Cover
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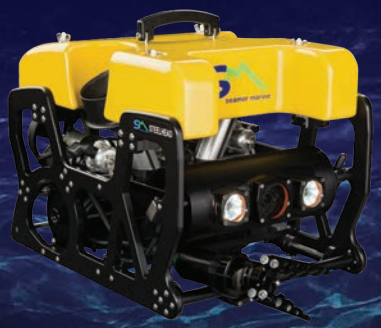

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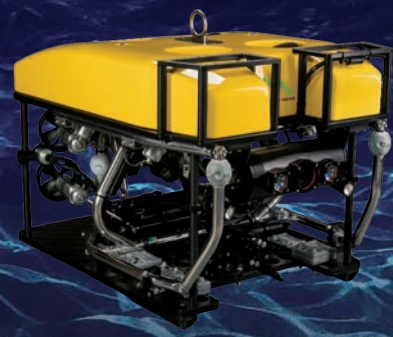

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Editor's Note

I don't know about you, but today's world feels a bit surreal, of course factoring in that we are headquartered in New York City, which has become the global epicenter for COVID-19. Trust when I say it's not a title we want, but onward we march, always. Personally, the entire staff of *MTR* is healthy and well, particularly the Florida-based crew who, at the least, have the signature sunshine to help brighten the days. Our business is built to be conducted wherever we happen to be, and having traveled the globe for the page 28+ years regularly for visits, conferences and exhibition, I and most of our crew are quite adept at working remotely.

The biggest disruption has been the lack of personal one-on-one contact with people throughout the industry, whether it be meeting with you in your office or on the trade show floor. While it certainly was not our intention as we rapidly ramped up our electronic media options over the years, the advent of 'social distancing' as the new norm has certainly seen that strategy pan out as we are able to engage our audience in a variety of means across traditional print, web and social media, with a wide variety of options from webinars to video interviews and podcasts.

As we collectively traverse the brave new business world currently defined by a global pandemic, it was interesting this month to take a step back and have a look inside one sector of our business – subsea defense – that is booming with no sign of a ceiling. Navies globally have been on a mission to do more with less, and in many cases this means enhanced application of unmanned systems. To help us fill in some of the blanks we 'met' (virtually, of course) with a handful of key tech leaders in the sector to discuss new developments, pace and direction.

Gregory R. Trauthwein
Associate Publisher & Editor

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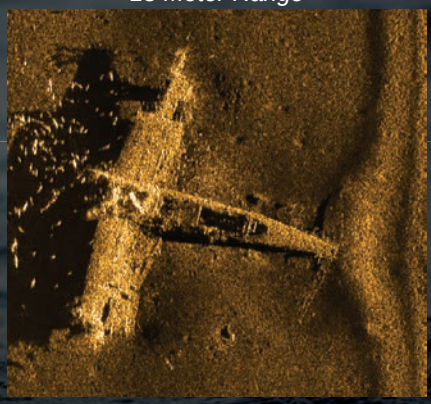

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REMUS 300: One Vehicle, Many Missions

Balancing flexibility with portability for maximum mission efficiency

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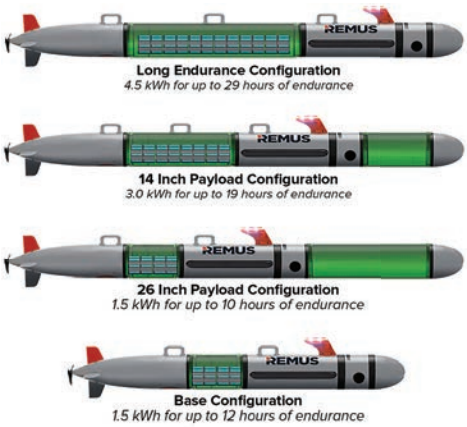
The REMUS 300 represents a generational leap in technology and is the culmination of 20 years of UUV development and feedback from customers worldwide. Building on the trusted, portable design of the small class REMUS 100, the REMUS 300 maintains the 7.5-inch diameter, increases modularity, can go to depths of 305 meters, and offers flexible payload and energy options. The REMUS 300 can be reconfigured for different missions,



from an 80-pound base configuration to a 130-pound long-endurance configuration. Balancing flexibility with portability, users can choose payload and energy modules that maximize mission efficiency with improved lithium-ion batteries and battery management software for up to 29 hours of endurance. Blind-mate module end caps allow for easy swapping in the field, adhering to IPX4 water resistance standards and allowing for quick vehicle turnaround. The REMUS 300 software is built on DDS middleware and is designed to be Unmanned Maritime Autonomy Architecture (UMAA) compliant, while maximizing Modular Open Systems Architecture (MOSA) principles.

Today, over 500 REMUS UUVs are in operation in 22 countries worldwide. Living up to a legacy that includes the REMUS 100 (aka MK18 Mod 1 Swordfish UUV), REMUS 600 (aka MK18 Mod 2 Kingfish UUV and LBS-AUV), and the deep-diving REMUS 6000, the REMUS 300 marks a new era in UUV design with the scalable REMUS Technology Platform that will allow for continuous evolution.

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William Stoichevski has written thousands of offshore-focused reports from his North Sea vantage point. William lives and works in Oslo. He started writing for Marine Technology Reporter in 2014.

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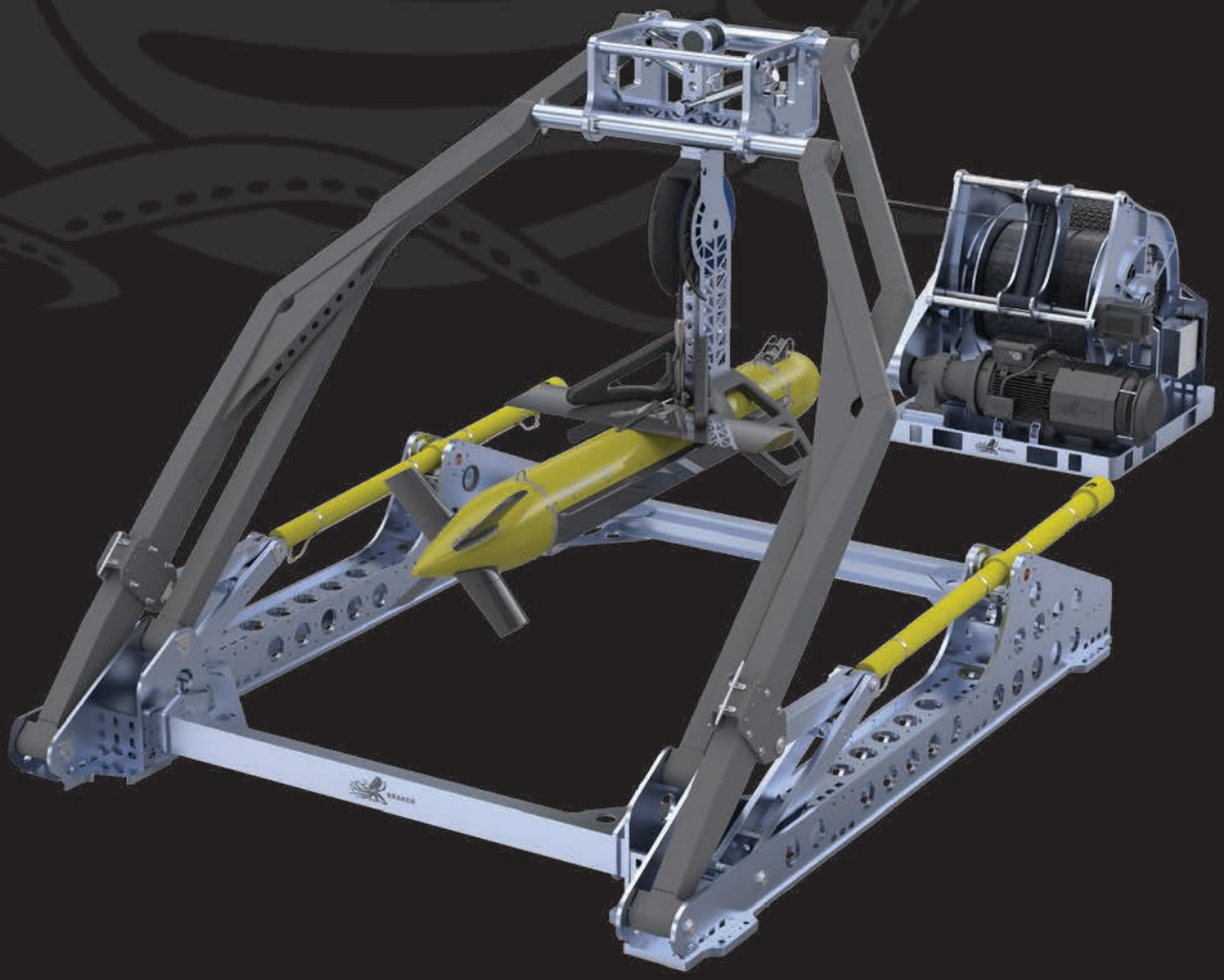

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Interview

Paulo Veronesi, General Director - Southern Cone, McDermott International Inc.

McDermott Experiencing Growth in Brazil

By Claudio Paschoa

McDermott completes phase 1 of the deepwater Atlanta EPS located approximately 115 miles offshore southeast of Rio de Janeiro for Enauta.

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Interview

Paulo Veronesi, General Director - Southern Cone, McDermott International Inc.

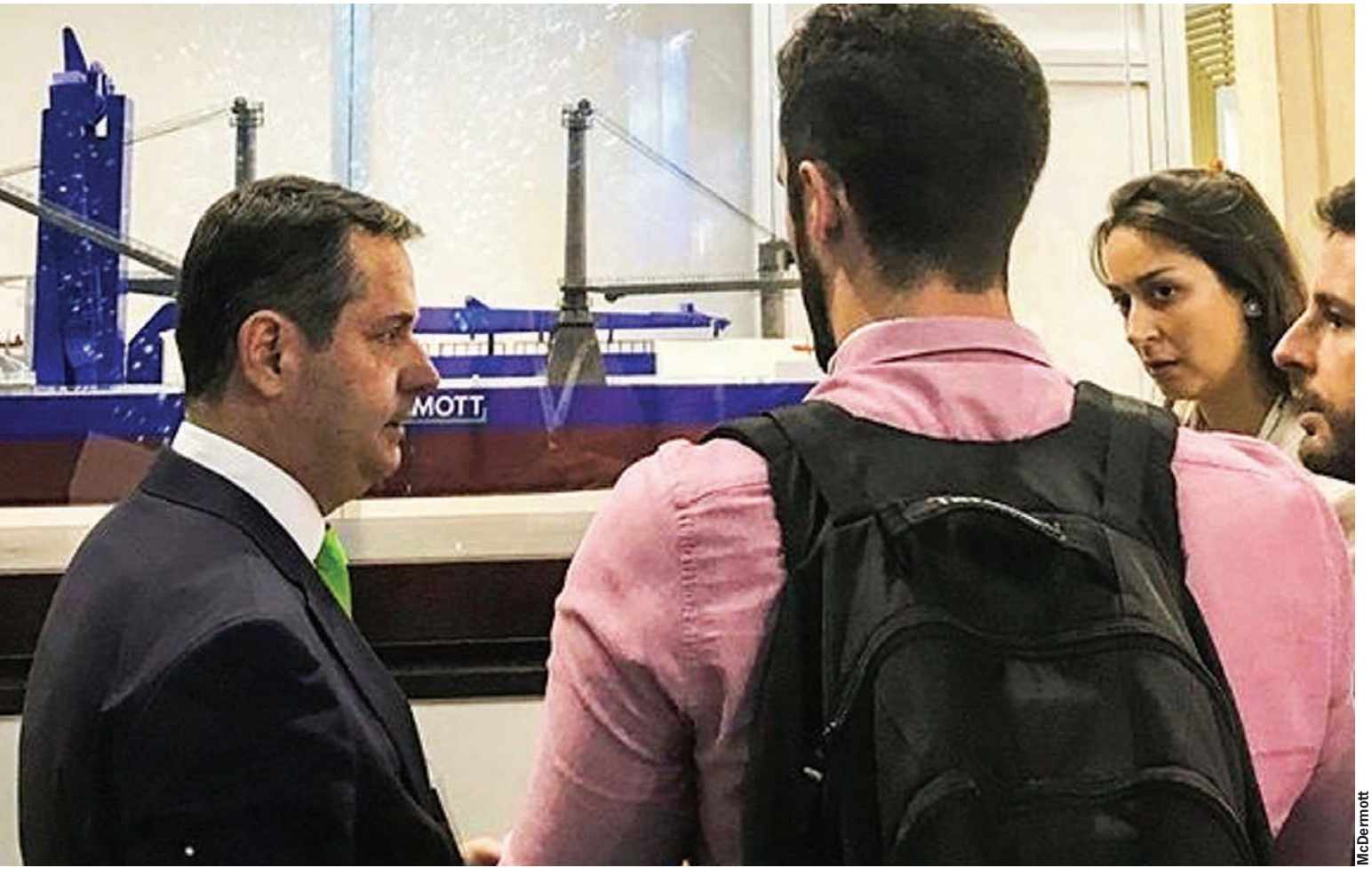
McDermott has been present in Brazil for decades and has flourished through the upturns and downturns of the local upstream and downstream markets. Last year, Claudio Paschoa, Marine Technology Reporter´s correspondent in Brazil had the opportunity to talk to Paulo Veronesi, General Director - Southern Cone, McDermott International Inc., about his views on the present state and the future of the offshore market in Brazil.

McDermott can boast a long history as a service provider in Brazil, dating back to the very beginning of offshore exploration, and to the birth of the refining sector in the country. "We have been present in Brazil since the early days of the O&G business, leading McDermott in the offshore area with fabrication of the first platforms, but also with key participation in the refinery sector with CB&I and Lummus Technology contributions," said Veronesi.

"Petrobras is our main client in Brazil; however, the market is rapidly growing in terms of clients and diversity of projects in the offshore area. We expect the onshore sector to catch up also with the new investments in LNG, refining and power generation that are coming."

– Paulo Veronesi,
General Director Southern Cone,
McDermott International Inc.

Paulo Veronesi is leading McDermott in Brazil and all of South America.



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Interview

Paulo Veronesi, General Director - Southern Cone, McDermott International Inc.

Since 2014, the Brazilian market has been struggling to regain momentum. Only around mid-2018 did the market really begin to heat up again. These four lean years were mainly a result of the backlash caused by the Petrobras corruption and graft scandal involving the highest levels of government, yet also magnified by a major drop in oil prices. “The business environment has improved a lot in the last year or so, although Brazil is still a complex place to do business due to taxes and legislation, among other challenges,” said Veronesi.

As the market heats up, it becomes increasingly difficult to hire specialized workers in certain areas. (*NOTE: This interview was conducted before the full effects of the COVID-19 pandemic impacted global oil markets), Some of that is caused by potential workers moving to other industries, sometimes due to the large demand for specific specialties by the industry, creating a strong competition to hire the best minds available, and sometimes simply because of low availability of specialists in a number of areas. “The market is getting tight for specific areas of specialization, although there are still knowledgeable experts who have been in the industry for more than 30 years available to help us, mixing them with young people full of energy seems to be the right way to go,” explains Veronesi.

McDermott was busy at the end of 2019 with a number of project underway for their main client, although they expect to increase their clientele shortly. “Petrobras is our main client in Brazil; however, the market is rapidly growing in terms of clients and diversity of

Image showing how Rota 3 pipeline will move natural gas from an offshore FPSO to the city of Maricá northeast of the city of Rio de Janiero.

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Interview

Paulo Veronesi, General Director - Southern Cone, McDermott International Inc.

projects in the offshore area. We expect the onshore sector to catch up also with the new investments in LNG, refining and power generation that are coming," said Veronesi. The service company is in the midst of a number of important upstream projects for National Operator and other clients, which is keeping them busy and allowing them to maintain a steady growth.

"We just finalized the Atlanta Phase I Subsea EPCI project for Enauta last year, which was a great success, and previously we had several vessels operating for Petrobras. We also designed and installed the Papa-Terra TLP platform recently. We are currently busy executing two EPCI projects for Petrobras – Rota 3, which is in the installation phase and Sépia, which is a pre-salt job where we will install the subsea infrastructure for the field," said Veronesi.

The executive agreed that there a many difficulties and major challenges to overcome when dealing with pre-salt development and deepwater construction. According to Veronesi – "Our challenges with pre-salt is being able to install all subsea infrastructure in 2,200 meter water depth as efficiently as possible. For that, we have converted the Amazon multipurpose vessel, adding a 1,500 ton J-lay tower to it, which will make it a game-changer for the pre-salt subsea market. The Amazon was delivered to IHC in the Netherlands in August 2019 for a conversion period, which is expected to last 10 months. Redelivery to McDermott is expected in the summer of 2020."

When asked about his outlook for the Brazilian offshore market, Mr. Veronesi was positive at the time of the interveiw.

"We are well positioned to serve this market with our converted vessel and the engineering capabilities that we have built over the last 18 months. It is a fact that the Brazilian O&G market demand has picked up in the upstream sector. Now, we expect to see growth in the downstream sector with major investments in LNG, gas-fired power generation, and later, also in the refining sector. McDermott is a market leader in these sectors and we are poised to benefit from the growth by offering solutions to these markets. Having said that, it is important to note that safety is our number one priority, and we are constantly working with our suppliers to bring them up to the safety standards of McDermott. This is a continuous effort that we are doing with very positive results," concluded Veronesi.

(*NOTE: This interview was conducted before the full effects of the COVID-19 pandemic impacted global oil markets),

McDermott pipeline fabrication

McDermott

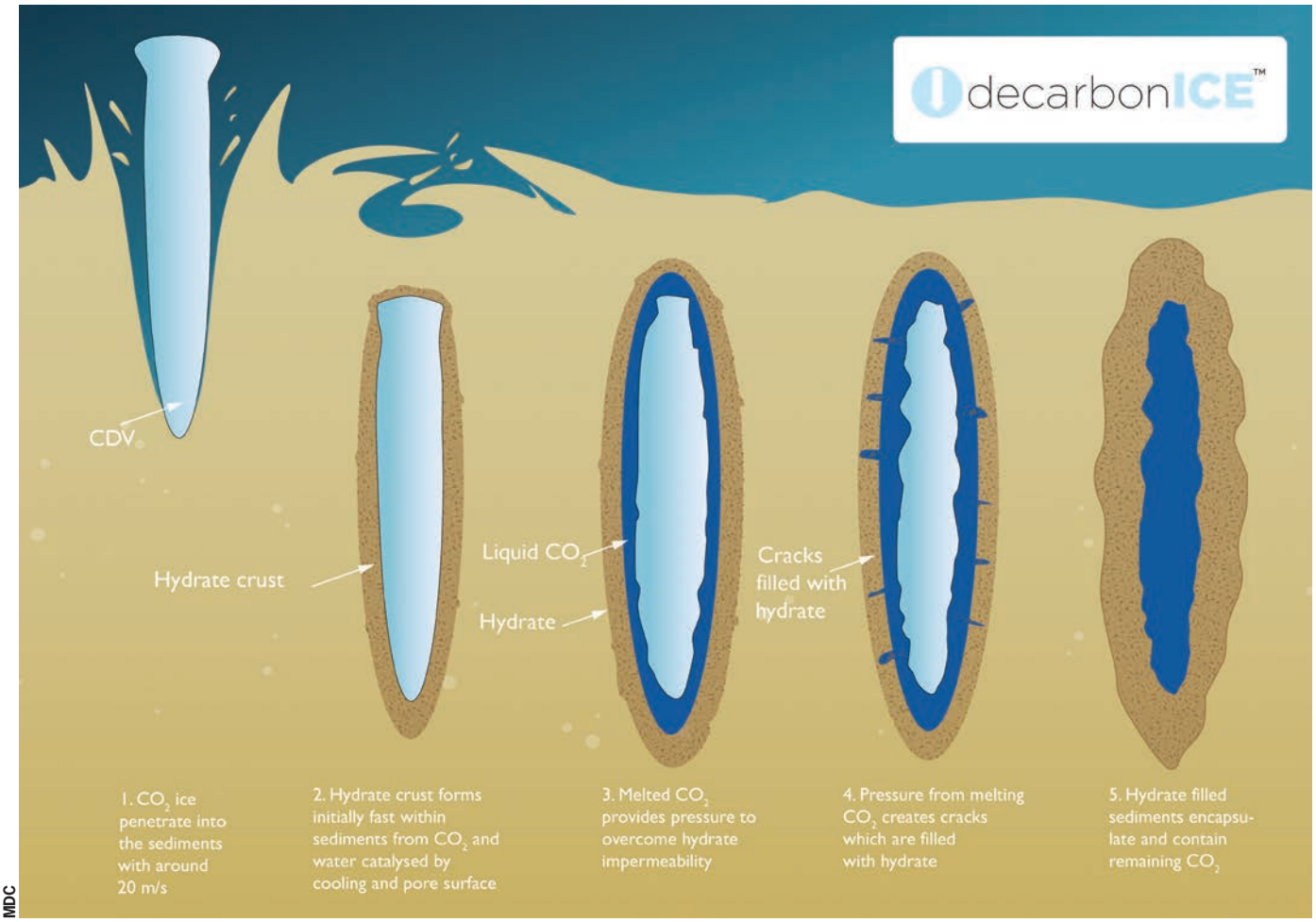
Creating a Pathway to Carbon-Negative Shipping

By Tom Mulligan

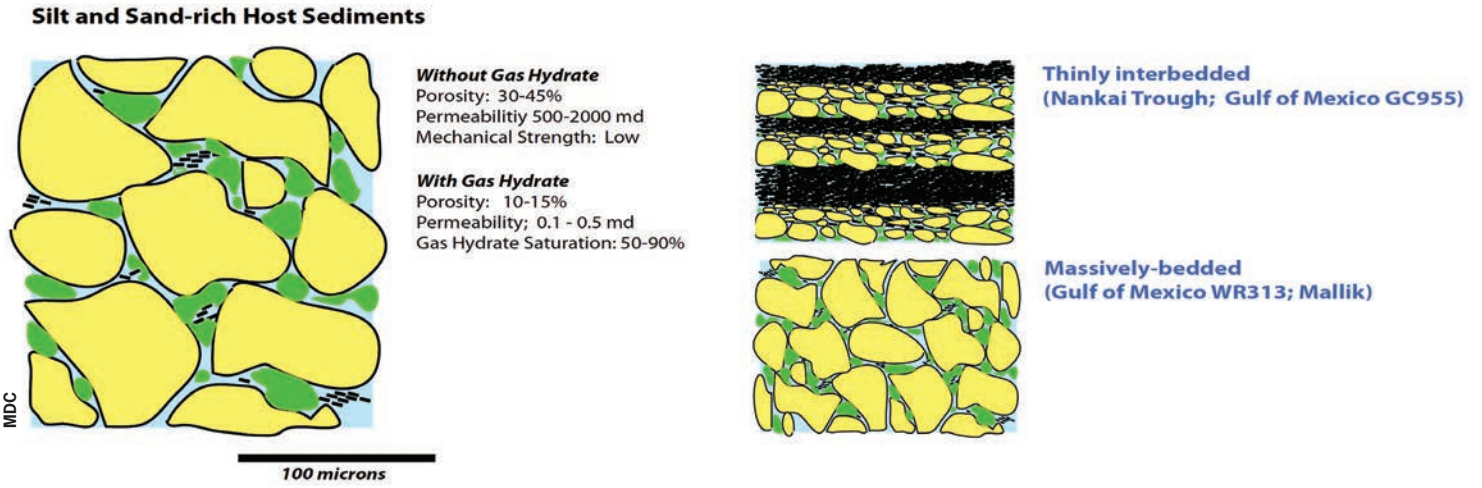
Greenhouse gas emissions capture and storage may be a more practical alternative to emissions reduction for meeting the IMO's 2050 CO2 target.

Shipping emits close to 1 billion tons of CO2 each year and the shipping industry needs carbon-free solutions to achieve the IMO's 2050 target of a 50 percent reduction, compared to the 2008 level, in these massive emissions. However, according to Denmark's Maritime Development Center, while better technical and operational solutions must continue to be pursued, they will only bring the industry part of the way: "Low- or zero-carbon fuel solutions must be introduced and scaled by 2050 to reach the target," the organization has stated. Thus, while a large number of initiatives and pilot projects with zero-carbon or carbon-neutral fuels are currently being undertaken, a more

Dry ice formed by cooling exhaust gasses to -120 °C is formed into Carbon Descent Vehicles that sink to depths of about 500 meters, where they penetrate the seabed, storing CO2 safely as liquid CO2 and CO2 hydrate.



MDC



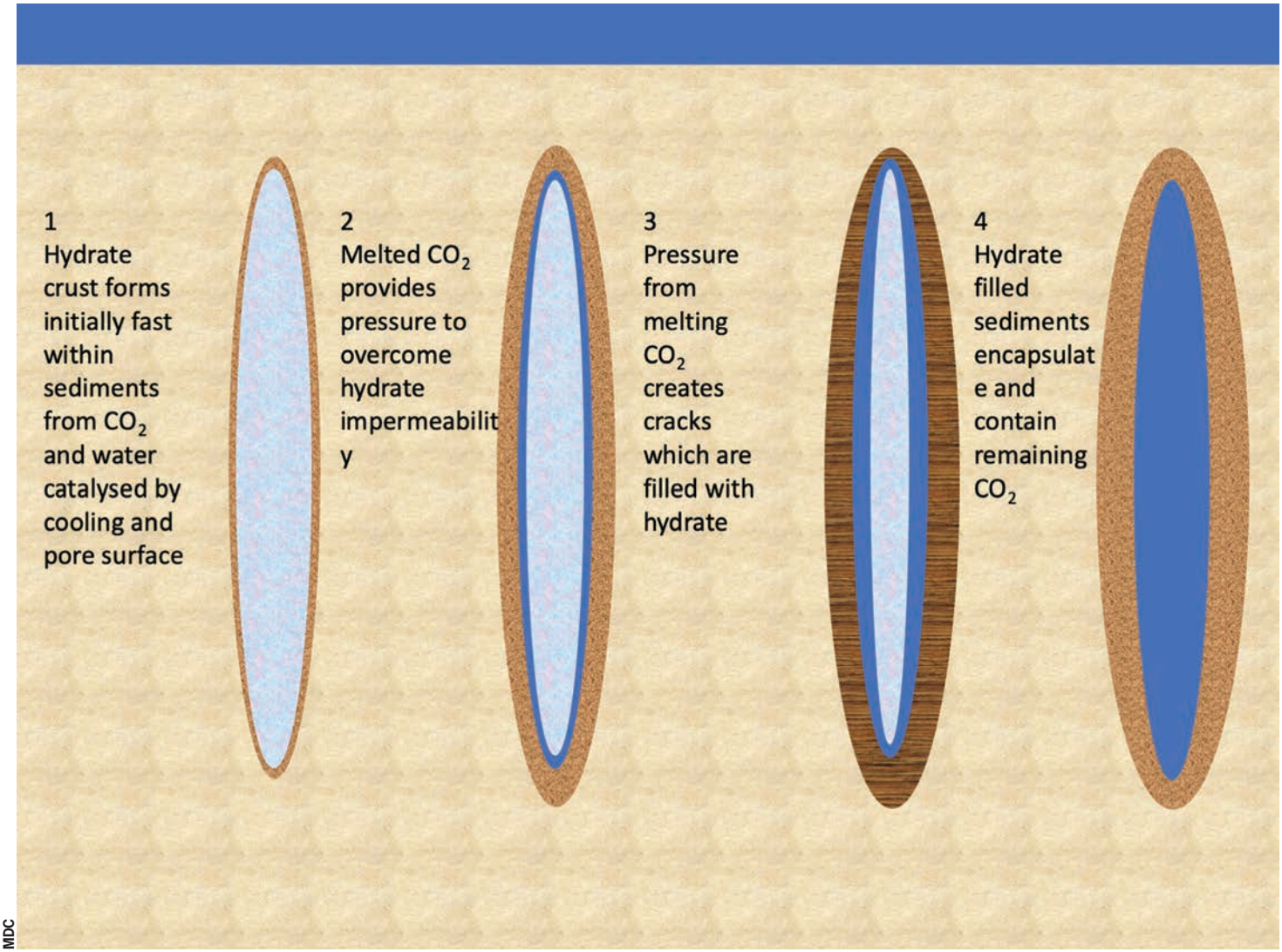
Silt- and sand-rich host sediments on the seabed in regions such as the Gulf of Mexico are the best locations in which to store CO2 in liquid or hydrate form, providing an environmentally-friendly, safe and permanent 'home' for captured greenhouse gas emissions.

practical approach may be the use of on-board carbon capture with subsequent storage at appropriate sites and, in this context, the use of conventional fossil fuels may become carbon free.

MDC sees analogies between the IMO's 2020 sulfur regulations and the 2050 zero-carbon target: "The expected energy penalties in adopting a zero-carbon strategy are low – it's a 'no-brainer'," said Henrik O. Madsen, former DNV GL President and CEO. "Shipowners should take responsibility and not compete but collaborate in the area of carbon footprint reduction to meet the 2050 zero-carbon target. In my opinion, this is an area that is far too important to become the victim of competition – this is a problem for the industry at large that will not go away, and the industry must collaborate to satisfy society's expectations."

decarbonICE CO2 capture and storage

Madsen is chairman of the decarbonICE CO2 capture and storage project being run by MDC, in which international shipping carriers act as project sponsors, supporting the platform financially, while producers of maritime equipment and services act as in-kind contributors, supporting the platform with non-monetary services and assets,



MDC

Hydrate crusts formed within ocean floor sediments ensure the encapsulation and safe and effective containment of captured CO2.

such as knowledge, experiments, working hours and equipment.

The decarbonICE technology is based on two new main ideas, one for CO2 capture and one for its storage. CO2 and other greenhouse gases (GHGs) in a ship's exhaust are captured on board by cooling exhaust gasses to about -120°C, creating dry ice. Some of the NOx, and in particular those that have a GHG effect, will also freeze and become part of the dry ice, while others will be vented to the atmosphere. There are several options for dealing with SO2, including the introduction of scrubbers. Water vapor is removed early in the cooling process.

Using well-established offshore technology, the dry ice is shaped into Carbon Descent Vehicles ('torpedoes') that are sent down to the ocean floor, sinking to depths of 500 meters at speeds of about 25 meters per second, where they bury themselves in seabed sediments, storing the carbon dioxide safely and permanently as liquid CO2 and CO2 hydrate. Each CDV will be launched to the sea and not lose any or at most 1 percent of its CO2 to the water during its descent to the sea floor. During this descent phase, it is furthermore ensured that no large mammals like whales are affected.

Started in October 2019, the decarbonICE project will run throughout 2020, initially with feasibility studies being conducted in the laboratory and the initiation of IMO approval for the technology. "Shipping companies will need to demonstrate the practicality and any operational issues or problems associated with the technology," said Madsen, "and full-scale operation will take place later on, however, the members of the project are already discussing the possibility of starting the first projects demonstrating parts of a decarbonICE technology on board a vessel."

A solution for newbuilds and retrofits

The decarbonICE concept is intended to be applied not only on newbuilds, but also to be retrofitted onto existing ships, thereby adding extra impetus to efforts to achieve the IMO 2050 CO2 target. MDC said that in combination with future carbon-neutral fuels such as biofuels and electro fuels, the technology could create carbon-negative shipping and thus contribute to atmospheric carbon reduction at a significantly lower cost than shore-based carbon capture. "While we support a goal of availability of zero-carbon or carbon-neutral fuels, we believe that a bridging carbon-free solution is needed, utilizing existing assets in terms of ships, propulsion systems and fuels," said Madsen. "The decarbonICE project is intended to offer exactly that at a predicted low energy penalty well below 10 percent. However, we have no illusion that we can provide a 100 percent emissions reduction solution – even a 70-80 percent solution for deep-sea shipping would be very attractive."

As well as being developed for use with existing fuels such as HFO, MGO and LNG, the decarbonICE project also intends to develop a concept that will work in a future where neutral-carbon fuels such as biofuels or synthetic fuels ('e-fuels') become available. MDC said the combination of such fuels and decarbonICE would lead to carbon-negative shipping, in other words that shipping would in future reduce the amounts of CO2 in the atmosphere. MDC added that it may be possible that the first system could be installed on board a newbuild some three years after IMO approval of the technology and that retrofitting on an existing vessel could be achieved even more quickly.

Innovative new platforms to conduct subsea work

The Hybrid Survey USV

By William Stoichevski

At the headwaters of initiatives advancing autonomous, urban ferries and other unmanned surface vehicles, or USVs, is a Norwegian company with international reach. Visiting Maritime Robotics again, we learn that huge advances in autonomous navigation and control are coupled a new practical up-link function in Maritime Robotics new USV for 2020. High on the excite-o-meter, the Mariner II is an upgrade to hybrid from the successful Mariner platform, a sealed, rib-like vessel that delivers larger radar and avoidance payloads. Chief beneficiaries ought to be bathymetric and seismic surveyors, inland, nearshore and in pirate-infested offshore waters.

Maritime Robotics

Rich data:
bathymetric survey data collected by a Maritime Robotics USV from a waterway north of Trondheim

TRONDHEIM — A cursory glance back at 2019 is enough to suggest it was The Year of the Pirate, as all manner of offshore vessel was attacked from the Singapore Strait to the Gulf of Guinea. Heavy lift, diving-support, offshore supply and seismic vessels were all attacked. Their crews, at best, retreated to an armored wheelhouse. Some caught in the open or amidships were kidnapped.

For the crews of seismic survey vessels, splashing around in a dinghy to share data with a seabed seismic survey node offshore the Niger Delta would seem like baiting pirates. That vulnerability to attack is but one weakness the new Mariner II USV addresses by robotically going out to up-link the valuable data in seabed seismic survey nodes. With its close marine ties to Norwegian offshore fleets — even in university town, Trondheim, with its scientific community — Maritime Robotics could check the value of servicing nodes for a growing seabed node survey market.

The same scientific community would confirm another need: nearshore, riverbed and offshore bathymetric surveys. The Mariner II can do large-scale bathymetric surveys nearly on its own, both in shallow and deep water. With January 2020 effectively its launch, just one Mariner II has been sold, although likely clients are lined up for three more sales. The main improvements of these over the original Mariner appear to be easier service for USV and node; new collision avoidance; better endurance and larger sensor arrays and payload. At upwards of EUR 300,000 each, they're customizable.

Oh, and the Mariner II USV is a hybrid. It's a hybrid in terms of power and propulsion and for incorporating elements from Maritime Robotics other offerings. A more efficient propulsion system means Mariner II can operate for five days of diesel-electric hybrid or five days of fully electric operations. Rounding out the improvements is a better LARS — the Mariner II now fits into a 20-foot container — and it deploys its payload and sensors through its own moonpool. It's battery can also now be changed out in two minutes

A better payload is understood to primarily be aimed at the bathymetric survey market. Mariner II's LIDAR sensors, like those on the company's Otter survey catamaran, have brought interest from port authorities; dredging companies and fisheries people keen to understand and map seabed conditions quickly. A logical next market would be offshore wind. So, while the EUR 48,000 Otter USV seems ideal for riverbed surveys, LIDAR in both UAVs has assured work with port authorities in Asia, the U.S. and Europe.

Vehicles

Innovative new platforms to conduct subsea work

SURVEY TYPES

A more lucrative use for the Mariner II is, potentially, the servicing of seabed seismic nodes that receive and refine acoustic signals "shot" from a surface vessel to provide real-time reservoir data over time. The Mariner II retrieves information from these and speedily transmits them to the seismic survey vessel

"The quality control of these nodes is time-time consuming, (so the Mariner II) is better than three guys in a dingy," says Maritime Robotics chief operating officer, Eirik Evjen Hovstein. "Especially when piracy is an issue."

Servicing nodes — normally a labour-intensive endeavour — normally leaves key people out in the open. Having the USV communicate with the nodes and relay the signal to the ship has reportedly been "a great success" for Seabed GeoSolutions, an early Maritime Robotics client. Sending out the USV seems as uncomplicated as sending out the seismic vessel's node-deploying remotely operated vehicles, or ROVs.

"In the morning, the operator launches the USV from a mothership carrying nodes and ROVs. Then, the operator goes to the control room to program the USV and to work with a map of placed nodes. The USV drives over those areas automatically, and when the USV is in the right area, it acoustically communicates with the nodes and checks that the battery's okay, the system's running right, there's enough (digital) storage and adjusts the parameters you want to monitor. That info is transferred to the USV which reports it to the mother ship as a live update. It's all live."

NODAL SEISMIC

While seabed nodal seismic has been a growth market for a decade, there could, according to Seabed GeoSolutions, be some disruption. Future nodes might deploy on their own.

To be sure, nodal seismic has picked up as a means of gaining less-costly up-to-date reservoir information. Seabed GeoSolutions has just declared itself a "nodal seismic company". After two downturns in 12 years, the industry is keen to use nodes over streamers where possible. While Hovstein doesn't see the Mariner II replacing larger vessels that supply massive power for the acoustic "shoot", there is a new multi-client market for seabed nodal surveys, as confirmed by Schlumberger's collaboration with Axxis Geo Solutions to promote seabed nodal seismic and the West African and Gulf of Mexico surveys of Seabed GeoSolutions, itself a business of CGG and Fugro.

Seabed GeoSolutions is in year three of its use of the Mariner USV and is understood to have applied it in this year's nodal survey of Mississippi Canyon blocks in the Gulf of Mexico. Depending on water depth and the size and ability of crews, the Mariner II can service between 300 and 700 nodes a day, so vast distances can be serviced. For the Gulf shoot, Seabed GeoSolutions does the data

Seismic survey work:
Seabed GeoSolutions operationg a Mariner in 2018 (the vessel would have been used to check the integrity of a wide area of accoustic receivers on the ocean bottom

Maritime Robotics

acquisition, including ROV-deployed CASE Abyss nodes in 2,000 meters of water, and CGG's Subsurface Imaging in Houston will process the imagery aimed at accurate drilling. We could not confirm whether the Mariner II might also be part of the nodal survey being shot by Seabed GeoSolutions and ARGAS in the Red Sea for Saudi Aramco.

MULTI-USE PLATFORM

Yet, there are other surveys for a "survey-boat drone" with the right stuff. Though the market is increasingly crowded, the Mariner II might have a leg up in the bathymetric survey race.

Its Norbit iWBMS Multibeam SONAR, LIDAR and all-weather performance are understood to have won over port authorities in Japan and the U.S. as a cost-efficient, customizable platform that can scan the seabed; do pipeline, harbour and lake surveys or begin hazardous spill-mitigation. To those ends, clip-on cameras; sensors; an integrated

New and improved: the Mariner II delivers at about 6 m x 2 m x 2 m and comes with its own moonpool for sensor deployment for periods of up to 50 hrs (diesel) or 8hrs (electric)

Maritime Robotics

KA aerial; different GSM modes for complex coms and up to 10 days diesel electric or two days all-electric operational time seem sufficient.

While the Otter is a proven harbour and riverbed multibeam survey platform than can be programmed "on the way to work", the Mariner II will do the same from a control station and farther out to sea. An underwater hyperspectral imaging camera can be equipped to detect algae types. Direction from an UAV is possible, as are operational modes that include remote control; way point tracking; pre-program or station-keeping enriched by a "return to control station" and sea chart and radar overlays.

As for the Sheridan & Verplank autonomy ranking — there are collision avoidance and detection alarms; multi-vehicle survey integration; the ability to replace a larger surface vessel and a knack for helping other USVs navigate.

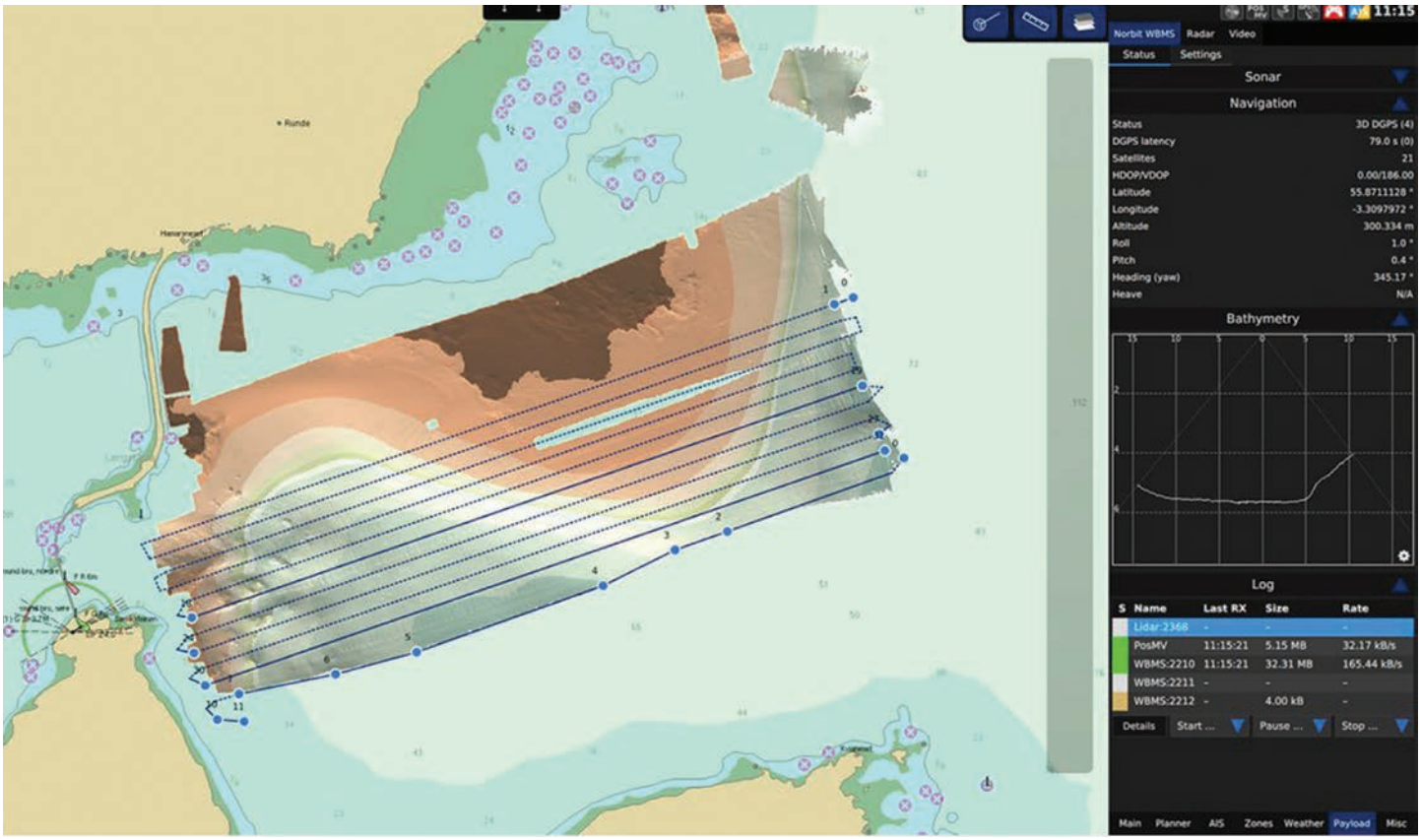
CONVERTIBLE

While 22 of the smaller Otter USVs — 2 meters long, 1 m wide, 81 centimeters tall and just 95 kilograms — were sold in 2019, the Mariner II may now also be finding solid interest for bathymetric surveys. There's a reported Dutch dredging order, and there's an untapped market in early-stage surveys for offshore wind parks, where a large compartment could conceivable also serve as tool carrier box to replace "seasick" crews. These wind surveys precede the cable-laying and pile-driving of offshore wind grids.

For now, Maritime Robotics is selling a lot of Otters and seeing the first sales of Mariner II's. Their No. 1 seller, however, is a conversion pack that converts nearly any type of vessel into a USV. You can turn your launch into a Mariner II — sort of. Deliveries of conversion packs have gone toward towing vessels, target vessels and converted oil-spill clean-up vessels, including those tasked with spreading dispersant and performing mechanical clean-up tasks. "Communications with the USV is set up in a way that allows instant manned-unmanned conversion at the push of a button," Hovstein tells us. "This is great value."

So, Houston's "Oil in water. Stay in vehicle," highway signs could, in future, mean a Mariner II or Maritime Robotics converted vessel is on its way to clean things up. As in the case of pirates, there's no need to put people at risk.

Survey points:
A view of the PC or tablet control interface.



Maritime Robotics

Nodal survey era:
a survey vessel and mother ship for ROVs, UUVs and USVs involved in seabed and bathymetric surveys

Fugro

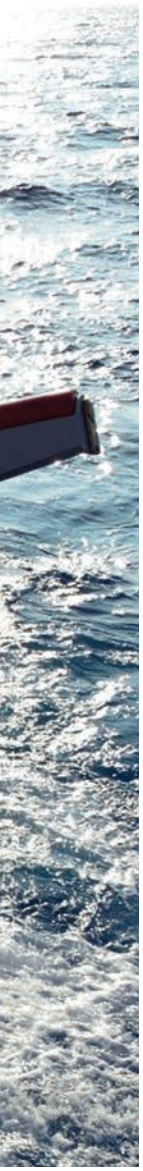
ISE Explorer AUV recovery on ramp LARS.

Photo: ISE

AUV LAUNCH & RECOVERY:

Why it shouldn't be an afterthought

By Alex Johnson & Luke Alden
International Submarine Engineering



AUV technology continues to rapidly improve as more companies, organizations, and governments worldwide add AUV operations as part of their capabilities, however, there continues to be a technological blind spot when it comes to launch and recovery. In commercial operations, ISE's market research suggests that up to 50% of possible survey days can be lost to bad weather due to the difficulty of launch and recovery offshore, depending on the time of year and operator's appetite for risk of damage to their AUV. This means that improving launch and recovery has the potential to double the performance of the AUV survey system. There is no other improvement in AUV technology that has the potential to offer as significant of an improvement to operational efficiency as addressing the challenges of launch and recovery by reducing or eliminating the days lost to bad weather. In spite of this, launch and recovery systems are often neglected or differed during the AUV procurement process for reasons of cost and a lack of appreciation of their importance to operational success. In this article the challenges of launch and recovery offshore are discussed, industry standard launch and recovery systems (LARS) are evaluated, and new and innovative solutions to the challenges of launch and recovery are presented which address critical shortcomings of existing LARS technology.

At ISE we say that if the number of launches doesn't equal the number of recoveries, you're having a really bad day. Though a bit tongue-in-cheek, this saying highlights the inherent risks of operating AUVs offshore. A successful survey counts for nothing if you are unable to recover the AUV and download the data. In this article we'll talk about the importance of considering launch and recovery, some LARS options as well as a look at some of the designs for improvements that ISE is working on.

Launch & Recovery

As we know, offshore weather is rarely calm. Depending on the location and time of year, sea state can vary considerably. When operators decide to launch their AUVs, they must consider what the sea state is likely to be 1-3 days later for recovery. If they decide it is likely to be too dangerous to recover the AUV without serious damage, then they will not launch. One operator reported that during the two best months of the year, they would likely lose up to 50% of days due to this issue. An AUV should be out surveying not sitting on deck waiting for a weather window!

When the window comes, launch and recovery is still a dangerous time for a multi-million-dollar AUV, when heaving seas threaten to smash it against the uncompromising bulk of the ship. The systems for launch and recovery attempt to mitigate this risk with varying degrees of success.

Nevertheless, the scars of rough recoveries can be seen on the surfaces of many AUVs. Missing antennas, damaged transducers and scratched paint are unfortunately a common occurrence. An AUV should be out surveying, not on deck being repaired!

A good way to measure an AUV's performance is by the number of kilometers surveyed per day of ship time, including days lost to weather, turnaround time on deck, and the AUV in-water performance. When evaluated through

Photo: ISE

AUV fit with nose hook capture mechanism connected directly to dorsal lift lugs.

this lens, no minor improvement to the AUV's propulsive efficiency or sensor performance compares to the potential gains from ensuring that the AUV can be recovered, with minimal damage, during harsher weather.

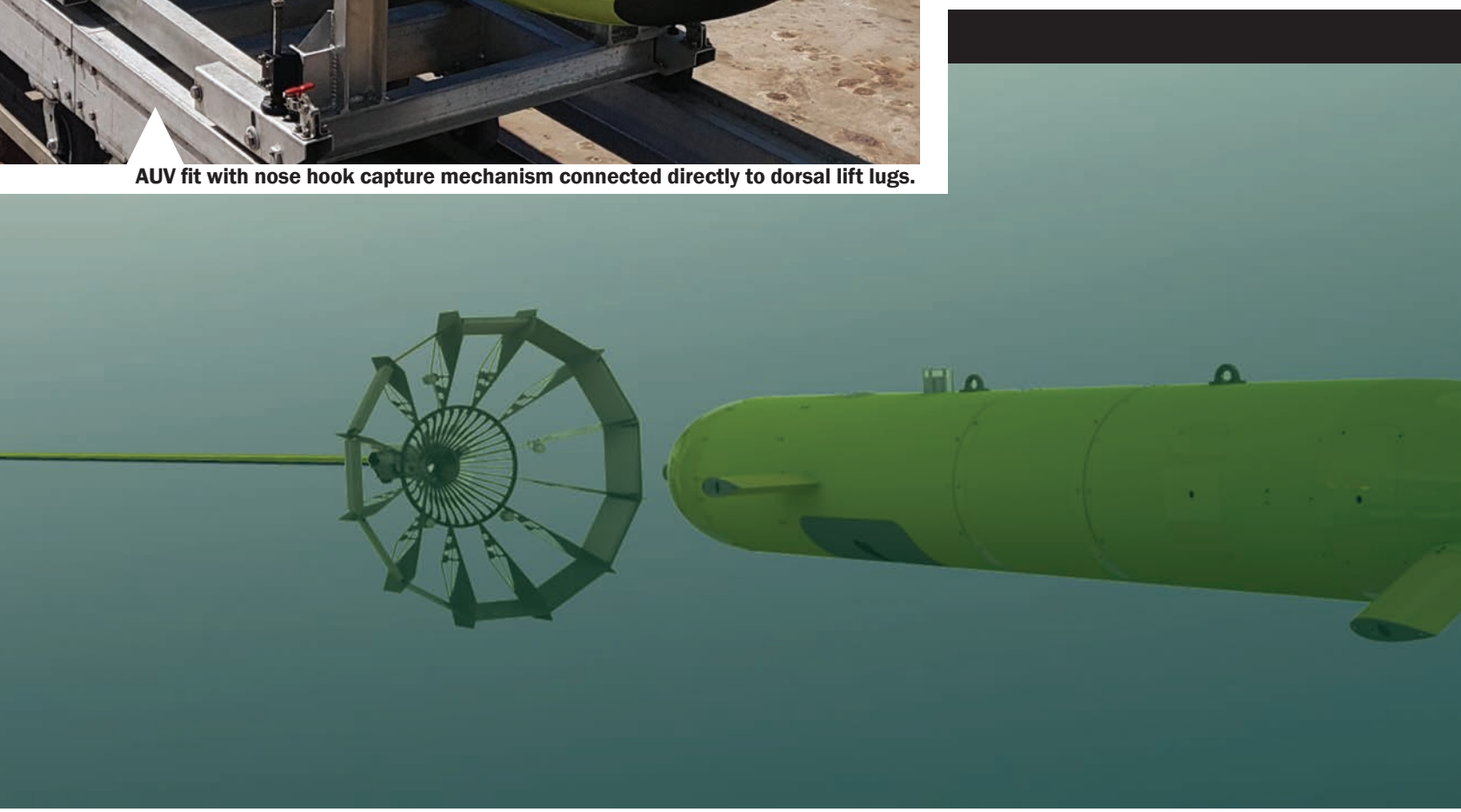
These risks highlight the importance of selecting the right LARS for your AUV. It is of crucial importance to ensure that the AUV survey rate is maximised.

Choosing the right LARS

To facilitate safe offshore AUV operation there are many different LARS concepts, each with their own strengths and weaknesses that need to be considered.

Ramp/Stinger

Several variants exist, however, one of the most reliable is the ramp LARS developed by ISE and Hawboldt to re-



cover ISE Explorer AUVs, which was later adapted for use with other AUVs. The strengths of this design include that it is intuitive for new operators, robust enough for operation in up to sea state 5, and that it can be operated fully as a containerized system. Its nose capture system settles the AUV down, aligns it, and maintains control of it as it is winched up the ramp. The limitations of this system are that the freeboard of the ship must be less than 3m, and that it is best installed with the ramp extending off the aft of the ship. Also, despite being able to operate in sea state 5, the AUV is prone to sustaining damage from an impact with the ramp.

Nose Lift

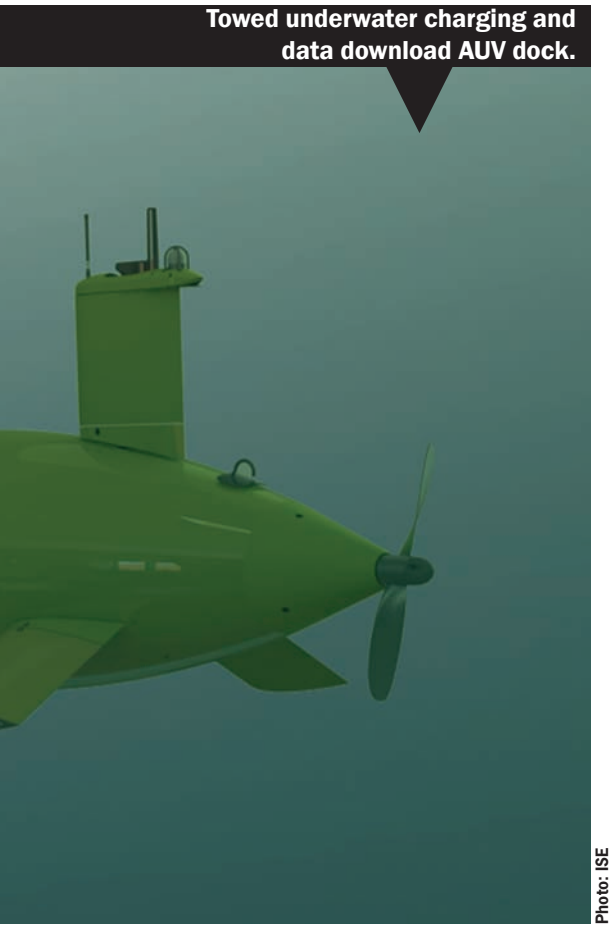
The nose lift LARS uses an A-Frame and nose capturing ring to lift the AUV out of the water vertically by its nose. Once the AUV is out of the water, the A-frame tilts inboard nestling the AUV into its cradles slowly and gently. The strengths of this LARS include its ability to be installed at any freeboard, anywhere along the ship, and that it does not come into contact with the AUV until it is hoisted above waves. The downsides are the large deck footprint, risk of the AUV slamming into the side of the ship during the hoisting process and that not all AUVs are designed to be lifted vertically by their nose like the ISE Explorer AUV is.

Crane LARS

For operators who already have an offshore rated pedestal crane or A-Frame, ISE has developed a cost-effective docking head that can transform a crane into an AUV LARS. The advantages of the docking head crane LARS are that it is 20% the cost of other LARS options and the AUV makes its first contact with the docking head above the waves and away from the ship, reducing the likelihood of damage. It can also be adapted to a wide variety of cranes and removed when not required, meaning less deck space is taken up for the AUV system. The disadvantages include that the strength requirements for the crane must be sufficient for the loads experienced during offshore launch and recovery.

Shore Launching

Avoiding the dangers of launch and recovery can be achieved by shore launching AUVs from boat ramps or docks. The advantages include that it is extremely inexpensive when compared to operating from a ship with a LARS, however, with limited AUV range and no ability to recovery the AUV in an emergency, the drawbacks are significant.



Towed underwater charging and data download AUV dock.

Photo: ISE

The Future

For operators to be able to get the most out of their AUVs, they must not only choose the best LARS, but must also demand improved performance and new technologies that mitigate the launch and recovery risks of operating in high sea state. Operators who take advantage of the latest developments in launch and recovery will be able to produce survey data more efficiently than their competition.

There are many obvious improvements needed to both the LARS's and the AUVs to make them more robust, many of which ISE are working on. For example, improving the padding and shock absorption capabilities of both the LARS and the AUVs composite structures.

On top of this ISE is also working on two specific innovative designs that we'll discuss now.

Line Handling

When establishing the first connection to the AUV during recovery, most AUVs rely on a system that jettisons a float which is connected to a recovery line. These lines often become fouled in the AUV resulting in a risky recovery and long delays. To resolve this, ISE has developed an innovative hook and capture system which can be retrofitted to Explorers and other AUVs. The

Photo: ISE

ISE Explorer AUV with crane LARS docking head

system allows the operator to make a secure connection to the vehicle prior to triggering the release of the float and handling lines, minimizing the chance of fouling.

Charging & Downloading Data

Eliminating or reducing the need to recover an AUVs is the next leap forward in technology to improve their operational efficiency. Based on in-air refueling systems for fighter jets, ISE is developing a towed underwater dock to allow charging and data transfer without need for recovery.

The dock is towed behind a ship or unmanned surface vessel and presents a stable docking target for the AUV at a depth of ~30 metres. The AUV uses its optical and acoustic tracking system to dock autonomously for charging and data download. At that depth, the surface sea state has little effect on either the AUV or the towed dock, drastically increasing the operational days available for survey. ISE completed successful initial trials in spring 2019 and final docking trials will be conducted in fall of 2020. Once completed, the towed dock combined with a LARS will allow for almost continuous operation through periods of bad weather.

Conclusion

Launch and recovery should not be an afterthought. It is clear that it is a critical link in the chain when it comes to having an efficient and productive AUV survey system. Significant efficiency gains are possible for AUV operators by adopting the latest LARS technology and demanding capabilities which allow for continuous operation even in high sea state.

If the launch and recovery limitations are resolved, the ship and its human occupants will become the next limiting factor in offshore operations, being prone to sea sickness and fatigue. Future operators will likely be able to monitor autonomous survey vessels and their AUVs from shore, while they happily survey in conditions which would halt manned vessel operations today.

Ultimately, fully autonomous operations, including recharging, data download, and launch and recovery, will greatly increase AUV capabilities in the coming decades.

2020 Editorial Calendar

JAN/FEB

Ad Close: Dec 21

Underwater Vehicle Annual

Subsea Defense Tech

Manipulator Arms and Tools

Autonomous Navigation GNSS MEMS

Unmanned Vehicle Propulsion

Event Distribution

Subsea Expo 2020- Feb 11- 13, Aberdeen
Underwater Defense & Security - Mar 3-5, Southampton
Canadian Hydrograpic Conference- Feb 24-27, Quebec City
Oceans 2020 Singapore - Apr 6-9 Singapore

FEBRUARY

Ad Close: Jan 22

MTR White Papers: Oceanographic

White Paper Electronic Edition Publication Date: February 2020

MARCH

Ad Close: Feb 21

Oceanographic Instrumentation: Measurement, Process & Analysis

Oceanology International New Tech Gallery

Fiber Optic Cables, Connectors & Slip Rings

Marine Drones

Hydrographic Sonar & Software

Event Distribution

Oceanology International - Mar 17-19, London
Sea-Air-Space- Apr 6-8, Baltimore, MD

APRIL

Ad Close: Mar 21

Offshore Energy: Oil & Gas, Wind & Tide

Subsea Electrification

Lights, Cameras, Lasers, Multibeam Sonar

Buoyancy Technology

Scientific Deck Machinery / LARS

Event Distribution

Offshore Technology Conference- May 4-7, Houston, TX
AUVSI XPONENTIAL- May 4-7, Boston, MA

MAY

Ad Close: Apr 21

Underwater Defense Technology

Comms, Telemetry & Data Processing

Hydrophones

Magnetometers & Streamers

Beacons, Flashers & Tracking Systems

Event Distribution

UDT- May 12-14, Rotterdam
Underwater Technology Conference- Jun 16-18, Bergen

JUNE

Ad Close: May 21

Hydrographic Survey: Single & Multibeam Sonar

Research Institutions

USV Platforms

GPS, Gyro Compasses & MEMS Motion Tracking

Interconnect: Underwater Cables and Connectors

JULY

Ad Close: Jun 22

MTR White Papers: Hydrographic

White Paper Electronic Edition Publication Date: July 2020

JULY/AUGUST

Ad Close: Jul 21

MTR 100 - Edition

The 15th Annual Listing of 100 Leading Subsea Companies
MTR looks at 100 leading companies and executives in all subsea disciplines, defense, offshore energy and science.

Event Distribution

Offshore Northern Seas- Aug 31-Sep 1, Stavanger

SEPTEMBER

Ad Close: Aug 21

Autonomous Vehicle Operations

Subsea Residency

ROV Technology: Work Class to Micro Systems

Thruster Tech: Underwater Propulsion

Underwater Tools & Manipulators

Event Distribution

SNAME Sep 29- Oct 3,Houston, TX
Offshore Energy Europe- Oct 7- 10, Amsterdam

OCTOBER

Ad Close: Sep 21

Ocean Observation: Gliders, Buoys & Sub-Surface Networks

Instrumentation: Profilers, Samplers & Sediment Corers

Seafloor Mapping

Harsh Environment Systems for Arctic Ops

Geospatial Software Systems for Hydrography

Event Distribution

Oceans 2020- Oct 19- 22, Biloxi, MS
Blue Tech Week, San Diego, CA
MAST Japan Defense- Nov 2-4, Tokyo

NOVEMBER

Ad Close: Oct 22

MTR White Papers: Subsea Vehicles

White Paper Electronic Edition Publication Date: November 2020

NOVEMBER/DECEMBER

Ad Close: Nov 21

Acoustic Doppler Sonar Technologies ADCPs and DVLs

Fresh Water Monitoring & Sensors

Offshore Inspection, Maintenance & Repair (IMR)

Underwater Imaging: Lights, Cameras, Lasers & Multibeam Sonars

The 2021 Subsea Market Planner

Event Distribution

Underwater Intervention 2021

information may be subject to change

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A New Take on PIPELINE INSPECTION

Sonardyne International

Photo: Sonardyne International

A young but ambitious team from Thailand are hoping to make pipeline inspection both easier and more cost efficient with a new autonomous underwater vehicle (AUV) they have designed from scratch. The team, part of unmanned vehicle system company HiveGround, has been working on the system for three years under a project initiated by a tech spin-off company AI & Robotics Ventures (ARV), a wholly subsidiary of Thailand's national petroleum company PTT Exploration and Production (PTTEP), with support from Department of Computer Engineering, Faculty of Engineering, Kasetsart University, also in Thailand. Following prototype testing last year [2019], an upgraded model called Xplorer AUV will soon be launched as ARV and HiveGround start to eye commercial projects.

Sompol Suntharasantic, an electrical engineer at HiveGround, says, "We want to build an AUV that you can drop into the Gulf of Thailand to collect electric field gradient (EFG) data for cathodic protection assessments on the pipelines and video and multibeam data of the terrain around the pipelines, to check for free-spans, etc. Our goal is to cover all of the pipelines in the Gulf of Thailand before looking for bigger opportunities." A key element of the system is its navigation and positioning suite from Sonardyne International Ltd., but more on that later.

DOING MORE WITH LESS

The Gulf of Thailand runs along the eastern coast of Thailand with Cambodia to the north. In these waters, PTTEP operates more than 400 platforms and about 1,000 km of pipeline, in about 75 m water depth. Many of the pipelines stretch just 3-5 km between facilities, but some go out as far as 50 km. Surveying all of that subsea infrastructure currently involves deploying a tethered remotely operated vehicle (ROV) from a Class 2

or 3 dynamically positioned (DP) vessel. DP is needed in order to be able to enter the 500 m platform exclusion zones in order to follow pipeline systems all the way up to the platform base. But DP vessels can be costly.

The Xplorer AUV solution provides an untethered and more autonomous vehicle, which can be launched and tracked from a lower class, and typically smaller, therefore less costly vessel that doesn't need to go into the exclusion zone – and so doesn't require the higher DP rating. "With this method, we can use a small vessel which saves operational cost compared with using a work class ROV or using a larger vessel," says Sompol

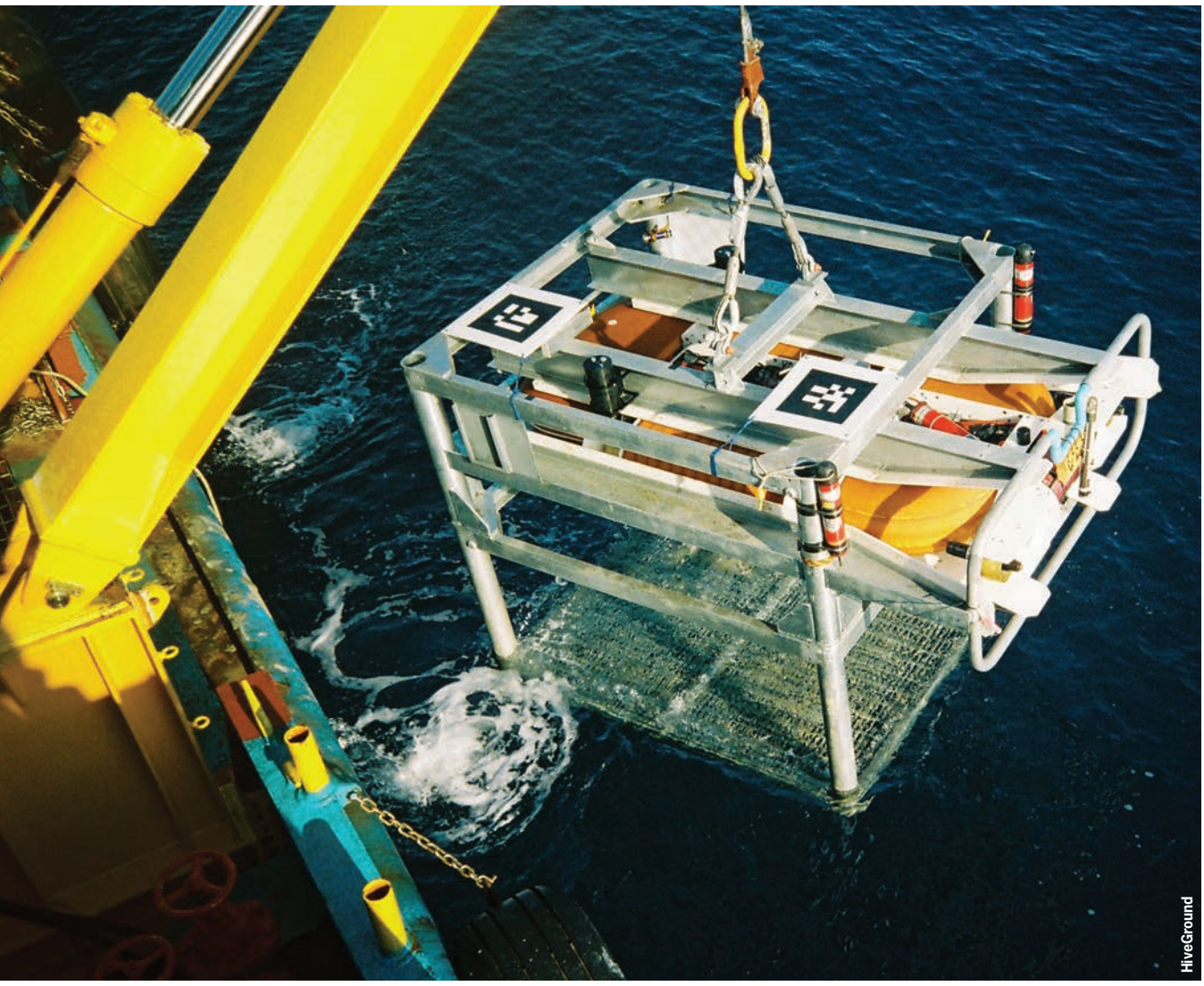
The Xplorer's initial 300 m depth-rated vehicle payload included a 10 kWh battery, powering six 500W thrusters and enabling it to work for eight hours, or to cover about 10 km per dive (or 30 km per day) at speeds of about 1.4 km/hr (0.75 knots), with speeds in excess of 2.16 km/hr (>1 knot) possible. The goal is to have a vehicle able to travel 100 km, i.e. out 50 km and back 50 km, says Sompol, as well as being able to work down to 200 m water depth.

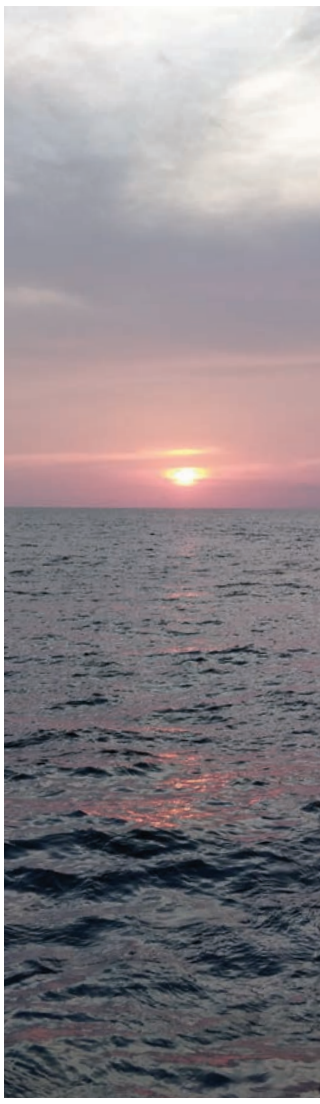
The payload also includes a video camera (SubC Imaging), an EFG probe (Polatrak), multibeam sonar (Imagenex) for terrain mapping and to support the pipeline tracking functionality and multibeam forward looking sonar (Teledyne BlueView). HiveGround's plans also include close range visual inspection and mechanical inspection such as a CP probe.

OPTIMAL NAVIGATION AND POSITIONING

Key to enabling a level of autonomy for the vehicle is having a reliable and accurate navigation solution, so it knows where it is. Sonardyne technologies have been chosen, specifically Sonardyne's SPRINT inertial navigation system (INS) and Syrinx Doppler velocity log (DVL). SPRINT is an acoustically aided INS which makes optimal use of acoustic aiding data from acoustic inputs, including Ultra-Short BaseLine (USBL) and Long BaseLine systems, as well as DVLs and pressure sensors.

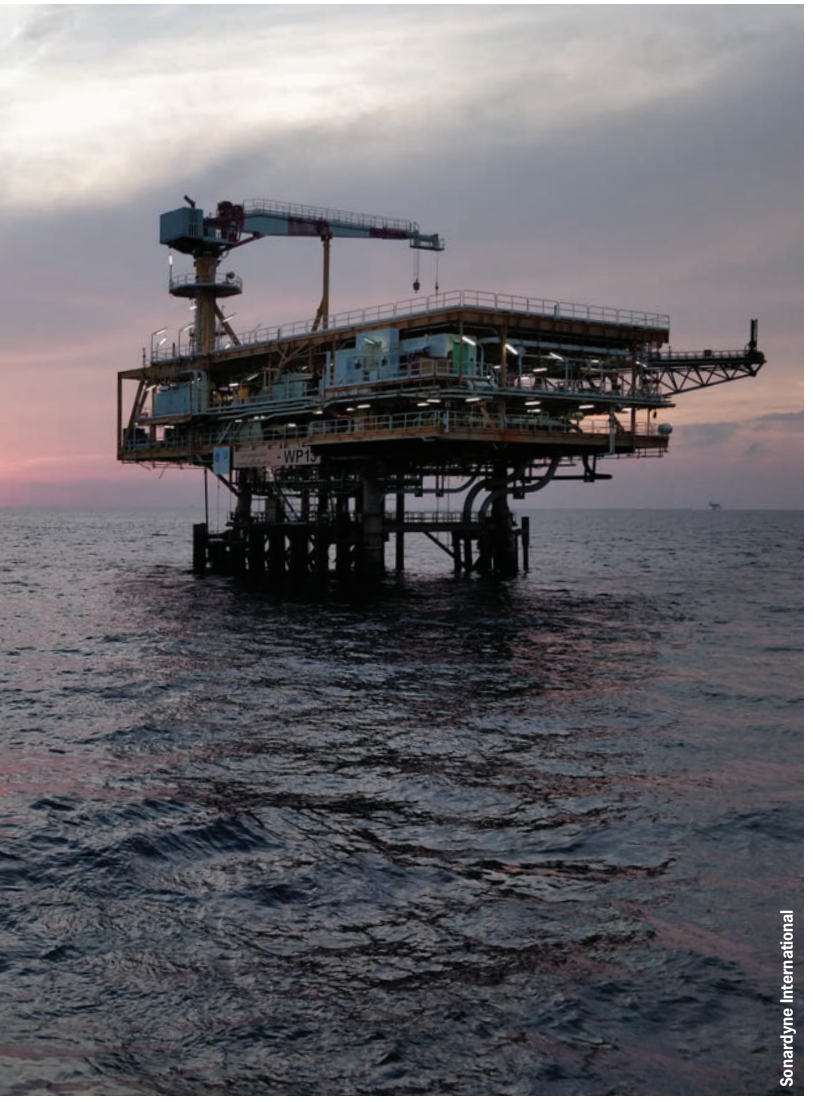
The 600 kHz Syrinx DVL offers a wide operating range – from 0.4 m to 165 m – with the velocity resolution of a high frequency DVL, making it hugely versa-


HiveGround



tile and capable instrument, with optional acoustic Doppler current profile (ADCP) functionality. A bonus for the Xplorer is having instruments that are designed to work seamlessly together and then built and tested together, all by the same company, which means users get optimal performance and one-stop-shop support.

For positioning from the vessel, a Micro-Ranger 2 USBL system, with an AvTrak 6 integrated into the AUV for positioning and telemetry, has been chosen. Built around Sonardyne's Sixth-Generation (6G) hardware and Wideband 2 digital acoustic technology, Micro-Ranger 2 is an easy to use system that provides ideal support for shallow water operations from smaller vessels. Used with AvTrak 6, Micro-Ranger 2 unlocks tracking, telemetry and vehicle command capability. In addition, Wideband Sub-Mini 6 Plus (WSM 6+) beacons are being employed to support its launch and recovery system. This involves deploying a cage containing the AUV overboard and then through the splash zone to deployment depth, where the AUV swims out.


Sonardyne International

For tracking pipelines, the team at HiveGround has developed a Robot Operating System (ROS) based navigation software to locate an actual pipeline which has a small offset from the CAD drawing. The software has an AI module that processes real-time multibeam data to output a pipeline position, then the AUV path can be calculated following the pipeline to accomplish the mission.

”When we drop the cage down to the seabed, we drop it about 20 m away from the pipeline and from there it will automatically start searching for the pipeline and then tracking it up to the platform riser base and then fly back,” says Sompol. “After it has done its mission, we can send a command via the USBL to the AvTrak 6 to tell the AUV to find its cage. It will then start moving from a nearby pipeline to the cage.” The AUV further locates the cage using the two WSM 6+ beacons, as well as Alvar AR tag machine vision markers for orientation. This makes deployment and recovery faster and saves the vehicle battery, says Sompol, taking just 15 minutes to get from seabed to deck.

In an emergency, the vehicle is programmed to drop a weight and float to the surface where it would report its position via satellite communications for up to 45 days. If it is not safe to surface it could move to the bottom and use the AvTrak 6 as a relocation beacon for 30 days, he adds.

IN-WATER TRIALS

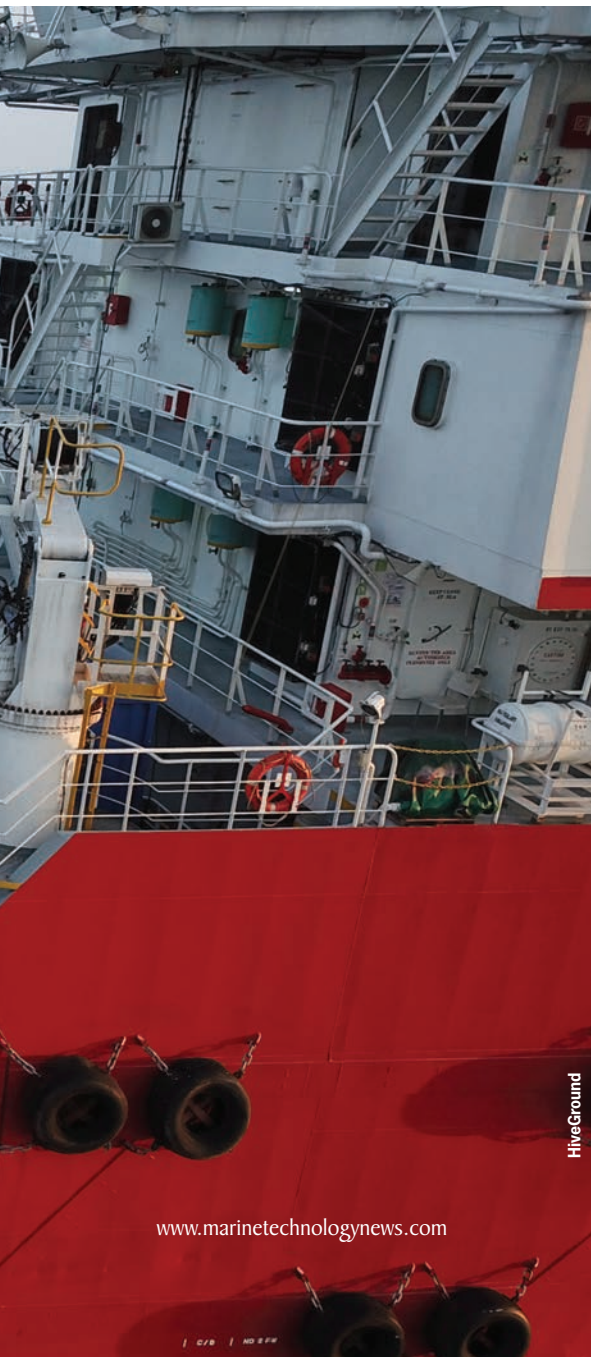
Following pool testing of various sensor and navigation packages and systems, initial offshore trials were carried out in 2018, in the Arthit field, in the Gulf of Thailand – just two years after the project team was launched. The Xplorer engineering team, consisting of ARV and HiveGround, then performed a further two offshore trials of its fully integrated AUV in July and November last year. Both trials had technical support from Sonardyne engineers – another benefit of going to the same company for a suite of navigation and positioning systems.

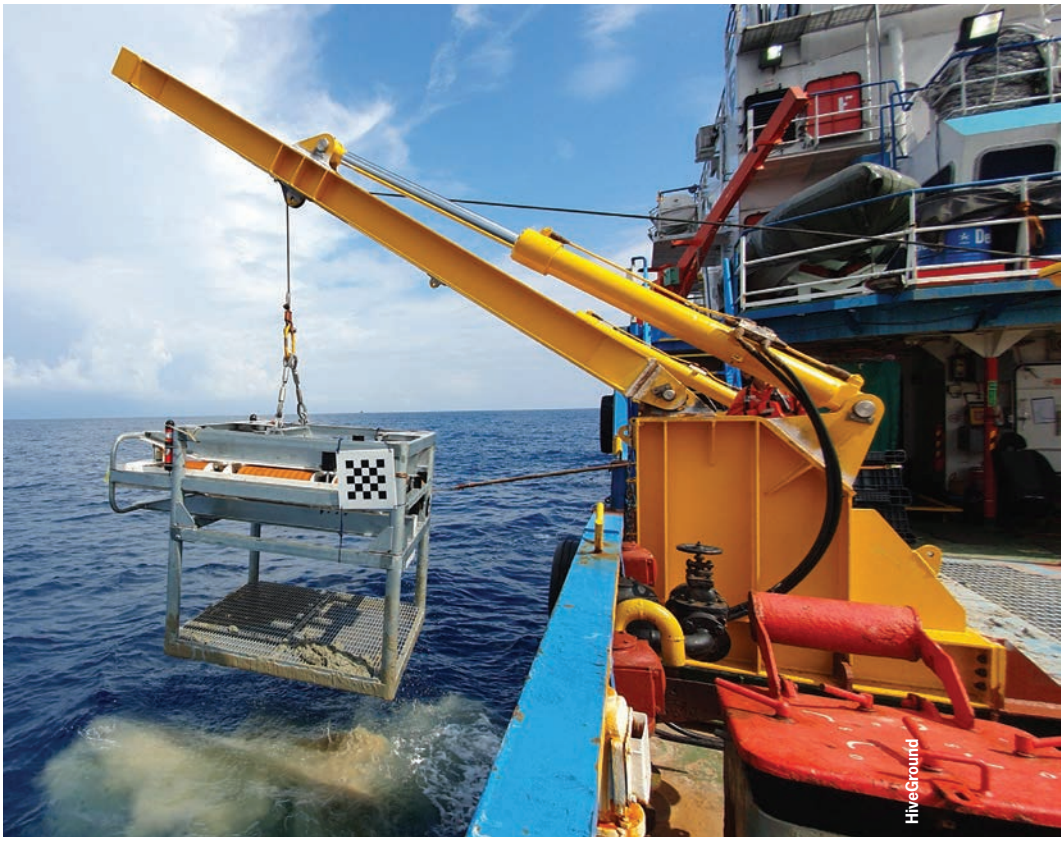
The latest trials, in November 2019, also in the Arthit field, saw the 500 kg, 2.4 m-long, 1.3 m-wide and 53 cm-tall untethered AUV deploy from its cage and successfully find its way back into the cage, says Sompol. It was also tested for obstacle avoidance and automatic path generation at two pipeline crossing points. The vehicle also performed semi-

autonomous exit and re-entry of its cage, auto search for pipeline targets, auto-pipe tracking and semi-autonomous approach to a riser flange on a well head platform. During these trials, the AUV was fitted with an AvTrak 6 tracking and telemetry beacon, was tracked using a rented Mini-Ranger 2 USBL and used WSM 6+s on the cage for homing.

INCREASING CAPABILITY

This year, the joint-effort between ARV and HiveGround's continues – with the key objective to build the latest model of the vehicle for more trials to ensure system robustness and pave ways to a full commercialization.





ONE-ON-ONE WITH DUANE FOTHERINGHAM

PRESIDENT, UNMANNED SYSTEMS, HII

Hydroid, a familiar name in the Unmanned Underwater System defense market, was bought this year by Huntington Ingalls Industries (HII). We checked in with Duane Fotheringham, President, Unmanned Systems, HII, for insights on the path forward for autonomy in the defense sector.

By Greg Trauthwein

Pictured Above: From left to right, Machinist Mate 1st Class Micah Patterson, Boatswains Mate 1st Class Stephen Wodraska, Mineman 1st Class Coy Tully and Mineman 3rd Class Pete Calvert, assigned to Commander, Task Group 56.1, launch a MK 18 MOD 2 unmanned underwater vehicle from a rigid-hull inflatable boat during Squadex 2016. Squadex 2016 demonstrates U.S./U.K. mine detection capabilities in the U.S. 5th Fleet area of operations.

(U.S. Navy Combat Camera photo by Mass Communication Specialist 1st Class Blake Midnight)

> ""By leveraging advanced GPUs to run machine learning algorithms, performing data fusion from sensors and maintaining greater situational awareness, vehicles will have the ability to adapt in real-time to their environment."
>
> **Duane Fotheringham**
> President, Unmanned Systems, HII

Hydroid is a long-established, well-known name in the subsea Autonomous Underwater Vehicle (AUV) sector that recently had a change in corporate ownership, joining the Huntington Ingalls Industries family of companies. "The immediate impact is that we are now part of a much larger organization and have access to those resources," said Fotheringham. "The Unmanned Systems business unit consists of the REMUS, Seaglider and Proteus product lines as well as support to Boeing on the Orca program, which broadens our portfolio and allows us to offer the full range of UUVs, from small class to extra large class."

HII is not simply a larger corporate entity, but one with a treasure trove of experience serving the U.S. Navy with surface ships, nuclear aircraft carriers and nuclear submarines. "We are also able to leverage HII's expertise in submarine and ship design to provide increased capability in platform integration," said Fotheringham.

With the move under the HII banner the Hydroid brand is transitioning into Huntington Ingalls Industries. According to Fotheringham, "the REMUS and Seaglider brands will remain product lines within the organization. We will also continue to advance REMUS as part of our partnership with the Woods Hole Oceanographic Institution (WHOI) through our technology transfer agreement."

Serving the Navy

While traditional subsea companies manufacture product primarily for three broad targets: military, offshore energy and science, the military clients come with a unique set of requirements. "With the U.S. Department of Defense focusing on Unmanned Maritime Autonomy Architecture (UMAA) and Modular Open Systems Architecture (MOSA), open architecture is vital to ensuring compatibility across systems, platforms and domains," said Fotheringham.

"Launch and recovery becomes a challenge when a UUV might be launched from a dock, a RHIB, a submarine or a vessel with a high freeboard. Our new-generation UUVs are all being designed with modularity and flexibility in mind to ensure compatibility across many different mission types.

Regardless of end customer, Fotheringham has guidance over an enviable family of UUV's to meet the mission. "Our main product lines have always been the REMUS 100, REMUS 600 and REMUS 6000. However, the technology that goes into these systems is scalable," said Fotheringham. "The REMUS Technology Platform includes advanced core electronics, open architecture, autonomy and modularity that can be scaled to everything from small-class to extra large-class UUVs. While physical parameters are designed to the specific requirements of a vehicle, the key to this technology is independent of hull diameter, size or depth rating.'

The Seaglider product was integrated into the portfolio last year. The M1, a 1,000 meter-rated buoyancy-driven glider, has been in development since 1995, and according to Fotheringham more than 150 have been sold worldwide. "We are also beginning to manufacture the Seaglider C2, a 200 meter-rated glider that can go from fresh to salt water without the need to reballast."

As with any tech company in the sector, resting on past success is not an option. "Recently we delivered the REMUS 300, a small-class UUV, to the Defense Innovation Unit (DIU) for evaluation by the Naval Information Warfare Center," said Fotheringham. "With advanced modularity that includes swappable payloads and battery sections, this UUV provides flexibility to maximize endurance and portability in easily changeable configurations."

With the market for offshore energy production currently is disarray, military markets offer potential for suppliers of advanced unmanned systems. "Based on recent U.S. Navy requirements for the small and medium UUV RFPs, modularity and flexibility seem to be key. They have requested systems that can perform many different missions from different platforms," said Fotheringham. "With an increasing focus on unmanned systems, I think we will continue to see the need for advanced autonomy. UUVs act as a force-multiplier, expanding the reach of our defense forces and helping them to complete missions more efficiently."

Challenges Ahead

While technology has evolved rapidly in the subsea space, there remain challenges to work efficiently, effectively in what is arguably the harshest environment on the planet. "Our customers want to perform longer and more complex missions," said Fotheringham. "The key to being able to accomplish this is autonomy and reliability. With UUVs the ability of an operator to interact with the vehicle is limited; therefore, the autonomy must be advanced enough to accomplish the mission and overcome unforeseen challenges and changing environmental conditions with no operator input. It also must be reliable enough to operate for long periods of time without failure."

Advances in autonomy, artificial intelligence and machine learning will continue to push the boundaries of what is possible, according to Fotheringham. "By leveraging advanced GPUs to run machine learning algorithms, performing data fusion from sensors and maintaining greater situational awareness, vehicles will have the ability to adapt in real-time to their environment. Fielding these systems also requires new approaches to verification and validation to ensure their safety and reliability. Not only are we investing in these areas, but we have also focused on building an open architecture that supports insertion of new technologies and algorithms developed by us and other third parties.

Advances in autonomy, of course, require ample ability to invest. "As discussed, we invest heavily in advancing the modularity, reliability, open architecture and autonomy of the REMUS Technology Platform," said Fotheringham. "We are also investing in ways to make the vehicles easier to use and

THE IMPACT OF COVID-19

No business is immune from the impacts of the COVID-19 pandemic, and Huntinington Ingalls Industries Unmanned Systems is no exception. "Massachusetts, the base of our Unmanned Systems business unit, is currently under regulations that require non-essential businesses to remain closed," said Fotheringham. "The production of technology related to national defense is considered an essential activity, so we are continuing to manufacture all product lines with some modifications. Anyone who has the ability to work from home has been doing so since March. This limits potential exposure of our manufacturing and engineering personnel and allows employees to balance work with their family requirements. Personnel who can only work onsite also have the option to change to a more flexible schedule. We've instituted social distancing requirements at our facility to ensure employee safety, and we are doing everything we can to make sure our employees remain safe while continuing our responsibilities as an essential business."

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maintain. On our latest REMUS 300 vehicle, we introduced field-swappable, environmentally sealed batteries in several sizes that allow the user to quickly get the vehicle back in water in a configuration that meets their mission profile. We have also maximized the use of common parts and assemblies throughout the REMUS Technology Platform, reducing logistics and total ownership costs for our customers."

In addition, he said the company is constantly on the lookout for new options to shorten the cycle between data collection and putting the data to use. "Recently, we integrated an in-mission processor onto a REMUS 600 with high-resolution interferometric synthetic aperture sonar (HISAS). This processor compresses the imagery as it's collected, reducing data offload times when the vehicle returns," said Fotheringham. "This is ideal for time-sensitive missions like mine countermeasures, where faster data access means safer, more efficient operations."

Arguably the greatest challenge today, still, lies in the ability to find and deliver increasingly robust power supply. "We anticipate that improvements in safe, reliable, long-endurance energy systems over the next few years will have significant immediate impact on UUV capabilities," said Fotheringham. "The physical endurance of a UUV is much greater than the energy systems that currently power them, so increasing the energy density on a vehicle pays immediate dividends. This supports the longer, more complex missions discussed previously. A vehicle designed from the bottom up to be modular and flexible, like the REMUS 300, can make use of any of these energy system improvements as they come online."

There are many developments ongoing to bring new, safe battery chemistries, fuel cells and other hybrid energy systems to the UUV domain. "These can be integrated over time to increase the endurance of an existing vehicle through spiral upgrades, using our well-defined hardware and software interfaces," said Fotheringham.

The REMUS Family: From top to bottom, the REMUS 100, REMUS 300 and REMUS 600 HISAS.

Photos: Hydroid

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DEFENSIVE *Drivers*

It is no secret that the defense industry is a driver for innovation in the subsea sector, with the deep pockets and the interest in driving tech to the next level. MTR checks in with four leaders in the sector of their insights on the pace and direction of development.

By Greg Trauthwein

The Participants

- **Ben Kinnaman,** CEO, Greensea Systems, Inc.
- **Mark Kenney,** General Manager, Unmanned Maritime Systems, L3Harris
- **Jesse Rodocker,** President, Strategic Robotic Systems
- **Chris Gibson,** VP of Sales, Marketing & Business Development, VideoRay

Tell us a bit about your company, its technology, with specific insight on your offering for the defense sector.

Kinnaman, Greensea

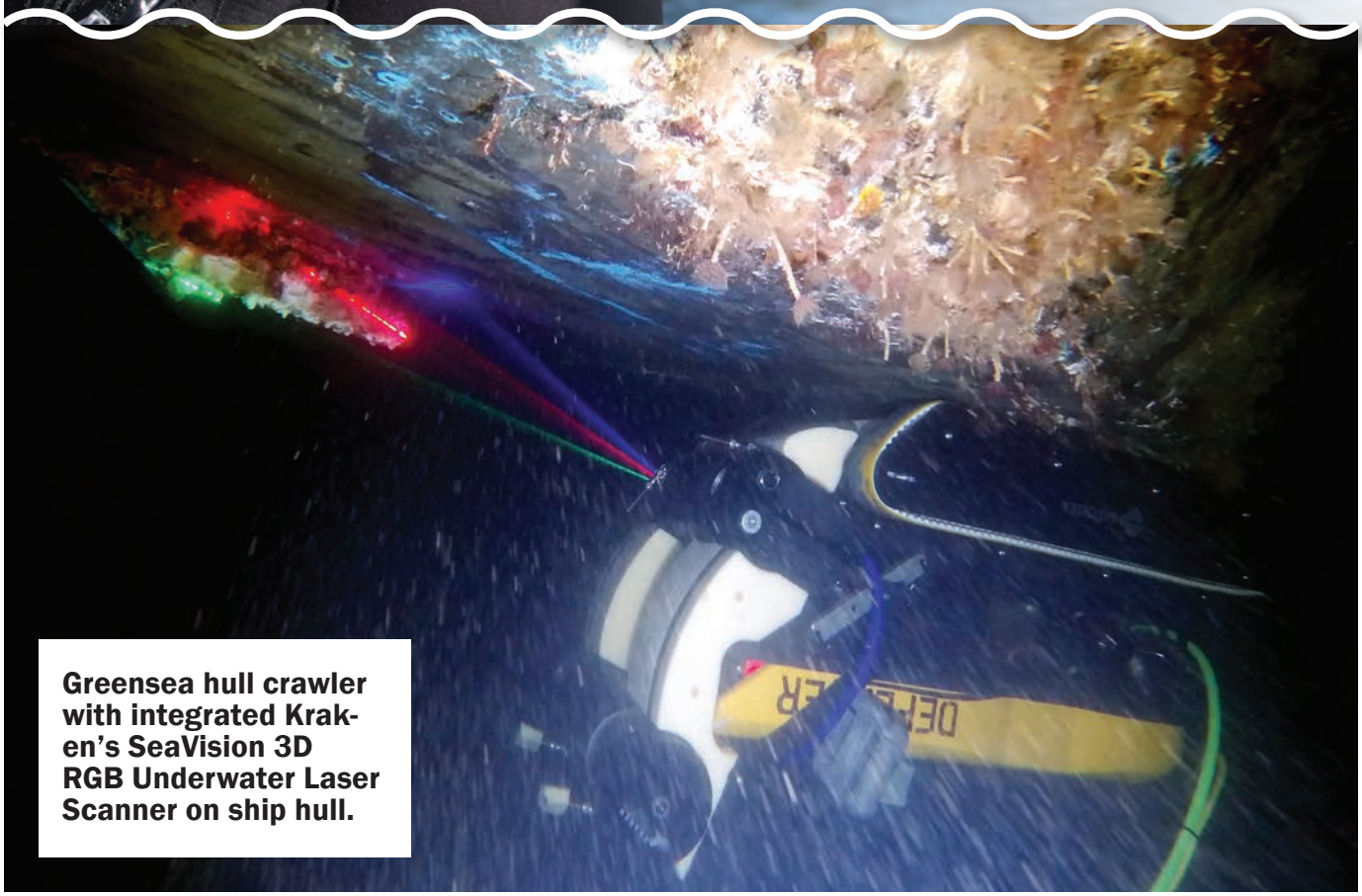
Greensea Systems, Inc. (Greensea), founded in 2006, develops advanced technologies to improve the relationship operators have with robotics and machines in the maritime domain. Our mission is to make operators and technicians working with robotics more productive. We do this through three primary technology areas: Navigation and Localization, Control and Autonomy, and Human Machine Interfaces. All of our solutions are built on an open architecture software framework for marine robotics called OPENSEA that Greensea owns, develops, and maintains. Greensea directly supports three key application areas in the defense sector: Maritime Explosive Ordnance Disposal (EOD), Special Operations Forces (SOF), and Ship Hull Robotics. In each of these areas, we provide operators with holistic, real-world solutions by partnering with them during product development, training, support, and research and development. Our work in these areas is actively supported by multiple US government programs including R&D programs, CRADAs with NUWC and NIWC, and SBIR/STTR programs.

Gibson, VideoRay

Founded in 1999, VideoRay underwater robots help prevent terrorism, find and retrieve objects, inspect infrastructure both inland and offshore, and keep divers safe from hazardous conditions. Hallmarks of VideoRay systems are ruggedness, reliability, portability, ease of use, and integration with a wide range

"The defense sector is a strategic priority for Greensea. Not only is the military a primary consumer of marine robotics technology, the warfighter faces more challenges than other operators."

Ben Kinnaman
CEO, Greensea



Greensea hull crawler with integrated Kraken's SeaVision 3D RGB Underwater Laser Scanner on ship hull.

Photos: Greensea Systems

of sensors and tools available for inspection-class vehicles. VideoRay specializes in one-man portable underwater systems.

Since launching Mission Specialist technology in 2017, the VideoRay Defender and Pro 5 models have become increasingly dominant for one-man-portable systems for the world's Navies and Coast Guards. The largest and most powerful Mission Specialist configuration, the Defender, is optimized for precise control, heavier payloads, lifting, and specialized operations. The most portable, the Pro 5, has similar advantages but is smaller. Mission Specialist technology is unique in the ability to add new sensors and accessories from a broad range of manufacturers, as it supports a wide range of power and communications options.

Standard VideoRay Mission Specialist ROV modules include cameras with a wide range of resolutions, bright and efficient LED lighting, and powerful thrusters capable of up to one horsepower. There is a broad assortment of accessories and instruments, including manipulators, positioning and navigation systems, radiation sensors, water quality, metal thickness, imaging and multibeam sonars. Options include purpose-built frames customized around the payload requirements of the operator's chosen sensor and tooling package.

Rodocker, Stratgic Robotics

Strategic Robotics Systems manufactures the FUSION hybrid ROV/AUV system, which was specifically designed for defense operators. The goal of the design was to create an effective acquire and reacquire tool for EOD/MCM operators by bring next generation designs and features. FUSION is designed to operate from a rubber boat by a couple operators without the need for a generator or large footprint. The system is tightly integrated around key sensors for most missions with the ability to accept unique options. Specifically the FUSION has a payload bay that features modules such as a release mechanism for payload delivery. With FUSION operators can take already captured target databases and using automation go to each target for ID and interrogation.

Kenney, L3Harris

L3Harris has approximately $18 billion in annual revenue and 50,000 employees, with customers in 130 countries. As part of our unmanned maritime system offerings to the subsea defense community, we offer the Iver family of UUVs. The Iver4 is a next-generation small diameter UUV featuring ultra-low logistics, extended mission duration, highest quality sensor data, and swappable payload and battery sections.

What percentage of your business in 2019 was in the defense sector?

Kinnaman, Greensea

A little more than 60% of Greensea's business in 2019 either sold directly to defense customers or to OEMs who sold into the defense sector.

Gibson, VideoRay

About 30% of VideoRay's business in 2019 came from the Defense sector.

Rodocker, Stratgic Robotics

SRS business is approximately 90% or more defense.

Kenney, L3Harris

Unmanned Maritime Systems does about 66% of our business in the defense sector. Much of this work is US and International defense contractors and agencies who procure our goods and services via commercial contracts.

In general, discuss the importance of the defense sector to your company and the trends regarding the size and pace of the market in recent years.

Kinnaman, Greensea

The defense sector is a strategic priority for Greensea. Not only is the military a primary consumer of marine robotics technology, the warfighter faces more challenges than other operators. Greensea have successfully provided the military with cutting-edge technologies to solve their most demanding operations.

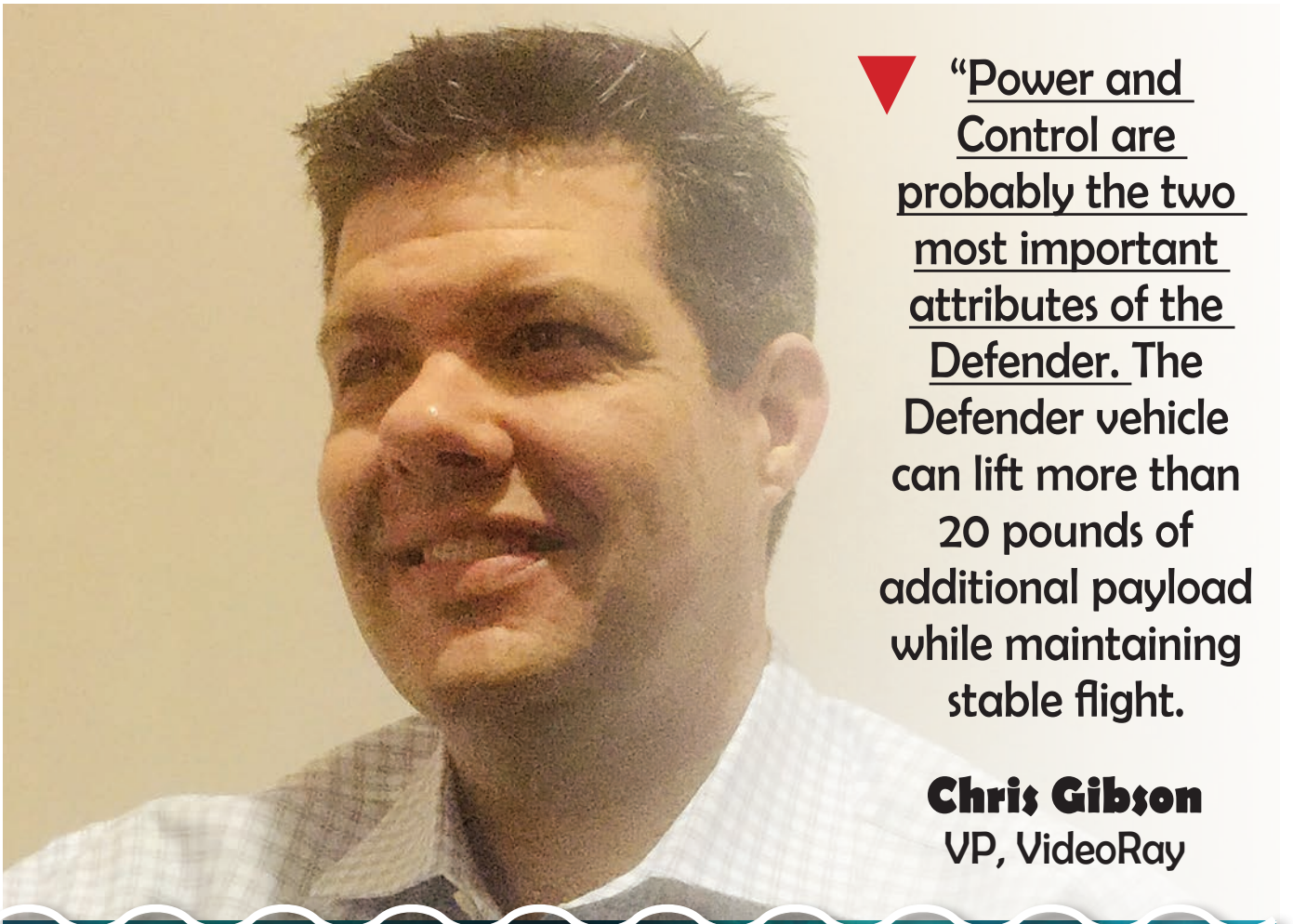
Greensea engages in the defense sector in three ways:

- Technology and product development. Direct-funded government programs to develop solutions required by the warfighter and to evolve existing products.
- Manufacturers and Defense Prime contractors. Prime contractors utilizing Greensea's OPENSEA open architecture software platform to develop emerging technologies and solutions for defense. Manufacturers providing Greensea's defense technologies in their robots, vessels, and products offered to the military.
- Direct support for the warfighter. Training, service, and support directly to technicians and operators using Greensea's defense products. This also provides invaluable feedback to Greensea's product development.

In the past two years, we believe the US military has made significant progress implementing processes to deliver needed technologies and capabilities more rapidly to operators and technicians. Greensea's software platform, OPENSEA, is an important component for supporting those initiatives because it is robust and flexible enough to support emerging requirements. It's not enough to be fast, the technology needs to be reliable and operationally ready. OPENSEA is the framework that can deliver both.

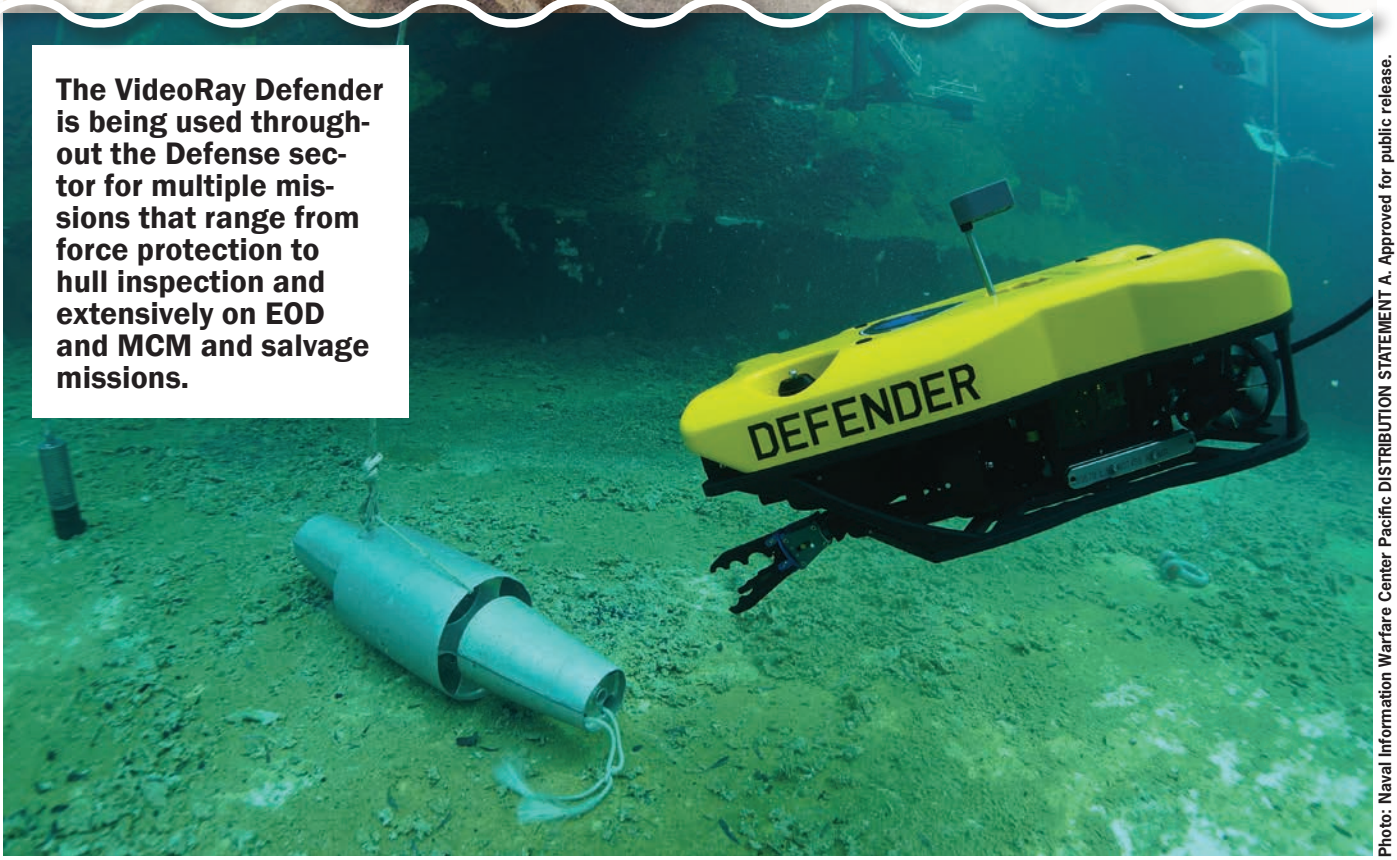
Gibson, VideoRay

We see technology initially developed for the Defense sector provides capability needed by commercial customers as well. We have also seen technology developed specifically for the oil & gas challenges demanded by our Navy users. VideoRay is positioned to share and commercialize technology across our more than 15 market segments.



"Power and Control are probably the two most important attributes of the Defender. The Defender vehicle can lift more than 20 pounds of additional payload while maintaining stable flight.

Chris Gibson
VP, VideoRay



The VideoRay Defender is being used throughout the Defense sector for multiple missions that range from force protection to hull inspection and extensively on EOD and MCM and salvage missions.

Photo: Naval Information Warfare Center Pacific DISTRIBUTION STATEMENT A. Approved for public release.

Rodocker, Stratgic Robotics

SRS was founded specifically to be a defense company and provide a solution to EOD/MCM operators globally. Beyond defense SRS only really works with public safety/law enforcement. Virtually all our R&D goes into improving the capability of FUSION for defense, albeit the system is a commercial product that could benefit many clients outside defense. More often we are seeing defense clients globally increase their use of UUVs as they try to remove the man from the minefield. There is only going to be more use by robots in the future.

Kenney, L3Harris

Growth of unmanned in the defense sector, whether it be international or domestic, is of critical importance to the growth of our business. There are five business units in the Unmanned Maritime Systems division and each were acquired to bring a unique and differentiating capability to compete in this space. It is the growing demand for unmanned systems to meet mission requirements for the U.S. Navy, whether under the surface or above, that is fuel for our business.

Discuss how defense sector requirements have helped to drive your company's R&D/ Product development over the past few years.

Kinnaman, Greensea

In addition to providing OPENSEA as a development platform to numerous defense contractors throughout the industry, Greensea directly supports three primary defense applications: maritime EOD, SOF combat diver mobility, and ship hull robotics. The solutions we provide in these three segments are based on years of direct feedback from technicians and operators throughout the defense industry, both domestic and international. We have carefully designed our business strategy within these segments to not only provide products, but to also provide training, service, and support directly to trainers, operators, and technicians. It is through this outreach that we receive the most valuable feedback that informs our product development.

Our company's R&D/Product Development for OPENSEA as well as for the products within our programs is guided by direct input from Program Offices as well as the Fleet. Greensea invests substantially to provide solutions to the military that address immediate requirements and that can evolve as those requirements evolve. Greensea also engages in funding opportunities that advance our products within our core program support focus.

Gibson, VideoRay

The Defense sector has driven several aspects of VideoRay's new Mission Specialist technology. Our engineering team maintains a close relationship with our military customers, through programs like our Cooperative Research and Development Agreement. This ensures rapid progression of projects through R&D, field trials, revisions, then production. Portability requirements have been designed into the Defender product. It is critical that the Defender be able to be transported anywhere in the world for rapid deployment while being operated and deployed by one man. Operational availability requirements are critical for the Defense sector. Modular Mission Specialist technology allows operators to quickly swap modules in the field minimizing downtime, while maximizing operational availability. Ease of use is another requirement that is important in the Defense sector. Auto flight controls delivered in Greensea's OPENSEA platform have engineered the talent out of piloting, making it much easier to perform operations. This also reduces training burden and skill fade.

Kenney, L3Harris

L3Harris had fielded more than 300 Unmanned Undersea Vehicles (UUV) before the Iver4 product was introduced. Through many years of successful operations and engagement with the warfighter, L3Harris saw a gap in capability between small and medium UUVs. Small diameter UUVs did not have the endurance, modularity, safe battery chemistry, and mission performance the operators needed, but medium class UUVs were difficult to handle with a large logistics footprint. After years of prototyping, L3Harris released the Iver4 900 to meet the requirements of the operators. It delivered a small diameter UUV (<10inches) that matched the capability of the medium vehicles (10-21 inches) without the logistics and battery safety challenges that kept these vehicles from being used for critical EOD, Submarine, and Naval Special Warfare missions.

What are the specific tech attributes of your system(s) that you have found to be particularly attractive to the defense sector (please be specific)?

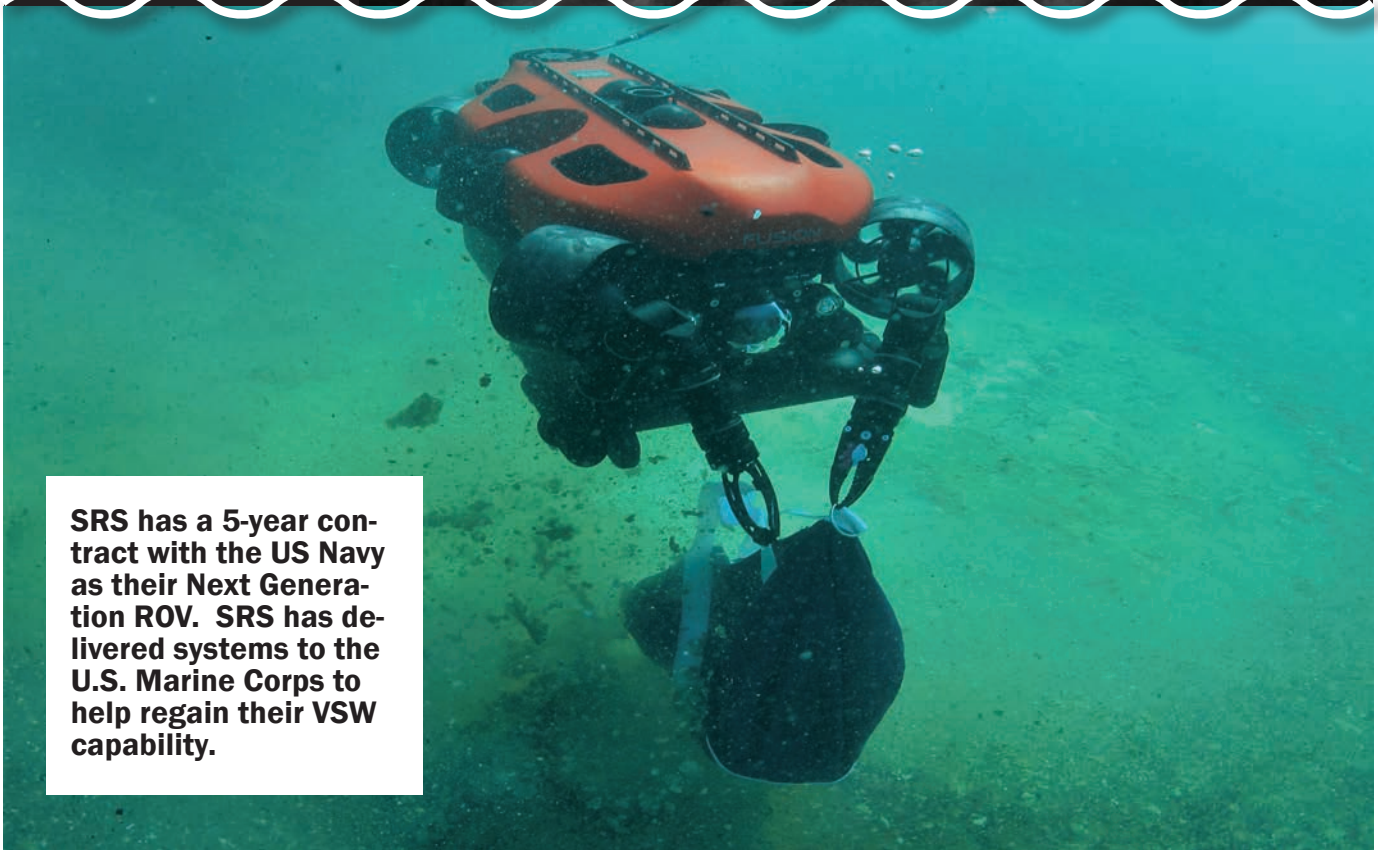
Kinnaman, Greensea

Both our platform and the technology we build on that platform have significant benefit to the defense sector.

We build all of our products and solutions on an open architecture software platform called OPENSEA. This is a commercially controlled open architecture software platform that enables the development of specialized capabilities leveraging existing robust solutions. OPENSEA provides the defense sector with a scalable, flexible, and severable platform that can respond rapidly to evolving requirements while maintaining the maturity of proven systems. We are using OPENSEA in several continuous integration and development programs where we are fielding new capabilities very rapidly, almost every two weeks, in mature software products to meet fleet requirements. This is a paradigm shift in defense technology development but essential for the modern fleet to respond to changing threats. An open architecture platform such as OPENSEA also allows the use of existing technology investments and provides a path for

"FUSION is a completely different approach to UUVs. FUSION is built around specific sensors that are more tightly integrated through strategic industry partnerships."

Jesse Rodocker,
President, Strategic Robotic Systems



SRS has a 5-year contract with the US Navy as their Next Generation ROV. SRS has delivered systems to the U.S. Marine Corps to help regain their VSW capability.

Photo: Strategic Robotic Systems

emerging technologies, regardless of the developer. This a powerful concept for the defense industry. Greensea specializes in technology that improves the way operators work with robotics. There are many application areas where robotics could solve tremendous problems, allowing our soldiers to be more effective and stay safe. Some of these most critical application areas cannot realize the full potential of robotics until specific technical problems are solved. These are typically navigation and localization challenges or control and autonomy problems. Often, the challenges could simply be the communication interface the operator is using to work with the robot. Greensea's technical products for the military provide novel solutions to these challenges. Our navigation technology optimizes the Size, Weight, Power, and Cost (SWaP-C) equation to provide exceptionally accurate navigation and localization solutions for constrained systems and CONOPS. A good example of this is our hull relative navigation solution we are developing with support from the US Navy Office of Naval Research. This is an open architecture navigation solution to provide 15cm positional accuracy for a miniature autonomous robot crawling on a ship hull.

Our control and autonomy technology specifically addressed the work-relationship of operators and robots. This technology provides robots with a high-level of control so that operators can have a smarter machine coworker. Moving more self-reliance, autonomy, and tasking capability to the robot frees the operator to be a Subject Matter Expert and conduct his job safely and effectively without having to be a robot operations specialist. This technology helps teams stay agile and helps minimize the specialized training for operators that has traditionally been required to field robotics for military applications.

Lastly, we focus heavily on the interface the operator has to communicate with the robot. Like our own relationships, the relationship an operator has with a robot comes down to communication. If he cannot communicate effectively the relationship is doomed. An operator needs to pass high-level instructions, receive concise and meaningful status, and execute quick accurate decision making. This comes down to the interface we provide for him to use.

To provide effective technology solutions to the warfighter, we have to listen carefully and then respond. OPENSEA provides us the ability to iterate on user interfaces quickly to find the best solution for our operators. We listen closely to what operators are telling us, and iterate until we get it right. This is the secret sauce and it is catching on the defense sector.

Gibson, VideoRay

Power and Control are probably the two most important attributes of the Defender. The Defender vehicle can lift more than 20 pounds of additional payload while maintaining stable flight. This power expands operational windows in high current or tidal areas where traditional ROVs struggle. The Defender can fly in pitch, which, for many defense customers, is a huge advantage. When you combine superior power with Greensea's OPENSEA control system, the operator can add unique payloads without needing to ballast or configure the vehicle for operation. The result is a powerful, flexible solution that a Navy can deploy as the operational environment dictates. When fitted with the Navigation package, the vehicle can mark and navigate very accurately to known points repeatedly.

Rodocker, Stratgic Robotics

FUSION is a completely different approach to UUVs and there are so many attributes that make a difference. Whats sets FUSION apart starts with the incredible attention to detail and thought that has gone into every aspect of the system. FUSION is built around specific sensors that are more tightly integrated through strategic industry partnerships. The user interface is recognized as the best in the industry. Completely battery powered system that doesn't require a generator and has a very minimal footprint requirement. The automation system is more stable, more precise and more intuitive. FUSION is both a ROV and an AUV. And to top it off the complete package is lower cost than our competitors.

Kenney, L3Harris

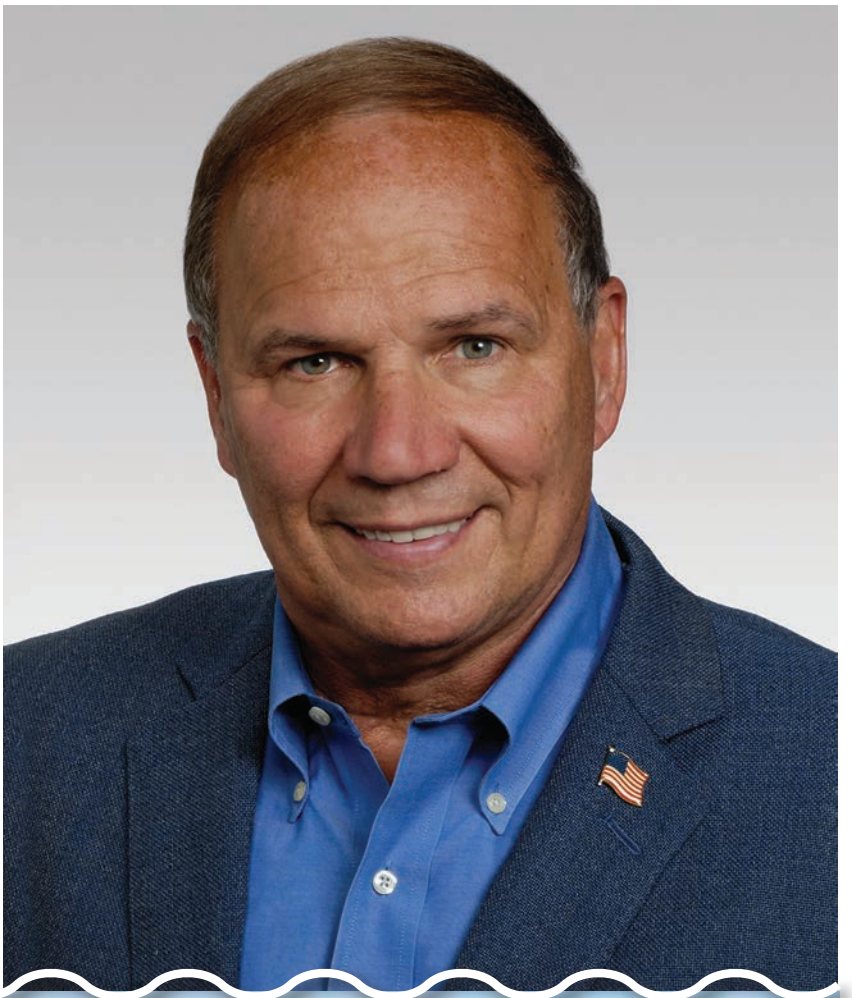
The Iver4 carries the highest performing navigation and imaging sensors available, while using swappable battery chemistries that meet flexible mission needs. The clean power architecture and signature mapping of the UUV ensure that the highest quality data is produced from the onboard imaging sensors. The unique, wet-mateable sections allow payload changes in the field that also ease commercial and military transport. The Iver4 provides an open interface and optional payload section for third party sensor providers to integrate their own hardware and software. Titanium and carbon fiber construction maximizes the useable volume in the pressure hull and decreases maintenance requirements when operating in harsh, open ocean environments.

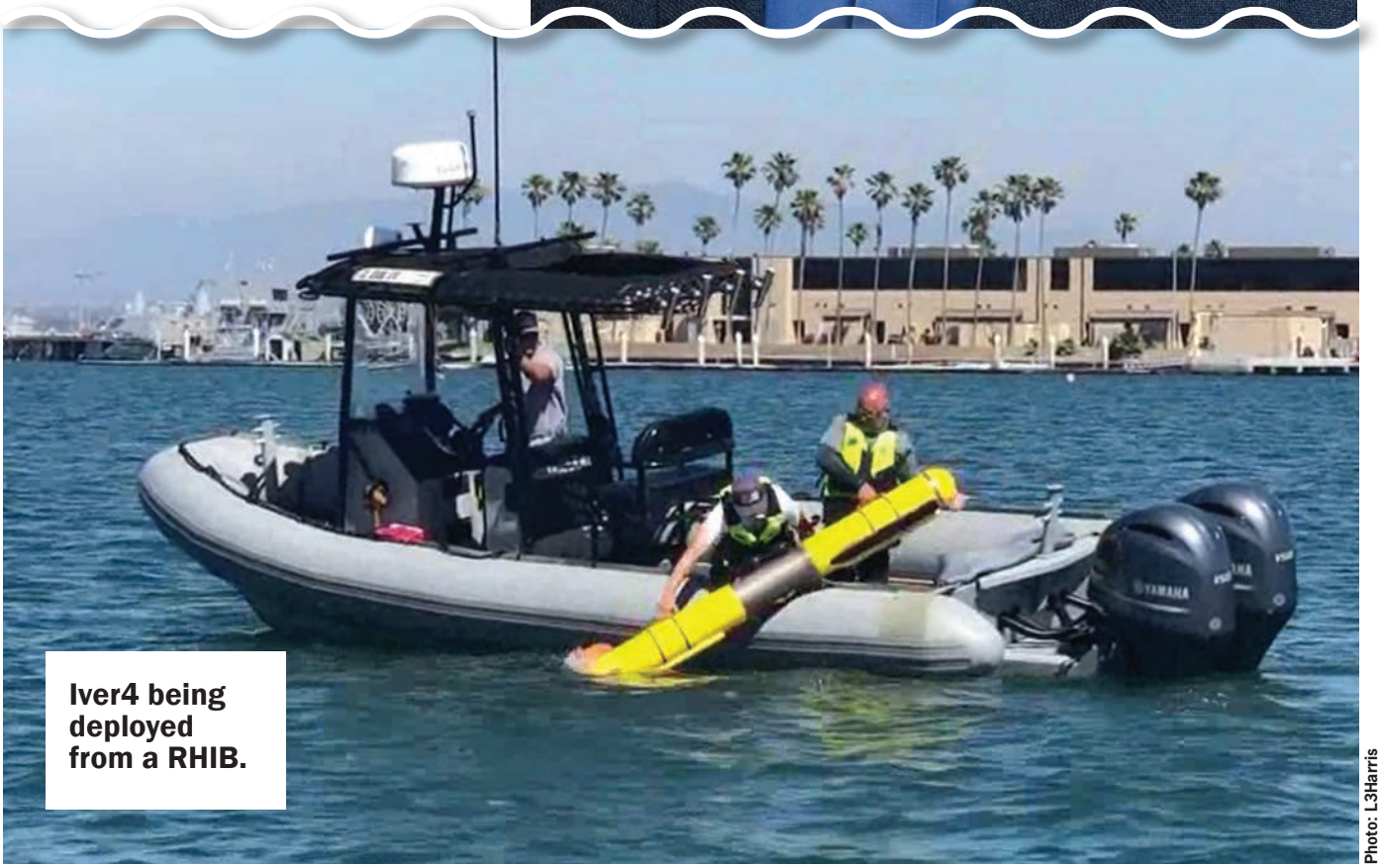
Get the Full Story on MarineTechnologyNews.com

This virtual round-table was conducted with individual interviews with the four subsea industry leaders profiled here. The full text of each individual interview can be found on *www.marinetechnology.com.*

"The Iver4 carries the highest performing navigation and imaging sensors available, while using swappable battery chemistries that meet flexible mission needs."

Mark Kenney,
GM, Unmanned Maritime Systems, L3Harris





Iver4 being deployed from a RHIB.

Photo: L3Harris

Case Study

Subsea defense technology put to the test

Greensea Systems and the EOD Workspace

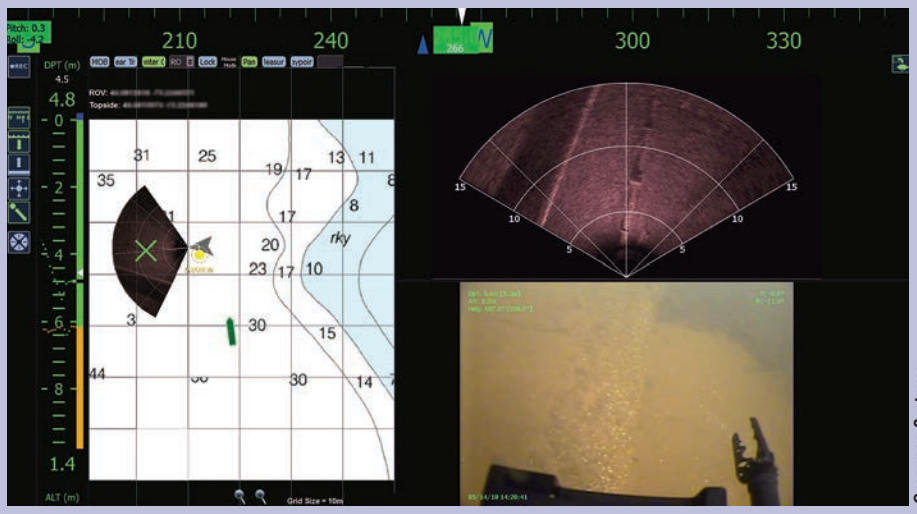
A good example of the application of Greensea's technology and business model is within our EOD Technologies business segment. This business segment is built around our EOD Workspace software product and is designed to fully support maritime Explosive Ordnance Disposal (EOD) activities using robotics. Within this segment Greensea provides open architecture software solutions based on OPENSEA as well as support, training, and R&D to develop additional technologies to meet emerging requirements.

Greensea has been supporting EOD forces since 2014 with several OEM software products fielded through various Remotely Operated Vehicle (ROV) manufacturers. Through this experience, it has learned of the growing disparity between the defense industry's expectations for miniature ROVs and what the commercial industry was providing. Commercially available ROVs were coming close to fulfilling what EOD forces needed, namely keeping pace with the evolving requirements of the military.

Traditionally, capability has been linked to hardware. Consumers purchased an ROV for the capability it provides. In this procurement model, the defense industry was limited by technology the hardware OEM could produce and support.

Greensea set out to change this paradigm by offering capability through software that could be ported to any hardware platform.

In 2018, Greensea released EOD Workspace for the US Navy to evaluate. EOD Workspace is a vehicle and hardware agnostic open architecture software suite designed specifically to support operations involving searching, identifying, reacquiring, engaging, and mitigating a submerged threat with a single robot or team of robots. EOD Workspace is often deployed as the command and control software system for a single ROV, but it can also manage multiple vehicles and vessels working within the total operational picture.



Greensea Systems

Screenshot of EOD Workspace software.

EOD Workspace uses the OPENSEA framework to provide a comprehensive open architecture solution for expeditionary robotics. It is based on Greensea's open architecture navigation, vehicle control and autonomy, and human machine interface technologies. EOD Workspace is designed to bridge the gap between commercial robotics and the requirements of expeditionary units. The sole purpose of this software is to make ROVs easier to learn, easier to operate, and more effective to use for highly critical tasks related to finding, identifying, and destroying subsea threats. It can also be extended to encompass data from other platforms, provide supervision and mission planning over other platforms, and allow interoperability between multiple teams and assets.

Perhaps the most powerful aspect of EOD Workspace is what it does not do today, but could do tomorrow. EOD Workspace, built on OPENSEA, is made to evolve.

This vehicle agnostic software platform is designed to deliver capabilities, fast, and with precision. It is designed to reach far beyond the physical system of a commercial or bespoke ROV and encapsulate capability. The open architecture allows the defense industry to use existing technologies already developed, rapidly transition emerging technologies to the fleet, and respond to new requirements easily.

Greensea has demonstrated the power of this open architecture framework since the 2018 release of EOD Workspace. It has provided support for several commercial and custom ROVs to EOD Workspace, extended EOD Workspace to diver hand-held navigation devices, and have integrated AUVs with EOD Workspace. It has also responded to new requirements by developing plug-in modules for EOD Workspace that include hull crawling capabilities, manipulator support, advanced intervention modes, tool operation, and long-range standoff command and control.

Greensea complements this technology and broadens the business segment by providing comprehensive support and training to EOD operators. Training and support include an online knowledge base, training videos, in-field training classes, and train-the-trainer courses. We are also releasing an EOD Workspace simulator in the second quarter of 2020 to assist operators learn the software, maintain proficiency, and practice operations on their personal laptops without the need to deploy an ROV.

Hydrophones

Novel Applications for Real-Time Hydrophones

By Rose Fisher, Ocean Sonics

The icListen Smart Hydrophone has been used around the world for many applications, spanning from the traditional to the novel. The differentiator of the icListen is it's real time processing capability, allowing users to actively listen and make decisions while the sensor is deployed. Discussed in this article will be novel applications for marine industrial noise monitoring, and for marine mammal study and conservation.

Noise mitigation is becoming an essential task for any organization or company working in our oceans and waterways. Those who work in marine construction, dredging and resource exploration know all too well the responsibility that comes with regulatory compliance.

Noise monitoring and mitigation laws are becoming commonplace around the world, yet the tools and methods that enable regulatory compliance are often lacking and difficult to use. Traditional systems put the onus on the users, requiring the operators to monitor 24/7 and perform difficult calculations to prove compliance. Most of these systems are unable to provide processed data in real-time, so if the mandated thresholds of sound exposure or sound pressure level (SEL,SPL) are exceeded, it is often not discovered until a report is compiled and calculations performed. Determining this after that fact is not helpful to the environment that these controls are put in place to protect, and as regulations become more stringent, it can mean legal trouble or fines for noise infractions.

The solution is to use a real-time ocean listening system that provides processed data. When real-time data is available, decisions can be made based on what is happening in that moment. If noise thresholds are being exceeded, it is clear to the operators. Compliance is simplified when issues are discovered when they occur. Using a real-time system can help industry operators avoid compliance infractions while protecting the marine environment.

Photo: Courtesy of Patagonia Project/Inset: Ocean Sonics

Hydrophone deployment. Inset: Launchbox laptop & hydrophone. Below: Patagonia Project group shot.

Real-time listening systems are not only for marine industrial applications, they are also changing the way researchers and marine mammal observers are operating. One such group, Patagonia Projects, located in the Patagonia region of Chile, has been using a real-time listening system to improve their research efforts.

Acoustic specialists have paired the icListen real-time audio with video footage from drones to improve the quality of their collected data. Researchers onboard the Patagonia Projects vessel, Saoirse, deploy the icListen along with a WiFi capable Launch Box, from a small floating platform. When marine mammals are detected, a video drone is flown from the vessel to the platform where researchers are able to capture synchronized video and audio streams. The researchers on board are able to communicate to their hydrophone using a simple web interface so they can configure the hydrophone in-situ without having to retrieve or redeploy the tool and risk disturbing their study subjects.

Through these efforts, the Patagonia Project team is looking to establish an MPA in the region. They are using these integrated and novel data collection approaches to bolster their case and gain the support of local government.

Sophisticated tools are changing the way we think about ocean sound data. Real-time data delivery and in-situ processing are making decision making easier and improving the way we work and study in our oceans. Tools, like the icListen Smart Hydrophone, are game changers for applications that rely on or are improved by real-time, accessible data. Delayed data is a thing of the past, get ready to Listen Now.

Tech Files

Innovative products, technologies and concepts

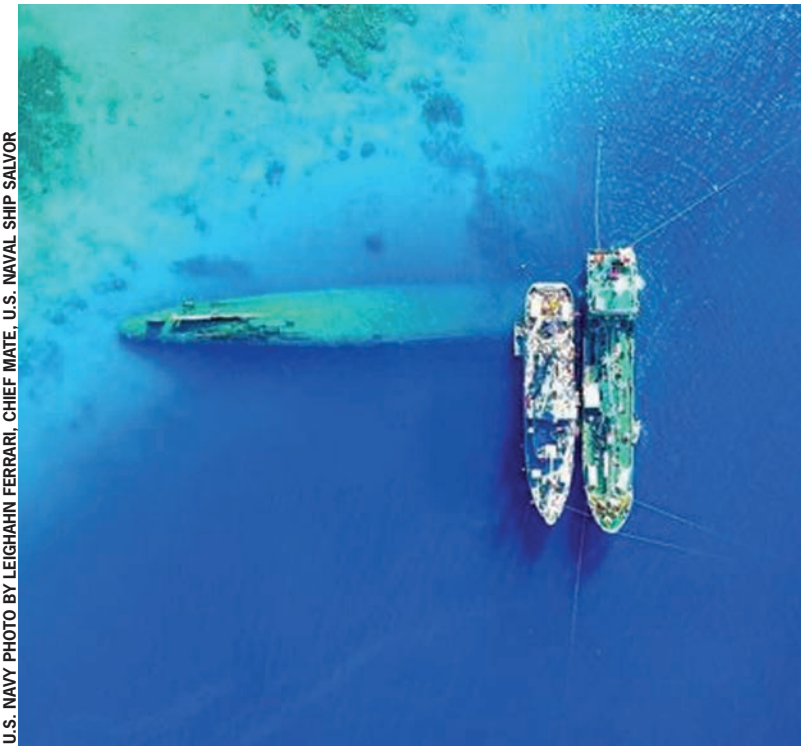
EvoLogics Modems for USN Use

ANU listing granted after favorable USBL accuracy tests

EvoLogics underwater acoustic modems were recently listed as Authorized for Navy Use (ANU), following a period of testing and technical evaluation by Naval Sea Systems Command (NAVSEA) and The Emergency Ship Salvage Material (ESSM) System. The ANU Program provides a list of selected diving equipment, tools and accessories which have undergone design safety reviews, testing and evaluation to ensure diver safety and acceptability. Engineers at ESSM who conducted the testing of the EvoLogics 18/34 kHz USBL modem system concluded "the system to be more accurate than our ability to physically measure the angle and distances between the USBL and the modem…these tests gave us confidence in the system."

The investigation of EvoLogics USBL positioning system was driven by ESSM in hopes of more efficiently locating fuel tanks in submerged shipwrecks for oil salvage. Specifically, ESSM were hopeful to use the system to locate fuel tanks on the wreck of the Prinz Eugen (shown below), a German battleship sunk in 1946 at Bikini Atoll.

ESSM tested the EvoLogics USBL system in Yorktown, PA using concrete floating piers. The USBL receiver was mounted in a fixed-location for the duration of the tests, suspended on a pole affixed to the side of the pier about 4 ft. below the surface. Repeated trials were conducted with the downside beacon modem moved to various positions to simulate a diver locating specific points on the hull of a vessel. EvoLogics modems utilize proprietary Spread-Spectrum Communication (S2C) technology, which stems from bionic concepts and allows for data delivery in challenging, shallow water conditions for a wide range of subsea applications. The EvoLogics system repeatedly demonstrated the necessary accuracy necessary to locate specific points on the hull.



U.S. NAVY PHOTO BY LEIGHAHN FERRARI, CHIEF MATE, U.S. NAVAL SHIP SALVOR

MacArtney All-Electric LARS

Image: MacArtney

Manufacturing has now begun and the first eLARS system, expected to come out of production in summer 2020, is underway.

The all-electric eLARS, developed in collaboration with MacArtney customers, features a number of eco-friendly benefits. Zero pressurized oil over water significantly reduces the risk of oil spillage, and energy efficiency is improved by more than 30% compared to hydraulic systems.

The new eLARS provides a low cost of ownership with Plug-and-Play mobilization, maintenance work reduced by up to 50% and cost-efficient spares with minimum lead times. Designed with a high degree of integrity, the actuation of the system is based on tried and tested MacArtney technology with built-in system redundancy and an emergency recovery mode. According to MacArtney the eLARS, surpasses existing LARS key performance criteria, boasts a compact design to increase workspace on the skid and is fully scalable to support any payload.

The all-electric eLARS includes the new MERMAC eA scalable A-frame, an a-Frame designed to meet any customer specifications. Winch options with the eLARS include the MERMAC R ROV winch series, the MERMAC S multipurpose winch series, the MERMAC Q stainless steel winch series and MERMAC M modular stainless steel winch series or custom winch options.

The first eLARS in production is designed to accommodate a wide range of Inspection and Observation Class ROV's and is designed around an ISO 20 ft. High Cube container size for easy transport and installation. SWL (Safe Working Load) is 3500 kg with a cable capacity covering a range from 3500m of Ø17 mm cable to 1250m of Ø31 mm cable.

MetOcean, FSU Collaborate on STOKES Iridium Drifter

MetOcean Telematics announced the development of the STOKES Iridium tracking drifter. The STOKES drifter was designed and tested in technical partnership with Florida State University (FSU). The STOKES drifter is a compact drifting buoy which tracks water currents at the surface. The small light-weight buoy is equipped with Iridium satellite telemetry, GPS positioning, and a sea surface temperature sensor. Iridium satellite telemetry enables the buoy to provide vital sensor and geo-positional location data in real time. Iridium also allows the buoy to have bi-directional capabilities. This is a critical ability, for example, if the buoy enters a region of interest the end-user can communicate with the unit by sending it a command to change reporting intervals or request essential time sensitive data. The applications for the STOKES are endless due to its overall size however, the buoy is ideal for purposes ranging from mapping large-scale ocean currents, oil spills monitoring, environmental monitoring, and aiding in search and rescue operations.

"The development partnership with Florida State University was invaluable. A group of true professionals who were committed and key contributors to the overall success of the project." said Tony Chedrawy, MetOcean Telematics President and CEO. "The STOKES is a complimentary addition to our suite of drifters and Iridium based products."

Image: MetOcean

CARIS: New Depth Data Management System

The Danish Geodata Agency (DGA) has completed a project to implement a new depth data management system, including the CARIS Bathy DataBASE, migration tools, system configuration and implementation. The project also delivered a range of training and consultancy.

The depth data management system from Teledyne CARIS provides the Danish Hydrographic Office efficient storage and management of depth data while supporting the current and future requirements, both internally and externally.

"DGA is a dynamic, data-centered, industry-leading agency that provides high resolution, quality data products. Their focus on automation for data storage and processing situates Denmark as a forward-leaning country," said Tami Francksen, Product Manager, Teledyne CARIS. "The challenge of migrating archives to a depth-management system has facilitated great discussion and idea sharing with our team."

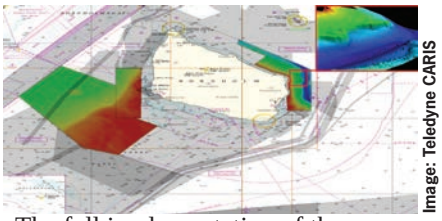


Image: Teledyne CARIS

The full implementation of the new depth data management system spanned over 18 months.

"Not only was the delivery of service met, the solution was also developed based on a proactive cooperation in an open-minded atmosphere which allowed development of the solution with the best fit to DGA´s needs for the future," said Yvonne Morville Petersen, Head of Function, Danish Geodata Agency – Geodatastyrelsen.

"With the new depth data management system we are ready to handle the exponential growth in data volumes acquired with modern survey techniques, as well as to respond to the increasing customer demand for bathymetric data and diverse derived products," Petersen said.

EvoLogics Acoustic Modem

S2C T "tiny" modems are the latest generation of light and ultra-compact modems from EvoLogics. Model T 42/65 with a wide-angle (100 degrees) beam pattern is optimal for vertical, slant, and horizontal data transfers over short- and medium distances, operates in the 42-65 kHz frequency range and is compatible with EvoLogics R- and M-series modems of the same frequency. With a speed of up to 31,2 kbit/s, the S2C T at only 25 cm standard height and 1200 g weight is a great fit for small AUVs and ROVs where seamless integration of hardware and software components is critical.


Image: EvoLogics

Tech Files

Innovative products, technologies and concepts

Kongsberg to Supply ASW Sonars for Finish Navy Corvettes

Kongsberg Maritime AS, Sensor & Robotics signed a contract with Saab that will see Kongserg delivering its Anti-Submarine Warfare (ASW) and diver detection sonars for the Pohjanmaa-class corvettes currently being developed by the Finnish Navy under its Squadron 2020 project. Under the terms of the contract, which equates to approximately $9.8m, Kongsberg will equip the vessels with its SS2030 and SD9500 sonars, both of which boast acoustic properties which make them ideally suited for deployment in shallow-water environments.

The SS2030, principally devised for ASW operations and capable of detecting torpedoes or other small objects in the water column, is an active hull-mounted sonar which uses sophisticated tracking algorithms. Its electronically-stabilized transmitting and receiving beams can be tilted to adjust to challenging sound speed profiles, with its integrated Sound Propagation Model determining the optimal tilt settings and enhancing the Probability of Detection (PoD) ratio. The SS2030 sonars will be delivered to the Finnish Navy complete with hoistable hull units and ice protection to ensure safe and efficient operation in the often harsh conditions of the Baltic Sea. The SD9500, meanwhile, is a light and compact over-the-side dipping sonar with horizontal and vertical positioning capabilities for diver detection, ASW duties and volumetric survey assignments in shallow, reverberation-limited waters.

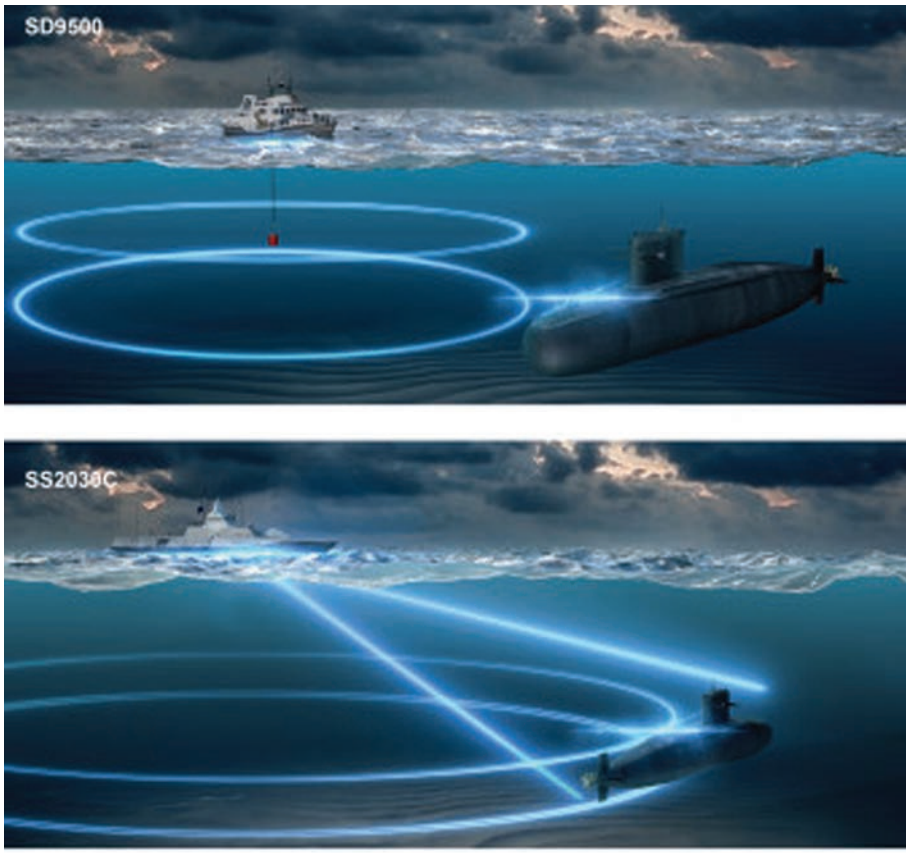


Image: Kongsberg

Elbit Integrated TRAPS on USV

Elbit Systems announced the integration of the Towed Reelable Active Passive Sonar (TRAPS) for Unmanned Surface Vessels (TRAPS-USV) onboard the company's Seagull USV. The sea trials included multiple deployment and recovery cycles, towing at different speeds and transmission at various power levels. Integration of the TRAPS-USV enables the Seagull USV to perform Anti-Submarine Warfare operations on-the-move, substantially extending its operative range and further enhancing its flexibility. The integration of the TRAPS-USV follows the recent conversion for operation, by the Israeli Navy, of Helicopter Long-Range Active Sonar (HELRAS) dipping sonar onboard the Seagull USV. TRAPS-USV is the compact and powerful low frequency towed sonar that was recently introduced by Geospectrum, the company's Canadian wholly owned subsidiary.

Image: Elbit Systems

Turner Designs C-FLUOR for Algal Culture Growth Monitoring

Monitoring algal growth in test tubes without affecting algal cultures is a challenge for researchers. Turner Designs recently demonstrated a solution to this concern using two standard products – C-FLUOR Chlorophyll probe with its In-Line Adaptor.

Multiple algal cultures were diluted to low concentrations of chlorophyll. Cultures were evenly distributed into 25 mm diameter glass test tubes and placed in a room temp environment near a window for exposure to natural light. Growth was monitored using Turner Designs C-FLUOR Chlorophyll Probe with the C-FLUOR In-Line Adaptor. Daily measurements were made and test tubes were returned to their original location near the window for continued natural light exposure. These measurements were repeated until each C-FLUOR Probe's response saturated.

C-FLUOR Probes output a voltage response proportional to the fluorescence detected. The C-FLUOR in vivo Chlorophyll Blue Excitation probe was used to measure the algal test tube cultures for this growth monitoring project. Turner Designs Databank Handheld Data Logger was used to display voltage. Maximum concentrations detected ranged from 90 to 183 µg/L and are plotted for five of the 12 cultures monitored.

Growth data can help determine ideal conditions for growth, calculate growth rates, or monitor densities for feeding experiments. Other sensors from the C-FLUOR product line can also be used to monitor for pigments such as Phycocyanin or Phycoerythrin which may indicate contamination of algal cultures. C-FLUOR are sensitive, low power single wavelength in situ fluorescence and turbidity probes available in several optical configurations. Factory-calibrated, each C-FLUOR ships with a calibration certificate used to convert the analog or digital output signal to a specific concentration estimate. In addition to in vivo Chlorophyll, Phycocyanin, & Phycoerythrin, C-FLUOR probes are also available for detecting: Crude Oil, CDOM/fDOM (dissolved organic material), Fluorescein Dye, Rhodamine Dye, Optical Brighteners, and Turbidity.

JW Fishers' ROVs Assist from SAR to Water Intake Inspection

Since the late 1980's, JW Fishers' Remote Operated Vehicles (ROV) have been tools used across the globe for various missions from the routine to the extraordinary. JWF's SeaOtter and SeaLion ROV Systems are often used to locate drowning victims with attached sonar systems, to search a ship lost at sea, or to conduct inspections on submerged tanks, dams, and water intake pipes.

The SeaLion-2 comes standard with four high performance motors, a 1,000-ft. (300m) depth rated housing, front and rear facing camera both with pan and tilt functionality, and an On-Screen Display (OSD) of basic time, date, and GPS coordinates. Illumination is provided by 4400 lumen LED bulbs and a 15-in. ultra-bright LCD monitor is seamlessly displayed in the system's splash-proof Pelican case. More thrust is available with a "power boost" feature that provides the ROV with an extra burst of speed for a few seconds when it encounters heavier than normal currents. The additional payload allows

the SeaLion-2 to be fitted with various options such as a SCAN650 sector scanning sonar system, a manipulator arm, scientific research equipment, or and RMD-1 remote metal detector.

The SeaOtter-2 comes with the same features as the SeaLion-2, but is instead rated to withstand depths up to 500 ft. (150m). The "power boost" feature is not available for the SeaOtter-2. Ideally, the SeaOtter-2 is suited for low current applications including piling inspections, lake searches, tank inspections, dam inspections, and water intake inspections.

Water Intake Inspection

One company purchased a SeaOtter-2 in 2019 for a particular task. The engineering technician shared that "we are using the SeaOtter-2 to perform a thorough visual inspection of our lake water intake piping at our pump station. We have two 48-in. lake water intakes that are approximately 975-ft. long that have two cribs each. We needed an ROV that was highly maneuverable, and the SeaOtter-2 fit that bill." Having an in-house ROV enables the organization to perform several inspections per year to monitor debris, pipe condition, and more importantly, zebra mussel infestation as we have gone away from chlorine for zebra mussel control. "Contract inspections can be quite costly, so we acquire quite a savings from owning this piece of equipment."

People & Companies

The people and organizations that made news

MTS, SUT Establish the Inaugural Captain Don Walsh Award

Photo: Don Walsh

Greensea

Fladung (above) and Truman, (below) join Greensea Systesm.

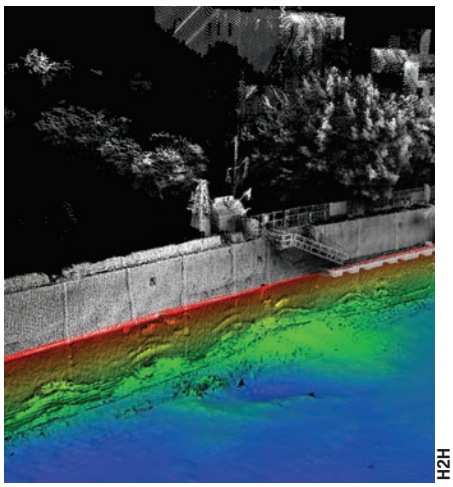
Greensea

MTS, SUT Establish the Inaugural Captain Don Walsh Award

The Marine Technology Society (MTS) and the Society of Underwater Technology (SUT) have established the **Captain Don Walsh Award** for Ocean Exploration to recognize outstanding, sustained, international contributions to the development, application, and propagation of marine technology in the advancement of ocean exploration. The inception of this award coincides with the 60th anniversary of Walsh's historic descent to the deepest point in the oceans in 1960. "This award both pays tribute to an icon in our community and recognizes the importance of technology in advancing the wonders of ocean exploration. Don Walsh is a heroic model for the truest integration of intellectual curiosity, technological savvy, and environmental awareness," said MTS President Rick Spinrad. "In creating this eponymous award MTS and the Society for Underwater Technology recognize the critical role played by technology in opening up whole new frontiers of exploration in the sea." Born on November 2, 1931 in Berkeley, California, Walsh has been involved in oceanography, exploration, and marine policy for more than fifty years. Upon graduation from the United States Naval Academy, he was commissioned as an officer in the U.S. Navy and spent 15 years at sea working aboard submarines. On January 23, 1960, Walsh, along with Swiss explorer Jacques Piccard, were the first to descend nearly 11,000 meters inside the bathyscaphe Trieste into the Challenger Deep of the Mariana Trench, the deepest known point in any of Earth's oceans. This feat would not be replicated until 2012, more than 50 years later.

Greensea Expands, Again

Greensea recently added key personnel to its engineering team in its Plymouth, Mass., office to support its hull robotics program. **James Truman**, Senior Robotics Engineer, is leading the development of Greensea's latest technol-



H2H

H2H Wins Bathymetric Survey Deal

Norcod

Hilde R. Storhaug, MD, Norcod

ogy, a hull crawling robot with precise hull-relative navigation and autonomy capabilities. Assisting James on the hull robotics program is **Sam Fladung**, Robotics Engineer.

Kraken, Greensea Partner

Kraken Robotics and Greensea Systems have agreed to expand upon collaborative efforts already undertaken between the two companies to advance the capabilities of marine robotics. Under the agreement, Greensea will support development, integration and testing work with Kraken across several of Kraken's technology platforms.

COVE, IGNITE Sign 'Fish Tech' MOU

The Center for Ocean Ventures & Entrepreneurship (COVE) and IGNITE have signed a Memorandum of Understanding (MOU) to strengthen the regional ocean innovation network, commercialization of new technologies, and to propel the success of entrepreneurs and businesses in the "fish tech" sector.

FarSounder Enters Brazilian Market

FarSounder announced Ulstein Belga Marine headquartered in Centro, Rio de Janeiro, Brazil is its newest dealer and their first in Brazil. Ulstein Belga Marine will integrate FarSounder's Argos series of 3D forward-looking sonars into its product offering.

H2H Wins Bathymetric Survey Deal

H2H Geoscience Engineering (H2H) has announced a new contract with Albany Water Board, providing topographic and bathymetric surveying services for their two reservoirs – Alcove and Basic Creek in Albany County, New York.

Norcod Appoints MD

Norwegian aquaculture venture Norcod is pleased to announce it has appointed **Hilde Rutledal Storhaug** as its new managing director effective from 1 May. The decision to recruit a new MD was taken in light of the company's planned growth over the next few years, and in collaboration with current incumbent Rune Eriksen. Eriksen will continue as Production Director also with responsibility for other key functions.

New Senior Exec Team for Rovco

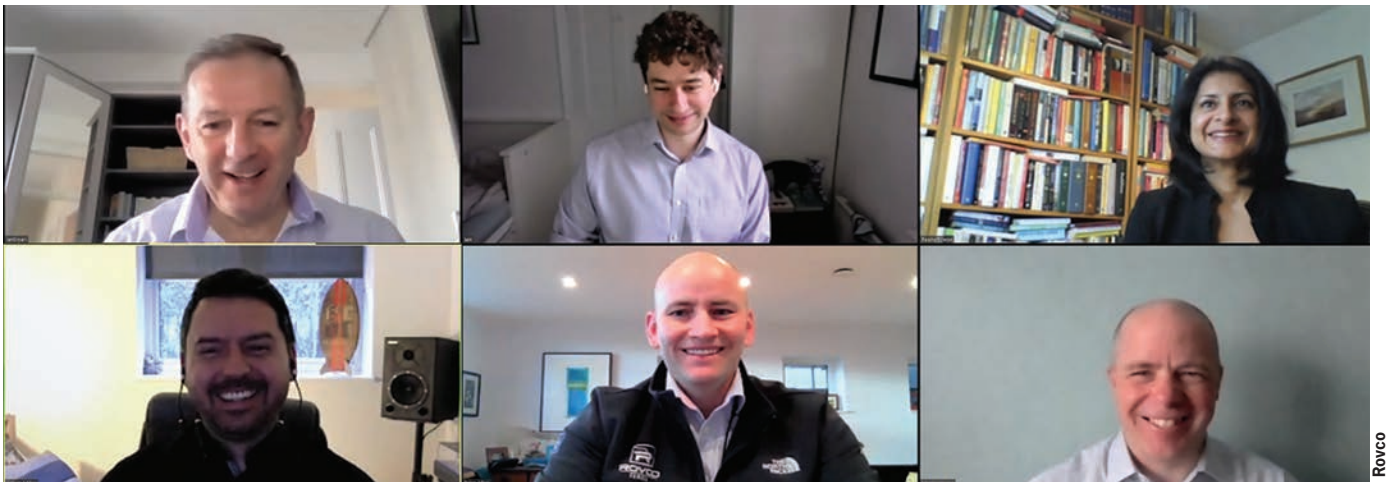
Rovco named several senior executive appointments. **Reena Rowan** has been appointed CFO; **Martin Young** was named Chief Technology Officer (CTO); **Iain Wallace**, Rovco's previous CTO, will now work as Chief Scientific Officer (CSO); **Ian Bryan** joins as Consultant Chief Operating Officer (COO); **Simon Miller** joins the team as General Manager of Rovco Scotland; **Brian Allen**, CEO at Rovco said "The announcements today are a further milestone in Rovco's development.

SOI Appoints Dr. Virmani

The Schmidt Ocean Institute appointed Dr. Jyotika Virmani as its first Executive Director, to lead the global non-profit in its work to advance the field of oceanographic science through innovative research and technology. The announcement was made at the Ocean Sciences Meeting, the flagship conference for the ocean sciences and larger ocean-connected community. With an extensive background in science and innovation, Virmani most recently served as the executive director of planet and environment at XPRIZE and the executive director of the Rainforest XPRIZE, a competition for innovations in biodiversity assessment technologies. She was also executive director of the Shell Ocean Discovery XPRIZE.

Schmidt Ocean Institute

Jyotika Virmani



Rovco

Top (L to R): Ian Bryan, Iain Wallace and Reena Rowan; Bottom (L to R): Simon Miller, Brian Allen and Martin Young.

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