UNDERWATER ROBOTICS

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SUT Society for Underwater Technology

MTS marine technology society

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ARMADA ARRIVES IN NORWAY

2023 has kick-started with the first Armada ship arriving in Norway – to VARD Søviknes – after its maiden voyage which begun on 19th of November in Vietnam.

The first of eight highly advanced, 78-meter vessels will be the first of their kind, enabling Ocean Infinity to perform tech-enabled lean-crewed operations for a safer and greener maritime future. They represent a giant leap forward for the maritime industry.

In partnership with Ocean Infinity, VARD has designed a unique, multi-purpose platform that will allow for onshore remote-controlled, lean-crewed and eventually uncrewed operations.

The ships will be made ready for future environmentally responsible fuels and renewable energy sources.

On delivery, they will accommodate a lean crew and use hybrid solutions that are designed to evolve through various stages of future fuels implementation to ensure they remain at the forefront of low-emission performance to minimize environmental impact of operations.

VARD Electro is equipping the ships with advanced marine electronics for remote operations from its SeaQ product range, while VARD Accommodation is providing the efficient accommodation solution.

Additionally, VARD's daughter company, Seaonics, is delivering modular launch and recovery systems for moonpool that can be adapted to various marine operations in support of Ocean Infinity's growing work in offshore renewables.

Ocean Infinity has taken the delivery of the first ship, which is expected to go into service on offshore data acquisition tasks in the coming months following its final installation work. This milestone marks the beginning of a new phase for Ocean Infinity, which has been pioneering the use of robotics to collect subsea data at scale with minimal environmental impact since 2016.

DRIX CERTIFICATION

Marine classification society Lloyd's Register has awarded its first certification for an Uncrewed Surface Vessel (USV) to the DriX maritime drone. Developed by Exail, a global high-tech company and pioneer in the field of maritime autonomy, the DriX USV is operated by major hydrographic institutes and energy companies worldwide and has already received Bureau Veritas Approval in Principle (AiP).

This new certification attests that the surface drone meets critical safety requirements to be operated at sea. The DriX system design was thoroughly reviewed against the Lloyd's Register Code for Unmanned Marine Systems. It included a detailed system level analysis, construction survey, as well as sea trials. The review covered essential design area such as structural integrity, stability, as well as command and control in the context of remotely supervised autonomy.

This new certification by Lloyd's Register is another milestone for the DriX USV and its operators and marks a major step forward in the transition of the maritime industry towards the adoption of new autonomous technologies.
 ment from Lloyd's Register," states Paul James, Naval Centre of Expertise Manager at Lloyd's Register.

"We hope to be able to help strengthen the global acceptance of maritime drones within our industries, as they support operational efficiency, as well as a safe, sustainable maritime energy transition."

DriX

LOWERING COST AND CARBON

LAST DECEMBER, THE GLOBAL UNDERWATER HUB HELD A CONFERENCE ON UNDERWATER ROBOTICS. IT OPENED WITH AN ACCOUNT FROM THE OPERATOR'S VIEWPOINT WHICH INCLUDED A PERSONAL PERSPECTIVE FROM PRESENTER ERIC PRIMEAU

"As the industry moves into 2023, we are not where we should be. The sector is facing an economic crisis on the back of COVID 19 and this has affected the delivery of technology. The industry is now behind the curve but nevertheless, we are anticipating real changes in the near future."

So says Eric Primeau, senior technology consultant at bp. He firmly anticipates that going forward, that this will improve many aspects of offshore operations.

There are a number of approaches we have traditionally taken to reduce costs, particularly to challenge suppliers to reduce scopes and advance technologies," said.Primeau.

" We are at a point however, that we can't challenge suppliers because suppliers are challenging us to ensure that the market is able to keep suppliers supplying. We have already reduced scopes and that means that going forward, the only real way is advance technology."

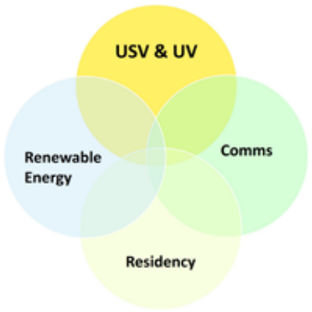
"Ultimately we are looking at underwater robotics to make an impact on Inspection Repair and Maintenance costs, both for the traditional hydrocarbons and the new energy space" he said.

BP has a vision to deliver innovative offshore energy systems targeting net zerooperations by 2050 but more specifically, 50% by 2030.

"Wind and alternative renewable energy systems cannot support the price of maintenance that oil and gas traditionally offered (although they probably don't need it as so far, most of these developments are in shallower waters the environments are not as harsh), but there are another important considerations.

"Applying underwater robotics will also see a reduction in operational carbon dioxide, lower personnel exposure, an increase in deliverable quality and speed of execution as well as automated delivery.

There are four main technologies that bp is looking at. Individually,



GUH

This year, Global Underwater Hub, the leading trade and industry development body for the UK's underwater sectors, will expand its presence across Britain, opening two new hubs. The move aims to bring the country's underwater sectors closer together. Chief executive, Neil Gordon, said: "New offices will open in Newcastle and Bristol to encourage increased collaboration between the underwater sectors and supporting organisations.

"We are coming out of a period of uncertainty and semi-hibernation, and there is now a real focus on green energy, achieving net-zero and delivering the energy transition. While the oil and gas and offshore wind sectors remain important, GUH is also strongly involved with underwater defence and security for seabed infrastructure, alongside aquaculture, marine science and wave and tidal energy. Many of the companies in the underwater supply chain don't work in just one sector, something we continue to see more evidence of.

"Last year we ran a three-phase programme with the Royal Navy and Babcock that sought to identify technologies and techniques used in the offshore environment that could be applied to the defence sector. It clearly illustrated the potential for cross-sectoral innovation and collaboration.

"In underwater robotics, we are seeing exciting changes. That sector is actively embracing automation and exploring better, more cost-effective ways of carrying out operations, which will bring comprehensive benefits in the future that can be utilised across the underwater industry."

they will make a difference but when combined and the fields overlap, the benefits will amplify.

"Holistic engagement offers more value and opportunity than any single item," said Primeau

HOW?
"We envisage applying a full suite of complementary multi functional uncrewed, sparsely crewed vessels and autonomous underwater vehicles working in a common dynamic and resident environment. This means developing robust common communicating protocols monitored in the virtual environment.

"bp recently re-joined the SWiG (Subsea Wireless Group) after many years of absence. The group is currently developing standards for protocols, acoustic wireless and optical communication as well as inductive transfer.

This will hopefully enable different equipment to be used by different operators within that space. Interoperability and interchangeability of equipment within a common communications network should help supply and reliability while improving economics.

"We are starting to see companies adopt an agnostic underwater communications protocol.

RESIDENCY
Many companies are looking at underwater residency- underwater docking stations that allow vehicles to be in location at all times and constantly measure the 'heartbeat' of the asset.

"Already the industry is seeing the emergence of underwater resident systems but this requires the development of power connectivity as well as communications.

These facilities should be powered by clean energy provided by either ocean waves or wind energy. This would include the development of underwater electric storage and distribution facilities.

In addition to residency, however, we are also looking to develop the link between uncrewed surface vessels and underwater vehicles.

In-house, we are looking at how technology projects are being accepted. This includes bridging the gap between medium to low TRL (technology readiness level) product to those that are market read . We have a couple of initiatives.

We have noticed that low TRL product numbers around about three or four seem to just drop off the horizon and then years later, if it's viable, it might appear again and it will be a TRL 5 or 6. What we are not trying to do is that if the product is not at TRL7 it will always be part of a technology acceleration project or trial to make it market ready.

Primeau also introduced the term "Techno stress" to the audience.

"This is not technophobia," he said. "It is the stress on project managers in adopting a technology. They might ask "is this going to work for me, is this going to do what it says it will do and will I have to go back and ask for more money because it didn't work in the first place and now I've got to go back to a traditional solution."

V8 M500

Ocean Modules has received an order for a V8 M500 ROV system. The V8 M500 is a small and nimble inspection class ROV with the unique capability to manoeuvre with six degrees of freedom. Its small size and significant power make the V8 M500 ideal for use in a wide range of tasks.

Perhaps its main design feature, however, is the upper and lower Divinycell floatation blocks. Traditional ROV design places the buoyancy material at the top of the vehicle and ballast at the bottom. In the V8 M500, however, the centre of gravity and centre of buoyancy in the middle of the vehicle which theoretically would make the inherently unstable and able to tip over easily.

Instead, Ocean modules use eight vectored thrusters, an advanced control system and feedback from precise sensors to maintain the stability. The propensity to tip over when uncontrolled is the same property that makes the ROV hightly agile and maneouvrable.

The result is that the ROV can hold any position, with unlimited pitch and roll, indefinitely. Changes in depth, heading, pitch and roll due to external forces such as tether drag, swell, current or payload are automatically corrected. This contributes to ease of operation in difficult environments, and access to spaces which would be difficult or impossible to work in with a traditional ROV.

Its capability to rotate 360deg in any dimension without losing stability is tremendously advantageous for sonar and video inspections as it allows the profile of sea floor, ship hull or subsea structure to be followed regardless of angle.

The system is able to maintain delicate attitude and position control without contacting the sea floor and with minimal thruster use to maintain its attitude. It is able deploy and retrieve instruments on the sea floor and collect both small and large objects from the sea floor including in areas with powerful currents.

NUCLEAR FAMILY

Saab Seaeye adapted a Tiger ROV design (called Tiger-N for nuclear,) with a total of six delivered to Sellafield. The modified ROV has since spent five years working in nuclear storage ponds, one of the most highly radioactive and highly alkaline places on the planet for a robotic vehicle.

Celebrating this record-breaking achievement are the Sellafield team and Saab Seaeye engineers who nuclear-proofed the Tiger to survive an extremely corrosive environment whilst sorting 15kg spent fuel rods in the nuclear ponds.

Les Barker of Sellafield's innovation team said: "The Tiger-N has improved the amount of work we can do in the ponds in a day- sometimes doing 10 times what we've managed in the past. The Tiger's reliability also means that the people using and maintaining them are getting less exposure to radiation."

To limit radiation dose risk to operators and maintainers, in an environment that is highly hazardous to humans, the Tiger was adapted to ensure systems and materials would survive extreme corrosion to limit exposure time spent on maintenance and cleaning.

Exposure to radiation is carefully limited as unplanned downtime would quickly exhaust operators' safe working period in any one year.

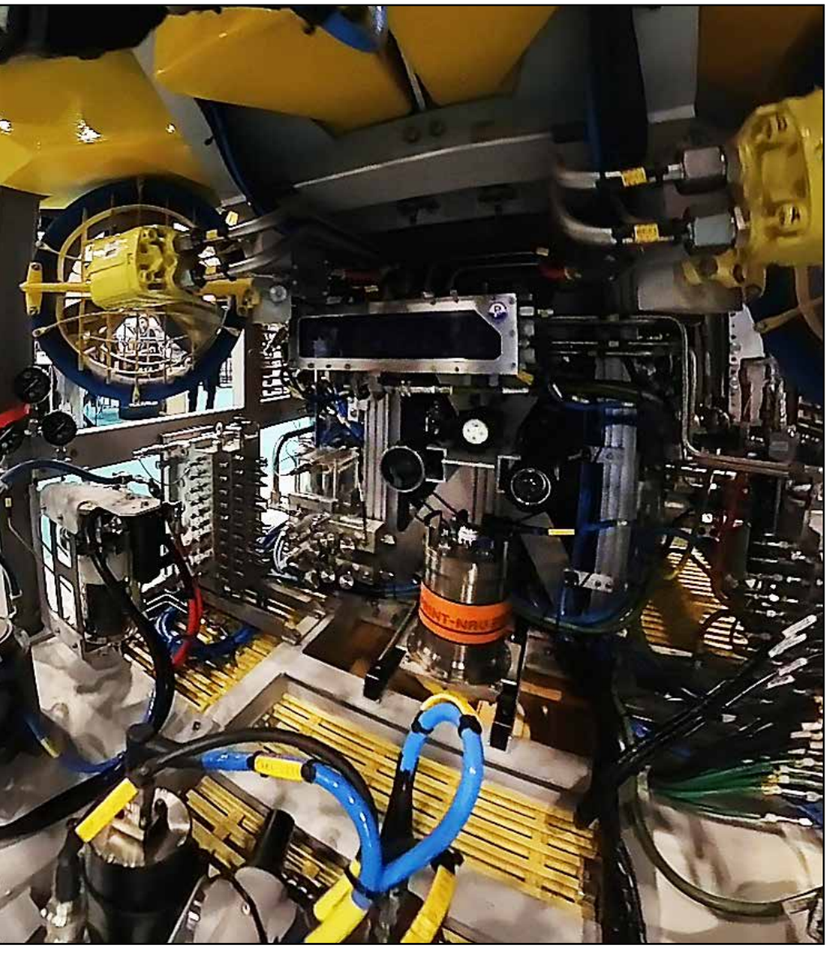
Not only does the Tiger-N need to be corrosion-proof, but also systems such as its quick-change tool skids. These include an under-slung manipulator skid, a four-function forward facing manipulator skid, sludge scoop dredger skid, cutting skid and an under-slung water-jet cleaning skid.

THREE XLX-C ROVS TO BRAZIL

Forum Energy Technologies (FET) has delivered three of its 200HP Perry XLX-C work-class remotely operated vehicles (ROVs) to Brazil-based OceanPact.

The systems, which were manufactured at FET's UK facility at Kirkbymoorside, North Yorkshire, will be deployed across two of OceanPact's vessels to support inspection, repair and maintenance services for the state-owned oil company's oilfields (Petrobras).

The 3,000m depth rated compact 200HP XLX-C delivers the high performance of a work-class vehicle in a smaller form. The vehicles benefit from an impressive high flow auxiliary hydraulic circuit combined with a high payload capacity to carry additional tools and sensors.



Perry work-class remotely operated vehicles (ROVs

Each XLX-C was supplied with an underslung tooling skid for additional tooling and options fitment, complementing the vehicles high performance. A comprehensive supplementary tooling package including torque tools, verification units and fluid injection systems was also provided.

The ROVs were supplied with active heave compensated Dynacon launch and recovery systems (LARS), as well as associated surface power and control installations.

As part of the scope, FET has also supplied a VMAX ROV Simulator configured with a complete XLX-C Console.

The simulator is provided with a host of training exercises or 'scenarios', each designed to train and evaluate pilot competence in a variety of skills such as tether management, manipulator control and operation of tooling.

VMAX can also offer bespoke scenario builds for training and engineering analysis purposes. Using VMAX as a pre-operation or pre-fabrication tool has proven to be a valuable way to verify equipment design, de-risk operations and ultimately save time and money.

THE PALM SUITE

Saipem and the underwater technical and digital solutions company, MCS, launch a new asset integrity management system called "The PALM Suite" (Platform for Asset Lean Management). The solution is designed to support offshore energy operators with asset data management, risk assessment and inspections planning of offshore infrastructures across oil and gas, renewables, power and data network for the entire data lifecycle.

The collaboration brings together Saipem's extended asset integrity expertise and subsea robotics portfolio with MCS' distinctive data science and software competencies.

"The PALM Suite unlocks a new layer of service-oriented capabilities and leverages advanced features such as 3D reconstruction for subsea dimensional control and IoT data gathering. This agreement represents a further step towards the digital and sustainable transformation of the energy industry." said a source.

RS AQUA PARTNERS WITH BLUE ROBOTICS

Established after a Kickstarter Campaign in 2014, Blue Robotics now offers over 300 marine robotics components which RS Aqua will offer to the UK market as their partners

Blue Robotics' story started in 2014 when they established a Kickstarter campaign for their original T100 thruster unit. Seeing the gap in the market for low-cost, modular and rugged thrusters, and an avid interest from hobbyists through to robotics companies, they set out to design a thruster unlike anything else available.

Since that memorable year, Blue Robotics has been on a mission to enable the future of marine robotics and now offers over 300 low-cost, high-quality components and systems including the BlueROV2 and the new T500 Thruster. Their stellar team has worked hard to make marine robotics components accessible with their open-source philosophy, community forums, and well-documented products.

Thanks to hard work and innovative thinking, Blue Robotics has been recognised by the Society of Underwater Technology (SUT). The highly competitive Gwyn Griffiths Award for Underwater Robotics 2022 was given to Blue Robotics CEO Rustom (Rusty) Jehangir, which he shared is an accomplishment for the whole team.

FET XLX-C

Forum Energy Technologies (FET) has secured a significant order from DOF Subsea to deliver four of its advanced work-class remotely operated vehicles (ROVs).

The ROV order comprises of two 200HP XLX-C's, which have recently been delivered and successfully mobilised in late 2022, as well as two 200HP XLX Evo II's to be delivered in Q2, 2023.

The XLX Evo II's hydraulic systems have been redesigned in line with this contract and now share a vastly increased quantity of common component parts with the XLX-C's, providing a customer benefit for spares commonality and subsequent availability.

All vehicles are being manufactured at FET's UK facility at Kirkbymoorside, North Yorkshire.

Mark Ainsworth, FET's DOF account manager said: "The four new ROVs, which now share so many common systems and components with one another, will bring a mix of smaller footprint benefits via the XLX-C as well as larger platform payload and stability advantages via the XLX Evo II, depending on the task at hand.

HABITAT-SAVING ALGORITHM HELPED BY SEAEYE FALCON

High-definition stereo camera and paired lasers are used to assess individual fish size and the density of fish in a measured field of view.

Scientists at the Washington Department of Fish and Wildlife (WDFW) have acquired a second Saab Seaeye Falcon underwater robot. The Seaeye Falcon is used to conduct surveys of marine fish and invertebrates in Washington's Puget Sound, where some rockfish populations were fished to levels that threatened extinction.

The surveys are used primarily to monitor the recovery of rockfish listed under the United States Endangered Species Act, but also provide information on the unique geological features in Puget Sound. The WDFW has also used their Falcon to survey the habitat surrounding U.S. Navy bases in Puget Sound to meet Federal permitting requirements, locate and recover lost equipment and conduct special studies of sea urchins and sea cucumbers.

The new Seaeye Falcon is a 300m rated system and equipped with a high-definition fibre-optic video system capable of collecting higher resolution imagery than WDFW's original Falcon, which has seen over 4000 hours of use since 2007.

"The HD imagery collected with the new vehicle will greatly improve our ability to detect small and cryptic rockfishes, leading to more precise estimates of abundance, and will be used to train machine-learning algorithms being developed to partially automate the video review process, which is expected to substantially improve survey and post-processing efficiency," explains research scientist Robert Pacunski.

"The Falcon can precisely manoeuvre amongst the cracks and crevasses of complex underwater rock formations favoured by rockfish and has the power not to be pushed around by the current," says Robert Pacunski.

Specialised equipment fitted to the Falcon includes a pair of parallel lasers and a stereo camera for assessing individual fish size and the density of fish in a measured field of view.

An Imagenex multi-frequencing gyro-stabilised sonar is used to identify target habitats and avoid uncharted obstacles (for example, derelict fishing gear, subsurface electrical and telecommunications cables).

Depending on survey needs, the vehicle can be fitted with a conductivity-temperature-depth meter to collect data in real-time for examining linkages between physiochemical water quality parameters and fish distribution/ abundance.

INTO DEEPER WATERS

Over the past few decades, ROV companies started to offer deeper water alternatives to their vehicle ranges in response to changing markets. So what issues did designers have to consider when extending the maximum water depth of their products?

The last issue of *Underwater Robotics* included a discussion of the different types of pressure housings that allow sensors and control systems to withstand the considerably larger ambient pressures.

Another important factor in increasing water depth is buoyancy. What types are the best for deeper waters?

Syntactic buoyancy on a ROV

SHALLOW WATER

"Many ROVs operating in the shallow water end of the market typically rely on relatively inexpensive PVC foam to provide sufficient buoyancy, " said Gregg Stewart, Technical Manager at the Aberdeen-based buoyancy, cable protection and insulation company Balmoral.

"The foam is rated to withstand specific water pressures and then the external surfaces are finished with GRP and a spray-on polyurethane to add toughness, impact and abrasion protection.

"Different manufacturers have various foam slabstocks at their disposal, each with different properties. The eventual buoyancy designs for shallow water vehicles, therefore, very much depend on the individual manufacturer's approach and track record.

"The downside of PVC and other similar foams is that if the ROV happens to go beyond its depth capability for any reason, the buoyancy will compress significantly, lose volume, increase density and the ROV potentially sinks. "

DEEPER WATER

For depths of greater than 500m, syntactic foams are typically used. These vary from manufacturer to manufacturer but most syntactic foams consists of hollow Borosilicate glass microspheres (HGMS) set in a polymer resin matrix.

HGMS is specified in terms of its density vs hydrostatic collapse resistance and the grades are selected with consideration to factors such as maximum service pressure, safety factors and service durations.

The diameter of the microspheres is generally less than 150µm with varying collapse pressures. What is critically important, however, is the density and strength of the microsphere.

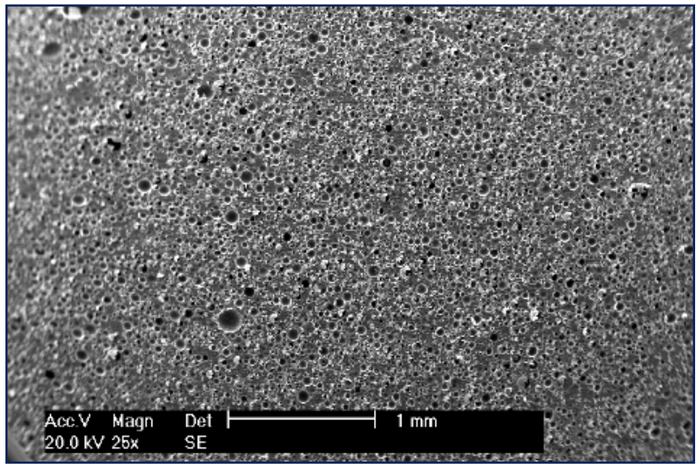
Foam manufactured as slabs bonded together

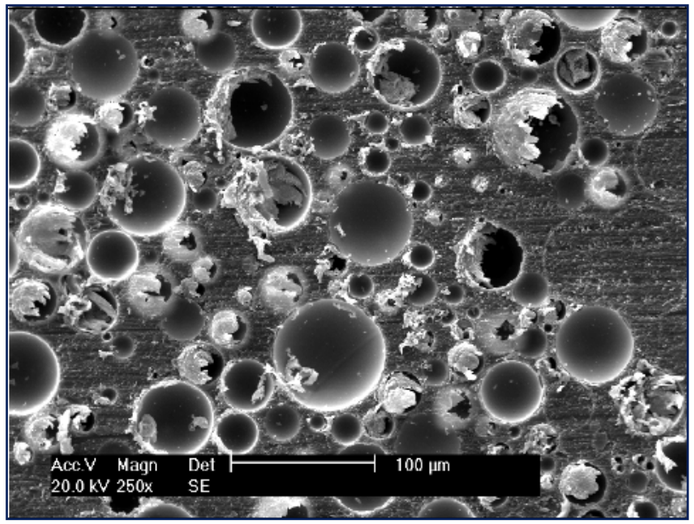
"Widely available hollow-glass microspheres have densities ranging from 100kg/m^3 up to around 600kg/m^3" said Gregg Stewart.

"Their collapse pressures range from around 10 bar (145 psi) to 2413 bar (35000 psi). The collapse resistance of the HGMS is further increased by varying the thermoset or thermoplastic polymer resin matrix referred to as matrix amplification (MA)."

In ultra-deepwater applications over 6000m it takes time for the ROV to get to operational depth and as a consequence, operators

Examples of 10mm macrospheres





SEM images showing a standard ROV-type low density foam with microspheres distributed in the resin matrix. Above: zoomed out image with scale bar 1 mm and below: zoomed in with a 100 µm scale bar.

often take a large amount of equipment to the worksite so that they don't need to return to the surface so often. Deepwater ROVs, consequently, are often much heavier due to them being both strengthened and having to carry the weight of a high payload.

This requires increased buoyancy to offset the mass.

SYNTACTIC FOAM

"Syntactic foam is a premium material due to its ultralight density and high strength-to-weight ratio. It is used for critical buoyancy applications," said Gregg Stewart. "It can either be cast to shape or manufactured as slabs which are bonded together in a controlled way. After bonding, the finished buoyancy block is CNC machined to the required shape according to the ROV design plans.

"We then prepare the surface to better accept the GRP skin (to provide abrasion and impact protection) or spray-on flexible polyurethane. This is typically applied to a thickness of 3-10mm but depends on customers requirements.

"The coating choice depends on the operational conditions, we may be required to use a thicker or alternative coating if there's an increased risk of impact against subsea structures for instance.
All things being equal, deeper-water buoyancy requirements are considerably more challenging in general."

For convenience, Balmoral's low-density ROV syntactic foam is classified by maximum depth rating. Regardless of depth-rating, generally the chemistry is similar however the HGMS is selected to accommodate deeper service requirements.

In general, as depth rating increases, the syntactic foam density also increases but there are other properties to be taken into account in the final selection including, but not limited to, the compressive, tensile, flexural, shear and hydrostatic compressive strength.

Another issue with working at high water pressures is water ingress into the syntactic foam and its resulting impact in increased weight and buoyancy loss.

Balmoral has a lengthy history of stringently developing and testing buoyancy materials for long-term service and has partnered with external test houses globally to develop understanding of the mechanisms of water ingress into syntactic (and composite syntactic) foams for deep-water, long-term service.

Example of 40mm macrospheres

DISTRIBUTED BUOYANCY

Where ultradeep-water service and low long-term buoyancy loss requirements are necessary, the cost of the glass microspheres and other raw materials used in manufacture often mean that Syntactic-foam ROV buoyancy can be relatively expensive.

At the same time, however, another product that Balmoral offers is a range of large distributed buoyancy modules that are permanently attached to risers, flowlines, umbilicals and underwater hardware. This offsets sometimes considerable masses and are deployed for around 25 years at depths to around 4000m. Buoyancy decreases stress on the entire floating structure. The line has to withstand high hydrostatic and mechanical loads and especially fatigue through Vortex Induced Vibration (VIV).

Distributed buoyancy uplift cost, however, is typically less expensive than ROV buoyancy. Could this technology not be used instead? Predictably, perhaps, the answer is a resounding NO!

"Both the ROV and the distributed buoyancy modules operate to different depth ratings and typically use different syntactic foam chemistries and require different design considerations," explained Gregg Stewart. "One characteristic of distributed buoyancy composite syntactic foam is the inclusion of 10-60 mm macrospheres. This lowers the density of the composite foam when compared with a syntactic foam without macrospheres, but the trade-off is foam mechanical strength.

"The other factor is that distributed buoyancy is required to stay at the same depth throughout its life. ROVs, however, characteristically move up and down through the water column throughout their operational life and this imposes an additional cyclic fatigue loading that needs to be taken into account.

Distributed Buoyancy

UCO AND ITS FOOVER

Underwater Contracting (UCO)has been awarded what is believed to be one of the largest Remote Operate Vehicle (ROV) contracts in recent years in the global aquaculture sector.

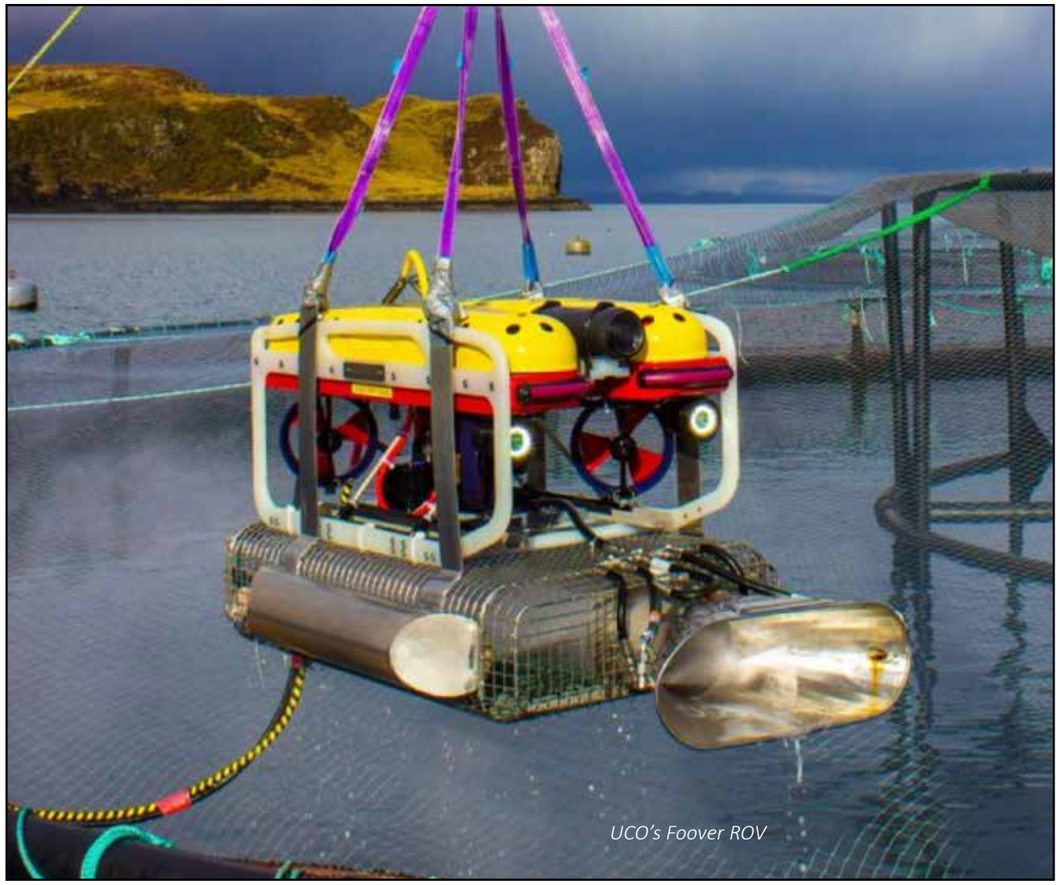
The new service agreement with salmon farming company Mowi Scotland, will see 15 submersible ROVs working 365 days a year over the term of the contract to provide a range of services in Europe and North America.

Mick Bower, managing director of UCO, which is headquartered in Aberdeen, Scotland, said: “We are delighted to have won this major contract which will help secure the future of the company for years to come.

Specialists in aquaculture, UCO, has successfully deployed Seaeye Falcon underwater vehicles since 2018, for animal welfare and installation integrity across aquaculture sites across three continents.

In that time, they have productively utilised the power and intelligence of the Falcon system when designing and developing industry-leading technologies, including their FOOVER Mortality Recovery system, NETFIX Net Repair system and G-LANCE Cage Cleaning system.

They chose the Seaeye Falcon as the world’s top selling underwater robotic vehicle in its class and for its versatility, being able to be utilised not only in aquaculture, but in the offshore energy and maritime sectors as well.



UCO’s Foover ROV

With a reliability record totalling over one million hours underwater, the Seaeye Falcon is a compact metre-sized vehicle that can be fitted with role-changing, heavy tooling systems. With five powerful thrusters and intelligent control architecture, the Falcon is capable of precise manoeuvrability amongst complex structures and strong currents.

Formed in 2017, UCO is part of Ocean Marine Group with sister companies Pirie & Smith, which offers marine and dynamic positioning assurance services, and ETPM, which recruits marine, subsea, ROV and survey and inspection personnel for clients.

Mowi Scotland employs 1500 dedicated professionals that produce salmon.

VIDEO RECORDING

Houston-headquartered Forum Energy Technologies (FET) has released its latest generation of video recording solutions for the survey and inspection of subsea assets. Like its predecessors, version 11 (V11) of VisualDVR is a multi-channel, rack-mountable digital video system designed for use on remotely operating vehicles (ROVs), supporting activities in the energy, defense and ocean science sectors.

According to FET, the system can record up to four channels of HD Video at 1080p / 60fps from HD-SDI sources and is equipped with a host of tools and complementary applications to support real-time documentation of video images with data from subsea sensors and inspection personnel.

As part of the update, V11’s user interface has been completely modernized, the company said, adding that configuration of recording quality, data paths, input and output profiles can be accessed easily, and channels can be developed in a simple step-by-step process. There are also new tools to flag potential setting conflicts while improvements have been made to allow video overlay set up to be simpler.

The new system is also supported by new hardware architecture. A proficient motherboard and high-end graphics card have been chosen alongside a leading-edge multi-channel video encoder card said to have been selected for optimum performance and reliability. FET expects that subsequent releases in the coming months will include the capability to stream video using an alternative protocol and also to output an HD-SDI signal using H.265.

GRANDEUR SUBSERV ACQUIRES GAPS M5

Grandeur Subserv recently acquired an Exail Gaps M5 USBL system for shallow water geophysical surveys on the Nigerian coast. Looking for an agnostic acoustic positioning system compatible with third-party transponders and capable of accurately tracking any asset in very shallow water, the Gaps M5 USBL system was particularly recommended.

“As part of a survey to determine the location of pipelines or hazards that could impede drilling on the Escravos field, we have to track sensors in water depths ranging from 8 to 100 m, which is a real challenge, especially since our client expects centimeter accuracy in positioning these sensors. We recently discovered and acquired the USBL Gaps M5 system for this purpose.

Embedding a motion sensor based on Exail FOG technology for stable heading roll and pitch compensation and a true north reference, Exail's Gaps M5 offers a positioning accuracy of 0.2% up to 995m operating range. It achieves maximum reception and transmission power levels, as well as interference cancellation capabilities to ensure optimal positioning data.

Especially suited for subsea positioning needs of 1000m or less, it is extremely efficient in shallow water and horizontal conditions and is suitable for any tracking operations, from diver to multiple subsea assets or inspection ROV tracking. Pre-calibrated, compact, and lightweight, it is easy to integrate and operate from any small vessel with reduced crew onboard or even deployed on instrumented buoys.

Exail Gaps M5 USBL

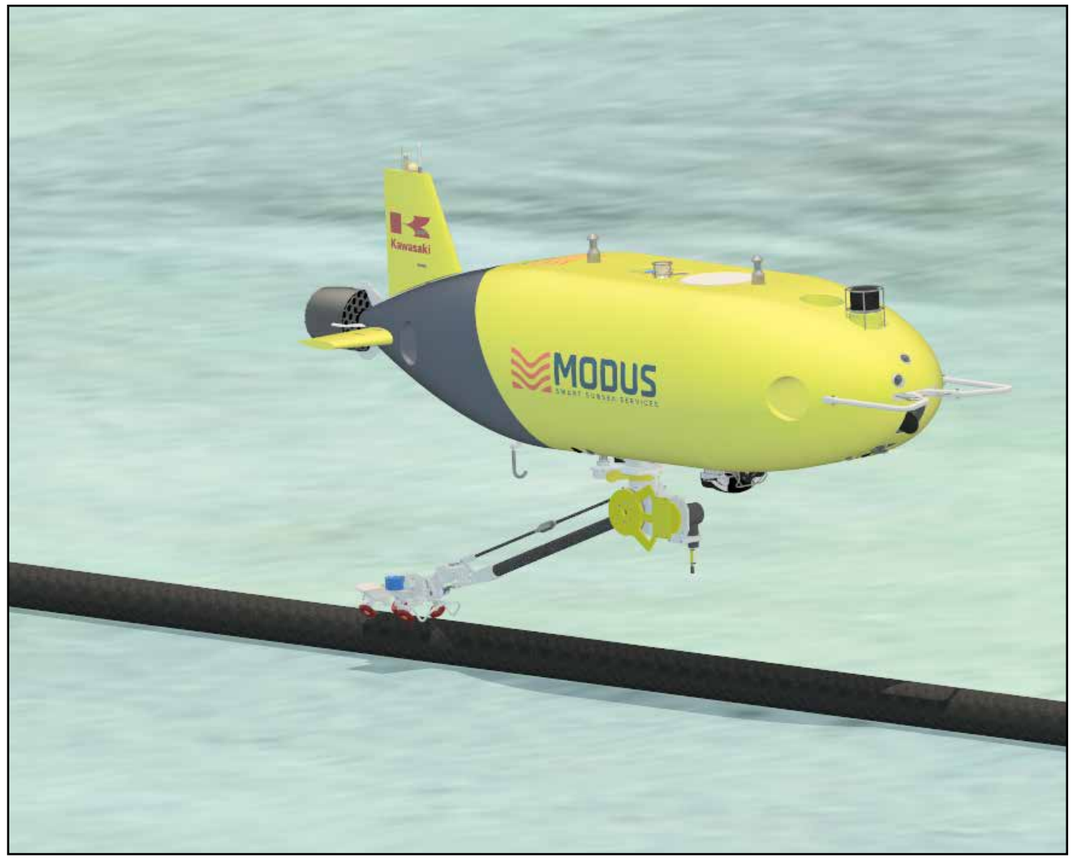
SPICE

Modus recently announced the world’s first resident subsea contract based on the autonomous deployment of its Saab Sabertooth AUV. Later this year, the company will take delivery of the new equally ground-breaking SPICE autonomous vehicles from Kawasaki. This provides an insight into how one company plans to react to a changing market.

In 2020, Modus took the bold decision to purchase two hybrid Subsea Precise Inspector with Close Eyes (SPICE) AUVs from Kawasaki. When delivered, these will be the world’s first AUVs equipped with a robot arm for performing subsea pipeline inspections. The design is a fusion of submarine-related technologies and the latest in industrial robotics fostered over many years at Kawasaki.

The SPICE AUV was originally scheduled for a late 2021 delivery although the production schedule slipped due to Covid and the subsequent unavailability electronic components and chipsets. The first of these new vehicles has now been confirmed for later this year with the second following in 2024.

“Despite the delays, we have been able to accelerate some of the developments through close collaboration with Kawasaki,” said Mahesh Menon, Chief Technology Officer. "At the moment the last few sensors are being integrated and software written to align the vehicle's capability to what we actually need. We are starting factory acceptance tests.



SPICE SPECIFICATIONS

Length overall	Approx. 5.6 m
Width	Approx. 1.4 m
Height	Approx. 1.1 m
Weight	Approx. 2,500 kg
Max. depth	3,000 m
Max. speed	4 knots
Propulsion	propeller ×1, side thrusters ×2, vertical thrusters ×2
Navigation	INS Sonar
Safety	Ballast release equipment, Iridium beacon

"We are one of the very few operators in the world driving the use of autonomous electric underwater vehicles. With years of experience using autonomous systems, we have identified gaps and plan to integrate capabilities and technologies to make autonomous survey even more effective."

Winning the contract for the world's first residency drone programme with its Saab Seaeye vehicle is a clear marker for the industry, but how will the new SPICE vehicle contribute to Modus' output?

“These hybrid autonomous underwater vehicles (HAUVs) types are in fact, two very different vehicles,” said Mahesh Menon

"The Saab Sabretooth is extremely agile and flexible and is able to perform a multitude of vital inspection tasks both in both the

"SPICE is going to be a brand new AUV class entering into the market and from what I'm seeing and following conversations with energy companies, the market is quite ready for it. Most companies are adopting their own decarbonisation strategy, closely reviewing their current operations to identify where they can be more efficient, greener and make use of alternative technologies.

offshore and renewable industry. This SPICE vehicle, however, is specifically tailored to conduct pipeline surveys and similar long, monotonous operations but faster and more comprehensively than anyone else in the market."

Many analysts have recognised that SPICE is almost like two vehicles in one package. The main body is a 5 deg of freedom vehicle but its novel robotic arm greatly expands its range of capabilities.

It allows sensors to be integrated into the arm so that they can be placed in closer proximity to the product. These may improve deploying cathodic protection tools or enhance imaging applications.

"Engaging much more closely to the product allows the gathering of very high quality data when compared with conventional systems," said Mahesh Menon. "We are presently trialling a series of tools but already, it has opened our eyes to different benefits and aspects.

"We are combining these high-value sensor and data outputs with machine learning to make the process more efficient to provide by effectively.

HAUV/SPICE

While the HAUV and SPICE are very different, they will share core technologies such as obstacle avoidance and the ability to identify anomalies within a mission.

"We have programmed the vehicle to engage more but we need to be careful in terms of *how* we engage" said Mahesh Menon. "There are several steps prior to full intervention. In the early stages, it will keep humans 'in the loop' as opposed to 'on the loop' but this will give a greater level of awareness /confidence in order for the development to proceed.

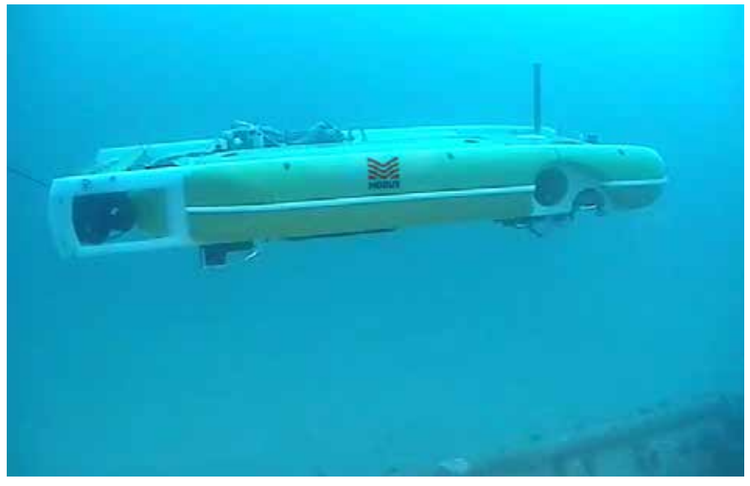
"A lot of people are jumping on the artificial intelligence (AI) bandwagon but a lot needs to be done in order for AI to be successful. In order for that machine to do a particular task based on making an informed decision, it means incorporating and training ancillary systems to fully understand how everything affects the surrounding environment

"We have standard equipment such as the usual mix of forward-looking sonar, bottom looking sonar, pipe detecting and pipetracking systems. When it comes to the cameras, we aren't using bespoke systems but instead, some interesting combinations which we plan to integrate into the machine learning platform.

"Once we have them incorporated on SPICE, we are going to do a combination of in water tests and full pilot programmes with some end users in attendance, with the intention of going fully commercialised by the end of the year."

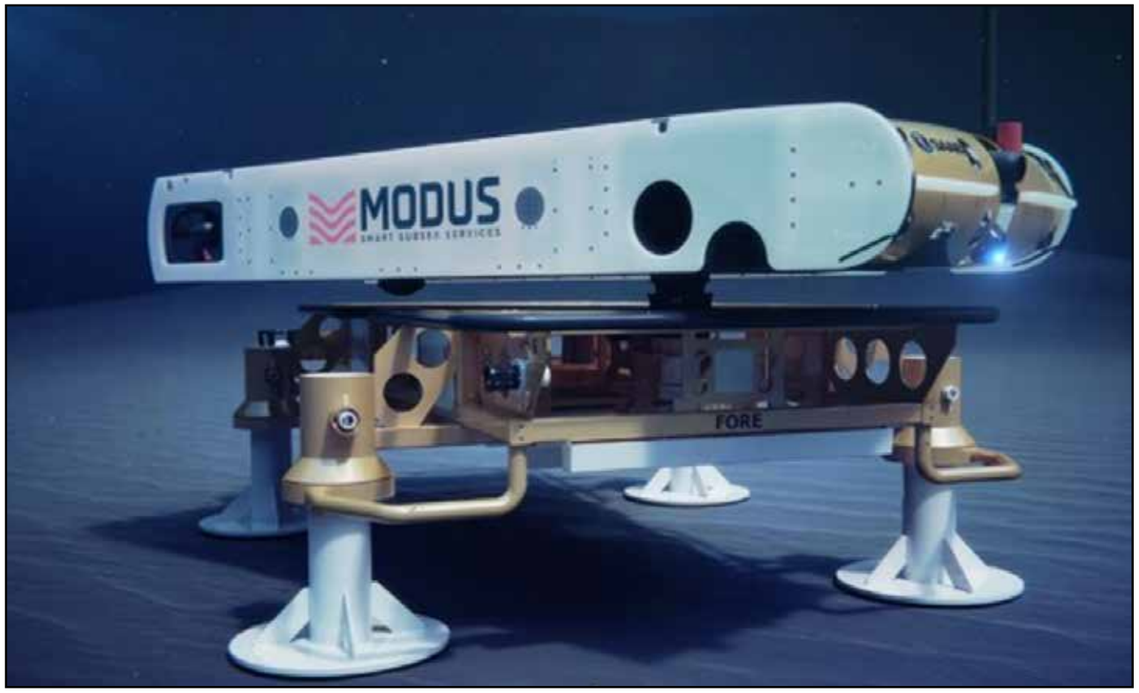
"Eventual SPICE operations will include underwater docking using the SPICE station. As a the result of experience with Sabertooth, we intend to build and integrate various behavioural missions onto the platform.

We plan to run controlled environment and open water testing sessions which will help us understand various sensors, software upgrades mechanical changes and whatever else that can be integrated into the vehicle and create a service that is of significant value to our customers."



Modus' Saab Seaeye HAUV

FIRST RESIDENT SUBSEA DRONE



At the Global Underwater Hub's recent Underwater Robotics conference in Aberdeen, business development manager Graeme Jacques of Modus talked in detail about HAUV capabilities that led to Equinor Energy awarding a contract for the world's first resident subsea system for its Johan Sverdrup oil field.

"At present, our main HAUV offering is currently provided by a pair of Saab Sabertooth roaming and hovering multi-role, 360deg manoeuvrable vehicles," he said. "Some companies employ the acronym HAUVs to describe hovering vehicles but we use them to denote hybrid systems. It simply means that we can plug in a tether to use the AUV as a conventional ROV. Interestingly, when it's on the surface, it can also behave like a uncrewed surface vessel (ASV), monitoring the sea bed while receiving full remote control via WiFi signals in real time.

"We trialled this in the Port of Sunderland, and the whole survey from the surface took 2-3hrs. The benefit with the vehicle, of course, is that if the water does become choppy, we can easily submerge a couple of metres to escape from the high energy waves.

"While the HAUV is 3000m-rated, most of the demand we have been receiving has been for relatively shallower projects. The main applications have been for cable or pipeline depth of burial, routing surveys, pipeline inspection, cathodic protection (CP) and decommissioning.

The vehicle can not only autonomously track the flat seabed, but also follow the risers vertically upwards to continue the inspection up the monopile or platform jacket legs. "

The Sabertooth uses a 30kWh battery capacity which provides a maximum speed 7.5 kph and can work for 20hrs even with a full suite of sensors running. When on surface, the control system is based on a Wi-Fi a link but once underwater, it reverts to use inertial navigation and DVL.

Onboard sensors include a short and long baseline positioning, cameras, dual beam echosounders side-scan and sub bottom profilers for detecting buried pipelines or objects in the top 2-3m of the seabed. It has advanced cable detection and can take contactless field

Underwater garage

gradient measurement for cathodic protection of underwater steel structures and pipelines.

DEPLOYMENT
"Because it's very efficient and hydrodynamic, the HAUV is an ideal vehicle for work in high current, shallow water areas such as the southern North Sea. These have low visibility and are notably There are a number of way of ways of challenging to ROV systems.

Deploying the system depends on the circumstance. If it is close to shore, we can run it down a ramp on the trailer into the water and retrieve it in exactly the same way.

Alternatively, We can launch it over the side of a boat or house it in a garage and lower it down by crane into the water, where it is removed from the wave effects. The vehicle can then take itself out of the dock and conduct a survey mission autonomously and independently of the mother ships. The installation vessel could be working alongside a platform while leaving the AUV is to conduct additional survey work. A potentially more exciting aspect is for the vehicle to reside semi-permanently on the seabed.

"The drawback to using an offshore vessel is that it burns large volumes of carbon-based fuel and is requires a relatively large crew," said Jacques. "This could be solved by operating the vehicle in residency mode, whereby, instead of returning to the mother ship, it would land on a underwater docking station. We have successfully carried out numerous docking operations on such a platform

The resident platform is a small table like structure enabling the vehicle to land on the upper surface. At the centre is an inductive coupler developed by Blue Logic. This incorporates a homing beacon allowing the vehicle to autonomously locate and land accurately in the correct place. The vehicle stays in position by its own weight but there is also a mechanical latch when working in areas of high currents

Communication between The platform and the vehicle uses free space optics Allows large volumes of information to be exchanged.

Equinor Plan to install the system on the Johan Sverdrup next year. Vehicle sitting on the seabed docking station will be effectively controlled the remote control command centre in Darlington.

NAVIGATION/COMMS	
Subsurface Comms	WiLAN/Radio/Iridium
INS	XBlue Phins 3 INS
DVL	Nortek /Teledyne RDI
Surface Nav	AAE101G / Novotel 638 DGNSS
Acoustic Nav	USBL / LBL Aiding
OAS	Imaginex 881L- 675 kHz
Acoustic Comms	Sonardyne Avtrac 6
Cameras	Colour Video, Still HD, low light
BASIC SENSOR PAYLOAD	
Bathymetry opt 1	R2 Sonic 2024 MBES With UHR (Single/Dual Head)
Bathymetry opt 2	Co-located Interferometric Edgetech 2205- 540kHz
Sidescan Sonar	Edgetech 2205 230/540/1600 Khz
Sub Bottom Profiler	Edgetech 2205- 2-16khz
HF imaging sonar	Norbit / Echoscope
Acquisition Software	EIVA / QPS QINSy
ADVANCED SENSOR PAYLOAD	
Cable Tracking	Orion Innovatum TSS 660 / 350
FDI- Laser & Photogrammetry	Cathx Scout
CP Survey	Contactless FiGS Ises
HD imaging Sonar Developments	Aris Artemis

ROBOTICS AS A SERVICE

An international consortium has been awarded a prestigious Enterprise Singapore- Innovate UK grant to develop a next-generation autonomous structural integrity inspection capability.

Autonomous robotics specialist BeeX, offshore survey and inspection specialist Sulmara, and structural integrity specialists at the University of Strathclyde share a vision to deliver an autonomous low carbon solution for windfarm integrity monitoring. Ultimately the end goal is a Robotics-as-a-Service (RaaS) solution drastically reducing the resources required to conduct essential underwater inspections and asset integrity assessment of offshore wind turbines. This solution would contribute to meeting Europe's net-zero commitments by slashing energy requirements and emissions related to inspection activities in the wind sector.

Large diesel fuelled and carbon intensive vessels are currently required to inspect energy assets, making the introduction of optimised, automated, lower carbon solutions a crucial part of any net-zero future.

Assisted by the grant funding, BeeX will be delivering their next-generation Hovering Autonomous Underwater Vehicle (HAUV) specifically for Offshore Wind; carrying specific survey & inspection payloads suitable for monopile and jacket inspections, piloted by artificial intelligence to automate inspection tasks & deliver repeatable efficient inspection of windfarm monopiles from seabed to the air water interface.

Wind farm inspection

Hovering Autonomous Underwater Vehicle (HAUV)

This HAUV platform will be enhanced with new features including enhanced endurance and improved sensor payload from critical learnings discovered from BeeX experience with their flagship HAUV, A.IKANBILIS on the Nordsee One windfarm, offshore Germany last year.

Sulmara's scope will define the vertical asset inspection capabilities and sensor payloads needed for this next generation HAUV to meet the demands of the offshore wind sector as well as managing field trials and demonstration of the system alongside BeeX in 2024, with the ultimate aim to integrate the HAUV into a bespoke Unmanned Surface Vessel. The inspection missions will be optimised based on research by the University of Strathclyde, in developing a Structural Integrity framework to generate risk-based, fit-for-purpose, inspection missions that will feed into the HAUV automated mission control software.

Offshore wind is a critical and rapidly expanding sector with UK government targets to deliver 5 GW of floating wind by 2030. Underwater inspections are essential in ensuring its safety. In many cases, these inspections are also mandatory by governments and financial backers. Operations and Maintenance Costs at offshore wind farms remain the biggest operational cost. The costs are largely driven largely by the use of large, specialised Dynamically Positioned (DP2) vessels to deploy work-class remotely operated vehicles (WROVs). With low carbon and reduced cost at the forefront of this project, it is clear that an HAUV hosted from an Uncrewed Surface Vehicle (USV), both optimised for the offshore wind sector can build on and improve the capabilities of the current Work Class ROVs hosted from larger crewed vessels.

SENTRY

When an underwater vehicle is used for mapping, it is important to know precisely where it is.

In a recent communication from Woods Hole Oceanographic Institution (WHOI) OceanInsights publication Hannah Piecuch revealed that last year, the Sentry AUV acquired software developed by engineers at MBARI (Monterey Bay Aquarium Research Institute) to enable it to course-correct, using a map of the area to recognise its position.

"Once the Sentry submerges, it uses dead reckoning," said Sentry team lead Sean Kelley, "using distance, time, and direction. As it drives a straight line, however, the vehicle cannot tell if it has also drifted and this is where the new software comes in."

Woods Hole has a contract, funded by the National Science Foundation (NSF), to carry out repeated mapping of the Axial Seamount. By measuring how much the surface of the summit has risen, scientists are studying the cycle of in this volcano: where the magma is stored before an eruption and how much the chamber beneath the surface fills with magma before it erupts. This seamount is an ideal study site because it erupts every ten to twenty years and is only a day's journey off the coast of Oregon. Also, it has a 40-year history of being studied, and hosts many real-time sensors as an Ocean Observatories Initiative location.

For the mapping portion of the project, the group needed a vehicle to repeat the same lines in a spider

The Sentry

web pattern for 20km (around 12 miles). Before using the MBARI software, Sentry could drift up to 40 meters (~130 feet) on some of the dives, which made comparing changes to the ocean floor difficult.

NAVIGATION

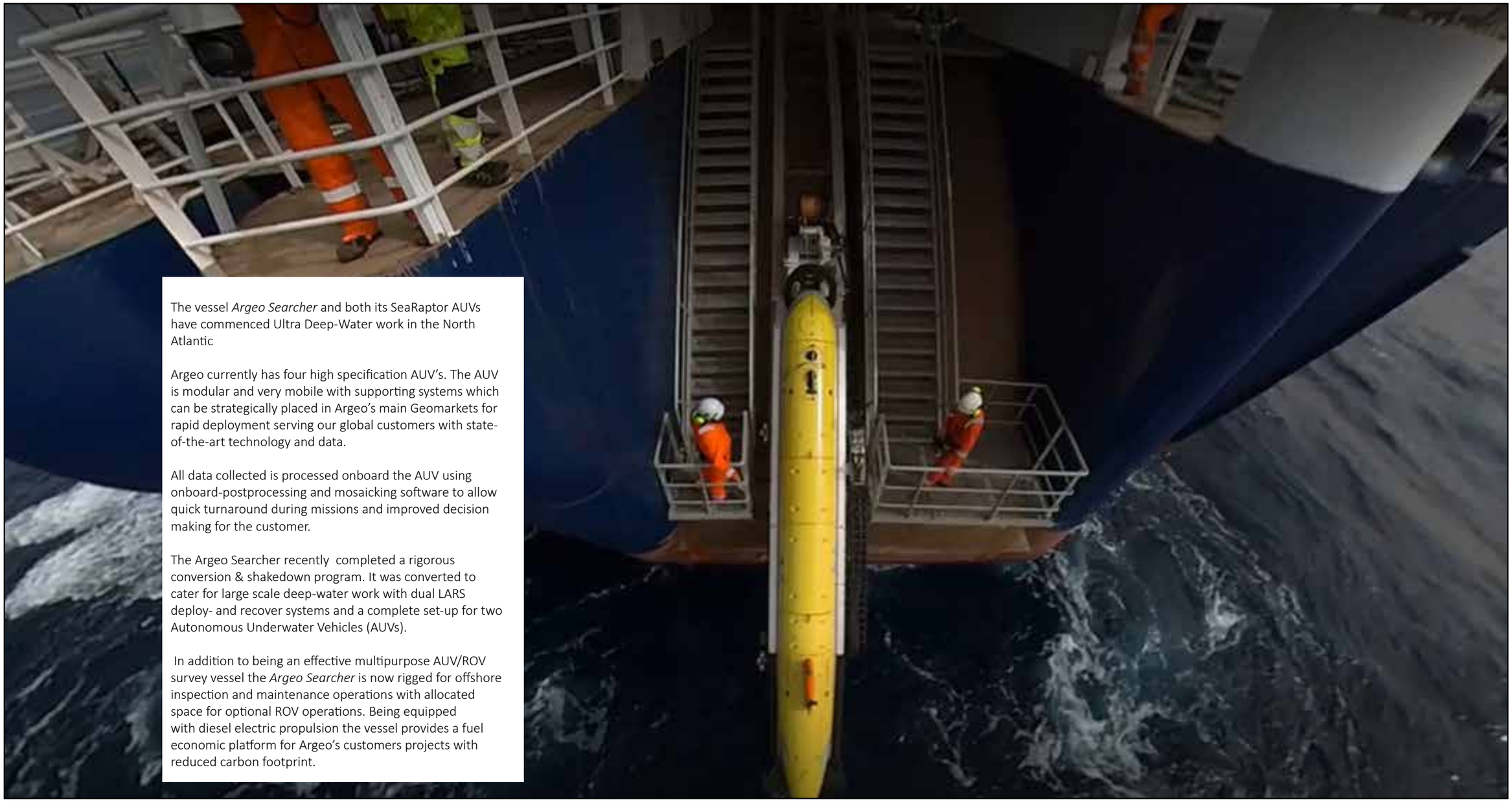
As soon as the vehicle disappears from the sea surface and loses GPS, it requires other kinds of navigation." The new software uses terrain relative navigation, which works by loading a pre-existing map into the vehicle and then using the real time seafloor map collected during the dive to figure out its position and make corrections.

Developing the software was one thing; testing it on the vehicle during an ocean dive was another. There are computer systems that allowed the MBARI and Sentry Teams to simulate using the new software on a dive, but in order to try it in the ocean, they needed to go to sea together. Last year, both teams headed to sea on an expedition where they ran the new software during actual dives, and Sentry was able repeat missions within ten meters of its original course.

This new capability is "a pretty big tech step," said Kelley. Using terrain relative navigation for Sentry is still in development, he added, but it is something the team hopes to offer to other principal investigators in the near future.

"Adding repeat mapping to Sentry's skill set is going to be especially valuable wherever you have seafloor changes from an active volcano," Caress said. "It also enables making repeated autonomous measurements, such as taking pictures of the same place on the seafloor, or taking a water sample in the same location."

ARGEO DEEPWATER WORK



The vessel *Argeo Searcher* and both its SeaRaptor AUVs have commenced Ultra Deep-Water work in the North Atlantic

Argeo currently has four high specification AUV's. The AUV is modular and very mobile with supporting systems which can be strategically placed in Argeo's main Geomarkets for rapid deployment serving our global customers with state-of-the-art technology and data.

All data collected is processed onboard the AUV using onboard-postprocessing and mosaicking software to allow quick turnaround during missions and improved decision making for the customer.

The Argeo Searcher recently completed a rigorous conversion & shakedown program. It was converted to cater for large scale deep-water work with dual LARS deploy- and recover systems and a complete set-up for two Autonomous Underwater Vehicles (AUVs).

In addition to being an effective multipurpose AUV/ROV survey vessel the *Argeo Searcher* is now rigged for offshore inspection and maintenance operations with allocated space for optional ROV operations. Being equipped with diesel electric propulsion the vessel provides a fuel economic platform for Argeo's customers projects with reduced carbon footprint.

OPTICAL COMMUNICATION STANDARD

COMMS

Hydromea is leading the development of the global underwater wireless optical communication standard for bandwidths up to 10Mbps within the Subsea Wireless Group (SWiG), of which Hydromea has been a member since 2019.

The Subsea Wireless Group (SWiG) is an international industry network of manufacturers and users of subsea wireless communication equipment (radio frequency, acoustic, free-space optic, inductive power, hybrid) and it promotes their interoperability).

Wireless optical communication assures wide-angle communication coverage as opposed to laser systems that require fine alignment. Hydromea's technology enables wireless, high-speed, low-latency communication between two or more communication nodes at depths down to 6000m.

Currently, there is no industry standard, which makes the deployment of such systems less attractive for the end users.

Felix Schill, co-founder and CTO of Hydromea, said: "We are very proud that our work on underwater wireless technology earned us a prominent place within the Subsea Wireless Group and that the industry players have entrusted us with leading the development of the standard."

Equinor, Chevron and TotalEnergies became members of SWiG to drive interoperability of underwater wireless technologies in the energy sector. They welcome initiatives that take a lead on development of industry standards. This will positively affect the adoption of underwater wireless technology by the industry.

In co-operation with an operator, Hydromea are drafting an open standard that will facilitate interoperable 1-10mbps FSO (free-space optical) communications for the industry. This standard will be donated to SWiG for review and will significantly accelerate the SWiG timeline.

End users will be able to deploy high speed FSO technology that adheres to a SWiG standard. Standardisation initiatives require collaboration and cooperation between vendor competitors.

HYDROFI

CSignum will make its CSignum HydroFi Modem commercially available in early Q2 of this year. The low-frequency HydroFi Modem, the first point-to-point wireless radio communications system that enables the transmission of data through the water-air boundary, is currently undergoing successful trials for three use cases: AUV and ASV data recovery, ship hull networking, and real-time ADCP data backhaul.

CSignum has successfully transmitted real-time data 28-30m from underwater modems to topside receivers connecting HydroFi technology to industry standard sondes, ADCPs and dataloggers. The HydroFi Modem is complementary to and overcomes the limitations of acoustic, optical and cabled data transmissions to provide the monitoring and navigational platform and solutions that digitize and scale IoT subsea devices for underwater industries encouraging greater sustainability, increased performance, and preparedness for unforeseen events.

HydroFi Modem

AUV/ASV DATA RECOVERY

HydroFi has also been used in an industrial asset integrity initiative underway at HESS for monitoring, inspecting, and repairing assets using autonomous vehicles in the oil and gas sector, a project that also has promising potential for environmental monitoring.

HESS and Ocean Aero have successfully completed initial trials in which a HydroFi Modem deployed on a Triton AUV sent and received information from underwater sensors positioned either on the sea floor or on submerged buoys. The companies are currently exploring how sensors could be further utilized to monitor overall water quality parameters in the future — from dissolved oxygen levels to turbidity to ocean temperatures. Initial trials have proven the industrial use case workable whether the transmitting modem and receivers are connecting with vehicles underwater, at the surface or in the air.

SHIP HULL NETWORKING

Working with partners and the HydroFi Modem, CSignum has successfully provided access to real-time wireless data transmissions from the keel of Her Majesty's Yacht (HMY) *Britannia*, which was decommissioned in 1997 and is now moored in Ocean Terminal in Edinburgh, to topside receivers on multiple decks without the expense and difficulty of fitting cables through the hull to monitor the environment around and under the ship and the ship's condition.

Prior to the successful trial, marine vessel operators have had no way to conduct inspections or to "see" what is happening below the waterline of their ships without dive crews, underwater vehicles or bringing vessels into drydock for routine maintenance – an inefficient, expensive and potentially dangerous process.

CSignum and its partners are currently evaluating other commercial use cases for underwater-to-air deck use cases in the under-hull domain.

Real-Time ADCP Data Backhaul

Working with a recognised leader in the field of water quality, CSignum is trialing a simplified system using the HydroFi Modem that eliminates the need for a cabled link (which can snag and fail due to repeated wave motion stresses) to an ADCP (Acoustic Doppler Current Profiler).

In the solution, which is deployed in the Baltic Sea, data are communicated wirelessly for a range of 25 meters from an ADCP modem on the seabed to a second modem with datalogger on a surface vehicle or buoy.

The system, which transmits data every five minutes, is planned to be expanded to allow the transmission of corrosion, strain, flow, motion, pressure, pH, sea levels, pollution, climate change and temperature data from seabed to air.

This solution is used in environmental monitoring and wireless deployment in turbid adverse conditions such as where fresh water and sea water collide, or out in shipping channels where buoys are tough to deploy.

SEATRAC IN PUERTO RICO

DBV TECHNOLOGY AND SEATRAC SYSTEMS IN DEEP OCEAN SEAFLOOR GEODESY

This past January, a team of Princeton geophysicists started off their new year by heading to the deepest part of the Atlantic Ocean where it meets the Caribbean Sea, a complex geologic area known as the Puerto Rico Trench. Stowed aboard their 77ft research vessel was a solar-powered 4.8m uncrewed surface vehicle (USV) and 2 novel seafloor sensors developed by a former Naval officer with sonar expertise.

The geophysicists were conducting a first-of-its-kind technology demonstration in seafloor geodesy, which is the science of understanding the depth, shape and movement of the seafloor, and how seafloor bathymetry relates to its gravitational and magnetic fields.

Specifically, the demonstration consisted of deploying a SeaTrac SP-48 equipped with a DBV Technology GPS-Acoustic (GPS-A) Surface System to execute survey transects in open ocean while communicating with Temporary Deep Ocean Geodetic

Above: It has four GPS receivers and two acoustic transducers (seen protruding from the hull just aft of amidships).

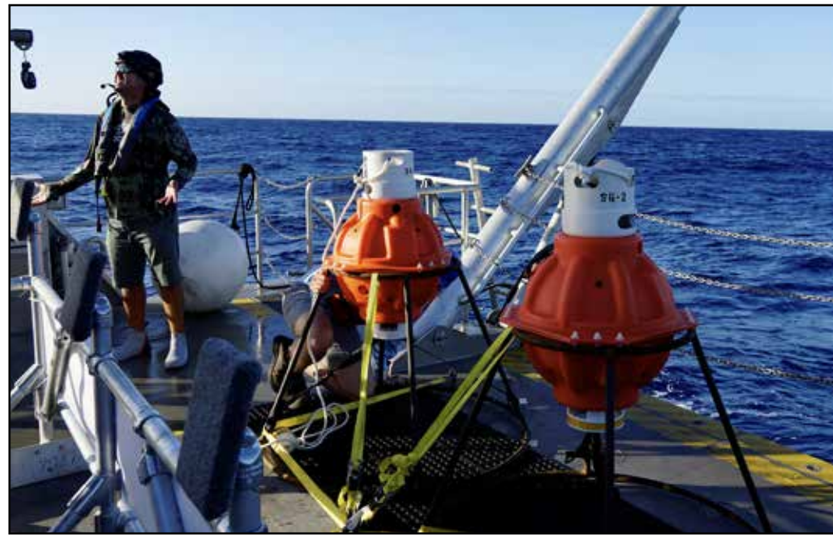
Below: Test location

sensors (T-DOGs) submerged in the trench at depths of 5500m and 3500m. By combining acoustic data with GPS/Global Navigation Satellite System (GNSS) data (GPS-A), the team is able to monitor deep seafloor tectonic plate movement to better measure its shape and detect change before and after earthquakes.

The USV operated autonomously while being monitored and controlled from shore by satellite at two remote locations – Puerto Rico (75 km to the south) and Rhode Island (2,400 km to the north) . The T-DOG sensors and SP-48 were deployed from the RV Blue Manta operated by Blue Tide Puerto Rico. When they weren't seasick, the team practiced deploying and recovering the SeaTrac USV in high sea states, up to 10 feet at times, and got adept at maneuvering the platform despite the limited deck space of the research vessel. The SeaTrac SP-48 demonstrated excellent seakeeping ability (+/- 3 meters cross track error) over sustained survey legs exceeding 20 km.

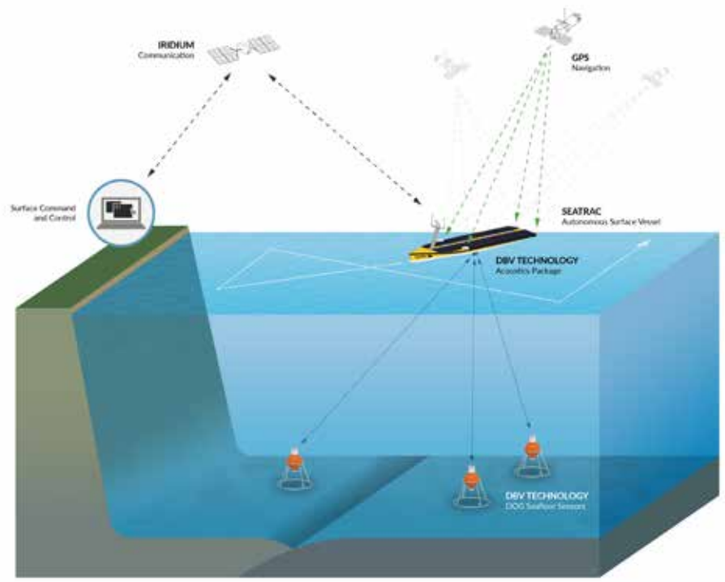
Additionally, the platform demonstrated the ability to provide enough power to operate the surface acoustic system with limited self noise.

"We think the SP-48 is well suited to this type of work. Despite suffering some damage in shipping to our



Above: TDOG in transit to their deployment locations. They are attached to anchor stands which are strapped to the deck.

Below: Seafloor Geodesy concept of operations. TDOGS are deployed to seafloor at region of interest (e.g. across a plate boundary).



solar panels which limited our charging power, we feel the system worked very well," said Jigger Herman, Co-Founder of SeaTrac.

Acoustic testing consisted of bi-directional transmissions from shore, to the sea surface via satellite, down to the seafloor and back again at horizontal distances up to 11 km.

Transmissions included signals for synchronization, survey, command and control, and data telemetry. Command and control messages consisted of putting T-DOGs into a low power state, waking up, transponding, and releasing.

The T-DOGs contain a Chip Scale Atomic Clock for precise synchronization with GPS to enable sub-centimeter level positioning of the sensors on the seafloor. For this demonstration, each T-DOG sensor was also equipped with a synchronized acoustic recorder to allow validation of embedded low power hardware that is essential to long term seafloor geodetic missions.

The Puerto Rico expedition is part of the Princeton team's longer-term effort to develop a more capable and economical geodesy system for sustained seafloor measurements. The Puerto Rico Trench is an excellent location for technology validation due to its close proximity to a major port, challenging open ocean conditions, and ready access to rapid response vessels for testing and intervention.
"We were very pleased to have the performance of our GPS-Acoustic system exceed design expectations," says DBV Technology President Bud Vincent.

"We are anxious to get the system ready for long term science missions

SeaTrac in Open Ocean

Cameras are mounted on the mast for situational awareness. GPS and Iridium antennas for navigation and vehicle mission control are located on the centerline just aft of the mast between the solar panels.

The geodetic survey GPS antennas are located outboard, port and starboard, outboard amidships and on the transom.

The GPS-Acoustic payload is contained inside the hull in the payload bay.

later this year," adds Princeton Professor of Geosciences, Dr. Frederik Simons.

"In addition to battle testing the technical capabilities, the demonstration also provided a learning opportunity by having parts of the tests controlled and monitored by graduate students."

Going forward, the Princeton geophysicists plan to use DBV's innovative method for seafloor geodesy, and its system built for the SeaTrac platform.

They will employ either Temporary or Continuous Deep Ocean Geodetic Sensors (T-DOGs and C-DOGs) which measure seafloor tectonic plate movement in any ocean depth, using very low power, and for very long-term deployments more accurately and economically than possible using present methods.

(T-DOGs are recoverable and intended for deployments up to 3 years. C-DOGs are designed to last 30-50 years and are not intended to be recovered.)

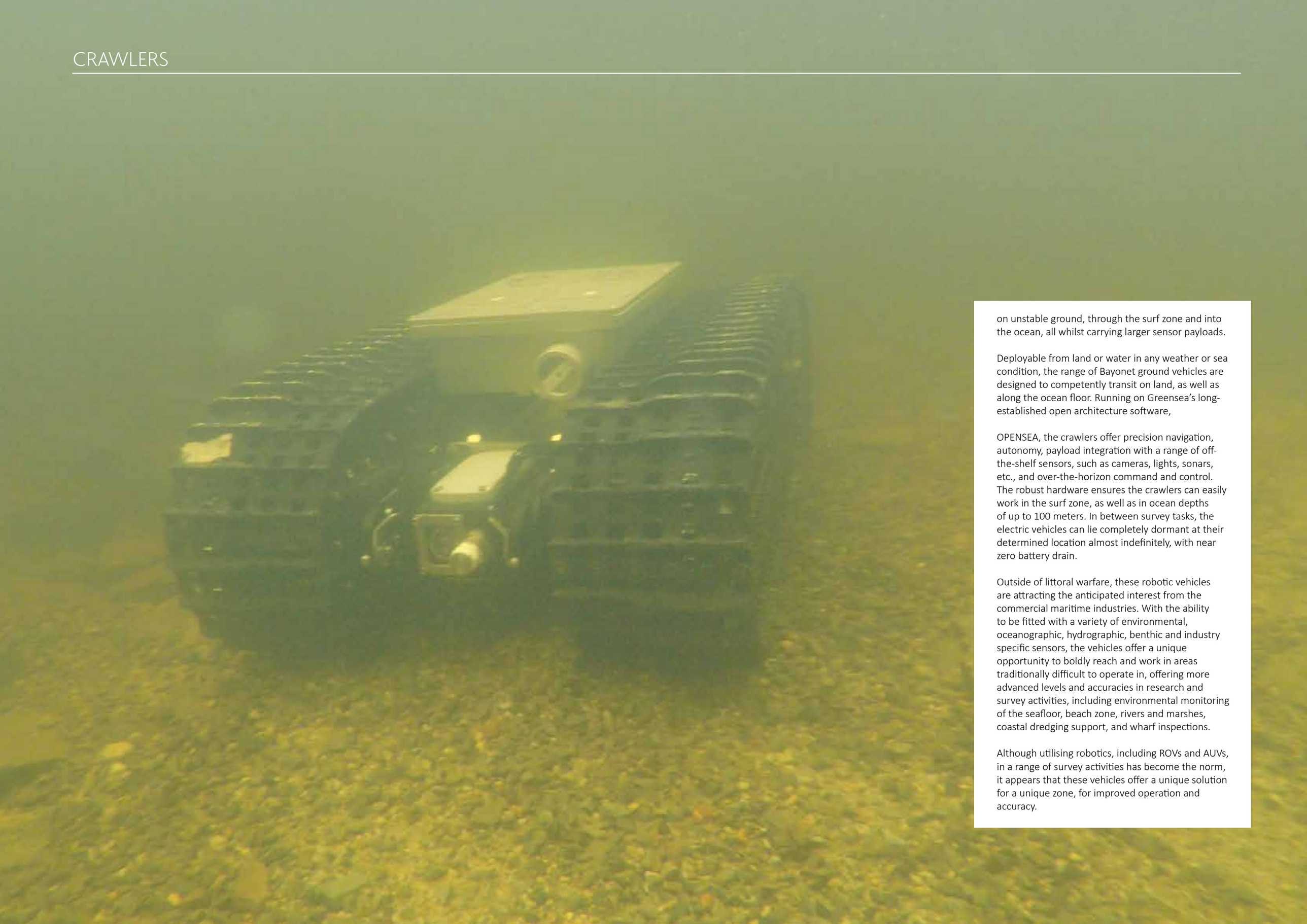
BOLDLY GOING WHERE NO ONE HAS GONE BEFORE

A range of autonomous tracked ground vehicles, originally developed to meet military needs, is now enabling commercial marine industries to benefit from robotic innovation to meet theirs.

The US Military's requirement to utilise state-of-the-art amphibious unmanned systems to support sea to land military activity, fast-tracked and funded the development of robotic vehicles. The requirement was to have robotic unmanned amphibious vehicles that can clear hazards in the surf zone for safer and more effective beach landing and shore based military operations.

Marine robotics specialist Greensea Systems, Inc. (Greensea) launched Bayonet Ocean Vehicles (Bayonet) early 2022 to meet military requirements, whilst seeing the potential for commercial applications. Bayonet now boasts a range of amphibious ground vehicles that fill the void in autonomous ocean systems, by being able to work

CRAWLERS



on unstable ground, through the surf zone and into the ocean, all whilst carrying larger sensor payloads.

Deployable from land or water in any weather or sea condition, the range of Bayonet ground vehicles are designed to competently transit on land, as well as along the ocean floor. Running on Greensea's long-established open architecture software,

OPENSEA, the crawlers offer precision navigation, autonomy, payload integration with a range of off-the-shelf sensors, such as cameras, lights, sonars, etc., and over-the-horizon command and control. The robust hardware ensures the crawlers can easily work in the surf zone, as well as in ocean depths of up to 100 meters. In between survey tasks, the electric vehicles can lie completely dormant at their determined location almost indefinitely, with near zero battery drain.

Outside of littoral warfare, these robotic vehicles are attracting the anticipated interest from the commercial maritime industries. With the ability to be fitted with a variety of environmental, oceanographic, hydrographic, benthic and industry specific sensors, the vehicles offer a unique opportunity to boldly reach and work in areas traditionally difficult to operate in, offering more advanced levels and accuracies in research and survey activities, including environmental monitoring of the seafloor, beach zone, rivers and marshes, coastal dredging support, and wharf inspections.

Although utilising robotics, including ROVs and AUVs, in a range of survey activities has become the norm, it appears that these vehicles offer a unique solution for a unique zone, for improved operation and accuracy.

RTS INVESTS IN IMPACT

Rental Technology & Services (RTS) have made a significant investment in Impact Subsea ISA500 Altimeters and ISD4000 Depth Sensors.

The investment is to compliment RTS's rental portfolio with high performance sensor solutions and provide rental stock for the newly opened Aberdeen base. The ISA500 provides long range, high accuracy, underwater distance measurements while the ISD4000 provides survey grade depth and temperature readings.

SEA360

NEOTEK has launched SEA360, an underwater data acquisition and analysis service.

This new approach, as an alternative to existing conventional solutions, is based on NEOTEK's unique expertise, combining cutting edge technologies and highly skilled personnel with a wealth of experience in data processing.

The dedicated SEA360 team operates at sea using a fleet of autonomous underwater drones (AUV RTSYS COMET and AUV RTSYS Nemosens) and ROVs, buoys and instrumented underwater stations.

SEA360 will help to reduce project times, simplify operations at sea while maximizing data quality in a low carbon impact and cost rationalization approach.

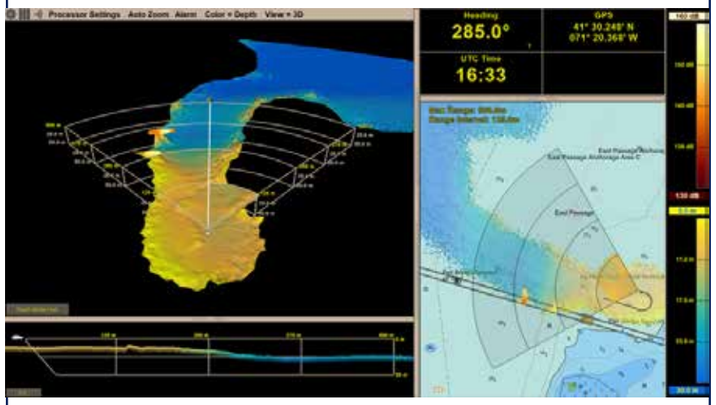
These marine data services are applied to rapid environmental impact and assessment measurements, marine pre and post construction surveys, underwater inspections of structures, cables, and pipelines, UXO detection, marine geophysics, hydrography, and marine archaeology.

3D SONAR

FarSounder Argos 3D Forward Looking Navigation Sonars have been included in the navigation control system for two Unmanned Surface Vessels (USV) built in Türkiye. The vessels have comprehensive automation technologies enabling them to sail autonomously.

The addition of the Argos systems will help them carry out their missions safely.

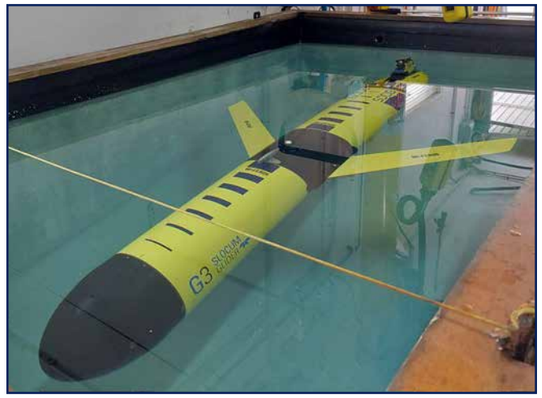
Argos sonars interface with the vessel navigation and control systems, providing vital information about the current state of the environment in front of the vessel and below the water line. This gives the vessel an invaluable level of situational awareness. The systems do all the data processing and provide the vehicle control system with the information needed to make intelligent navigation decisions and make real time course alterations.



Argos sonar

GLIDERS

Teledyne Marine has delivered three Webb Slocum gliders to the Royal Netherlands Institute for Sea Research (NIOZ). Scientists, engineers, and ship technicians at NIOZ recently underwent operational and maintenance training on the systems with field support staff from Teledyne Webb Research and the UK's National Oceanographic Centre (NOC), which is Teledyne's European Slocum Service facility.



NIOZ Glider

This training was conducted in Spain at SOCIB facilities in preparation for the glider science project to be undertaken initially by the *RV Pelagia* in the North Sea in the spring of 2023.

The Nose project will study the absorption of CO2 in the North Sea. Slocum gliders were acquired with a grant from the NWO Large-scale Scientific Infrastructure (NWO-GWI), awarded in 2020 to a broad nationwide marine research consortium of universities, institutes, and TO2 institutions.

FIRST SEA-KIT EXPORT DEAL

SEA-KIT has announced its first Uncrewed Surface Vessel (USV) export sale to ThayerMahan. The X-Class USV's award-winning combination of extended range, high sea state endurance and payload capacity attracted ThayerMahan initially.

"We envisage that the introduction of this hi-tech USV to our portfolio will enhance the protection of ports and vessels at sea as well as have a positive impact on illicit trafficking across international borders," said Mike Connor, President and CEO at ThayerMahan.

ThayerMahan plans to use the SEA-KIT USV to support introduction of the technology into government service, as well as for its own commercial activities in US and international waters.

X-Class USV's

SEABAT T50-ER MULTIBEAM SONAR SYSTEM CREATES HIGH-RESOLUTION HABITAT MAPS

Research conducted by the Greenland Institute of Natural Resources focuses on the living resources and environment in and around Greenland. They advise the government of Greenland and municipalities regarding the environment, flora and fauna, and climate change.

The institute recently purchased the Teledyne Marine SeaBat T50-ER extended-range multibeam sonar system for seafloor modeling to classify bottom types into habitats.

The SeaBat T50-ER multibeam sonar enabled them to organize these bottom types into habitats to model the seafloor for undersea landform analvsis or geomorphology. Seafloor terrain affects the distribution and diversity of fish populations and other animals. Effects of bottom types and geography have been reported in fish populations worldwide.

Seafloor mapping and landscape ecology analyses are essential in monitoring stock assessments and spawning sites.

The Teledyne Marine SeaBat T50-ER multibeam sonar system is a vital tool for understanding the geomorphology of undersea landforms to focus on monitoring commercial species. The SeaBat T50-ER plays a significant role in the ongoing scientific documentation of population sizes. For the Greenland Institute of Natural Resources, this monitoring is integral to the institute's research.

THE CHALLENGE

The importance of seafloor modeling and the ongoing exploration to classify bottom types into habitats is far-reaching. Because the institute is responsible for this vital research contributing to Greenland's economy, they acquired the SeaBat T50-ER multibeam sonar system to get the job done.

Knowledge of annual fish and shrimp assessments is a critical part of the report submitted by the institute to the government of Greenland. Weather conditions often make it challenging to collect the necessary data. Ice and wind conditions, along with funding for ship time, can be obstacles to getting the data necessary for undersea landform analysis. That is where the SeaBat T50-ER multibeam sonar system comes in.

THE SOLUTION

The SeaBat T50-ER is designed for swift mobilization on any survey vessel, securing minimal interfacing and low space requirements.

The SeaBat T50-ER is the latest addition to the world-leading SeaBat T-series platform.

The highly compact and flexible rack-mounted sonar system with a built-in INS allows for fast mobilization, minimal interfacing, and extremely low space require-ments.

Because the SeaBat T50-ER multibeam is fully frequency agile from 190 to 420 kHz, it allows for improved swath performance and reduced survey time under challenging acoustic conditions.

GREENLAND INSTITUTE OF NATURAL RESOURCES

The Greenland Institute of Natural resources collects, processes, and evaluates data regarding the utilisation and protection of living resources. It reports to Greenland's Self-Government.

They are responsible for researching to assess living resources of importance to Greenland and contribute to studies of processes and ecological relationships in nature.

The institute participates in studies and development work assessing tools and methods for utilising Greenland's natural resources.

The institute needed a system that could conduct bathymetric surveys to determine the geomorphology and bottom composition off the coast of Greenland.

KATFISH

Kraken Robotics has received an international Robotics as a Service (RaaS) contract for the high- resolution inspection of the critical sea routes and critical marine infrastructure.

The initial contract is valued at $0.8 million and will be undertaken using the KATFISH high-speed towed synthetic aperture sonar (SAS) system coupled with Kraken's Automated Launch and Recovery System (ALARS) on a vessel of opportunity. For confidentiality reasons, the location of the contract cannot be disclosed.

KATFISH is a high-speed, actively stabilized Synthetic Aperture Sonar (SAS) towfish that operates at speeds up to 10 knots. The high-speed capability, and constant resolution of KATFISH significantly increases Area Coverage Rates (ACR) by providing more useable data at longer ranges and higher fidelity than traditional Side Scan Sonars.

KATFISH provides acoustic seabed imagery with a range-independent resolution of 3 cm x 3 cm and area coverage rates (ACR) of up to 4 km2/hour, with swaths of up to 400 meters, including simultaneous full swath 3D bathymetry. With post-processing, 1.9 cm x 2.1 cm constant resolution imagery is available.

ERIC WIRSTROM

U.S. Navy veteran Eric Wirstrom has joined VideoRay as the new Vice President of Business Development to drive growth in the commercial and defense sectors. Initially, Wirstrom will focus on VideoRay's performance in its Maritime Expeditionary Standoff Response (MESR) program of record for the U.S. Navy.

The Navy has standardized on Mission Specialist Defender systems, and is gearing up to purchase them in higher quantities. Wirstrom will also work with VideoRay's government and defense business team to continue to introduce Mission Specialist technology to navies around the world.

Wirstrom retired from the U.S. Navy as an Explosive Ordnance Disposal officer, having attained the rank of Captain. Over the course of his successful military career, he held significant leadership roles as Commander of Task Force 52, the forward-deployed mine countermeasures task force in the Navy's 5th Fleet, and as Commanding Officer of Explosive Ordnance Disposal Mobile Unit ONE, at the time, the U.S. Navy's only very shallow mine countermeasures task force.

PAUL WALKER

Paul walker will be leading TDI's geotechnical, geochemical, and environmental labs as director of laboratory operations

Paul began his career at humble geochemical where he was tasked with method development, instrument maintenance, and general lab and project management. He then joined baseline resolution where he continued developing and optimizing specialized pyrolysis and hydrocarbon separation methods for onshore and offshore petroleum systems.

These specialized methods became the standard for baseline's global network of laboratories, ensuring that high quality and consistency were globally available within the lab network. Paul then worked with his staff to obtain an iso-9001 certification and began establishing a PVT laboratory for the marriage of geochemical and engineering data.

Weatherford international purchased both humble and baseline in 2007 and 2008 respectively, at which point Paul became the general manager of global geochemical operations, including instrument manufacturing (the source rock analyser), geochemical software/ database development, and the newly acquired interpretive services group (formerly oiltracers llc).

SAM ADAMS

Sam Adams has joined Strategic Robotic Systems (SRS) as Sales Engineer.

A professional with over 24 years of military and capability development experience, Mr. Adams has served with both the British Special Forces (Special Boat Service) and the Specialist Capability Cell.

"Sam brings with him a wealth of experience and expertise in military operations and most recently, in sales and business development," said Omer Poroy, CEO of SRS.

Prior to joining SRS, Mr. Adams worked as the Business Development Lead for Defense at L3Harris where he played a key role in identifying, qualifying, and maintaining a growing pipeline of new and follow-on business.

OMER POROY

General Oceans has appointed Omer Poroy as Chief Executive Officer of Strategic Robotic Systems. Mr. Poroy brings with him over 25 years of experience in the ocean technology space with expertise in sensors, robotics, autonomy, and the interplay of multi-domain maritime systems.

During his tenure at General Dynamics Mission Systems, Mr. Poroy led enterprise-level strategy and business development initiatives through various campaigns encompassing Undersea Warfare, Maritime Autonomy and Distributed Maritime Operations. Prior to General Dynamics, Mr. Poroy held various leadership positions at Bluefin Robotics and Teledyne Technologies.

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Mr. Poroy received his MBA from Massachusetts Institute of Technology, Sloan School of Management, and holds Ocean Engineering degrees from Florida Institute of Technology.

ERIC CHEWNING

Defence provider HII has announced that Eric Chewning, former chief of staff to the U.S. Secretary of Defense and deputy assistant secretary for industrial policy, is joining HII as executive vice president, Strategy & Development, reporting directly to HII President and CEO Chris Kastner. Chewning.

Chewning joins HII as it grows its customer set across the armed forces and executes on its significant shipbuilding backlog for its primary customer, the U.S. Navy. HII is the nation's only builder of aircraft carriers and its largest military shipbuilder; among defense technology distinctions it is the world's largest producer of unmanned underwater vehicles, the largest aggregator of cyber data across the U.S. Department of Defense, and sole developer and operator of the department's largest LVC (live, virtual and constructive) training enterprise that leverages artificial intelligence to maximize readiness while reducing costs.

With 20 years of experience in national security markets, Chewning will guide HII's corporate strategy, including identifying new opportunities for growth, cross-division collaboration, and potential investment.

Most recently Chewning was the Americas co-lead for the aerospace and defense practice at McKinsey & Company. A former U.S. Department of Defense senior official, he served as the chief of staff to the Secretary of Defense, advising on all policy, operational, personnel, and budgetary matters, and driving senior leaders towards execution of the national defense strategy. Prior to that role, Chewning served as deputy assistant secretary of defense for industrial policy, where he was the principal advisor on defense industrial base and supply chain issues for the secretary.

Chewning enlisted in the U.S. Army after 9/11. He is a former military intelligence officer and veteran of Operation Iraqi Freedom.

FRANK NIEMEYER

Subsea Europe Services has opened a new R&D centre at its premises in the Ocean Technology Campus Rostock. The new department is led by and has been established to enable the subsea systems, services and solutions provider's mission to simplify the acquisition of marine data by leveraging new integrated, autonomous and digital technologies.

Following Dr. Niemeyer's appointment as Head of Research And Development in January 2023, Subsea Europe Services plans to grow the department further with new data science, mechatronics, software development and platform management roles.

It ensures cross-discipline in-house expertise informs the development of truly autonomous survey platforms and new Data-as-a-Service workflows, which can significantly reduce cost and provide Cloud-access to high-quality marine data.

Offshore Technology Campus Rostock is widely regarded as one of Europe's leading marine technology and research clusters, making it the perfect location for Subsea Europe Services' next phase of expansion.

The new R&D facility measures 100 m2 and will be used for further developing the company's autonomous platform capabilities for marine survey with the "Autonomous Surveyor" Autonomous Surface Vessel (ASV) and underwater inspection, with the "A.IKANBILIS" Hovering Autonomous Underwater Vehicle (HAUV).

The Subsea Europe Services R&D team will also focus on creating new application specific AI-powered autonomous control systems and unlocking the potential of swarm surveys featuring multiple autonomous vehicles with crewed or uncrewed motherships capable of managing the entire operation.

These cutting-edge marine survey technologies and methodologies contribute to a unique and disruptive strategy that can positively transform marine survey and underwater inspection for all stakeholders.

Dr. Frank Niemeyer joins Subsea Europe Services from his previous role as a Scientific Research Associate at the Fraunhofer Institute for Large Structures in Production Engineering, where he has been on secondment at the Rostock branch office of the "Smart Ocean Technology" research group, working on diverse technical R&D projects. He has also held R&D positions including Research Associate at the University of Rostock, and Chair of Geodesy and Geoinformatics.

"Subsea Europe Services has quickly established itself among the top tier technology companies in this field and I look forward to becoming part of a team with huge ambition and the skills and expertise to make it happen."

Offshore Technology Campus Rostock

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