UNDERWATER
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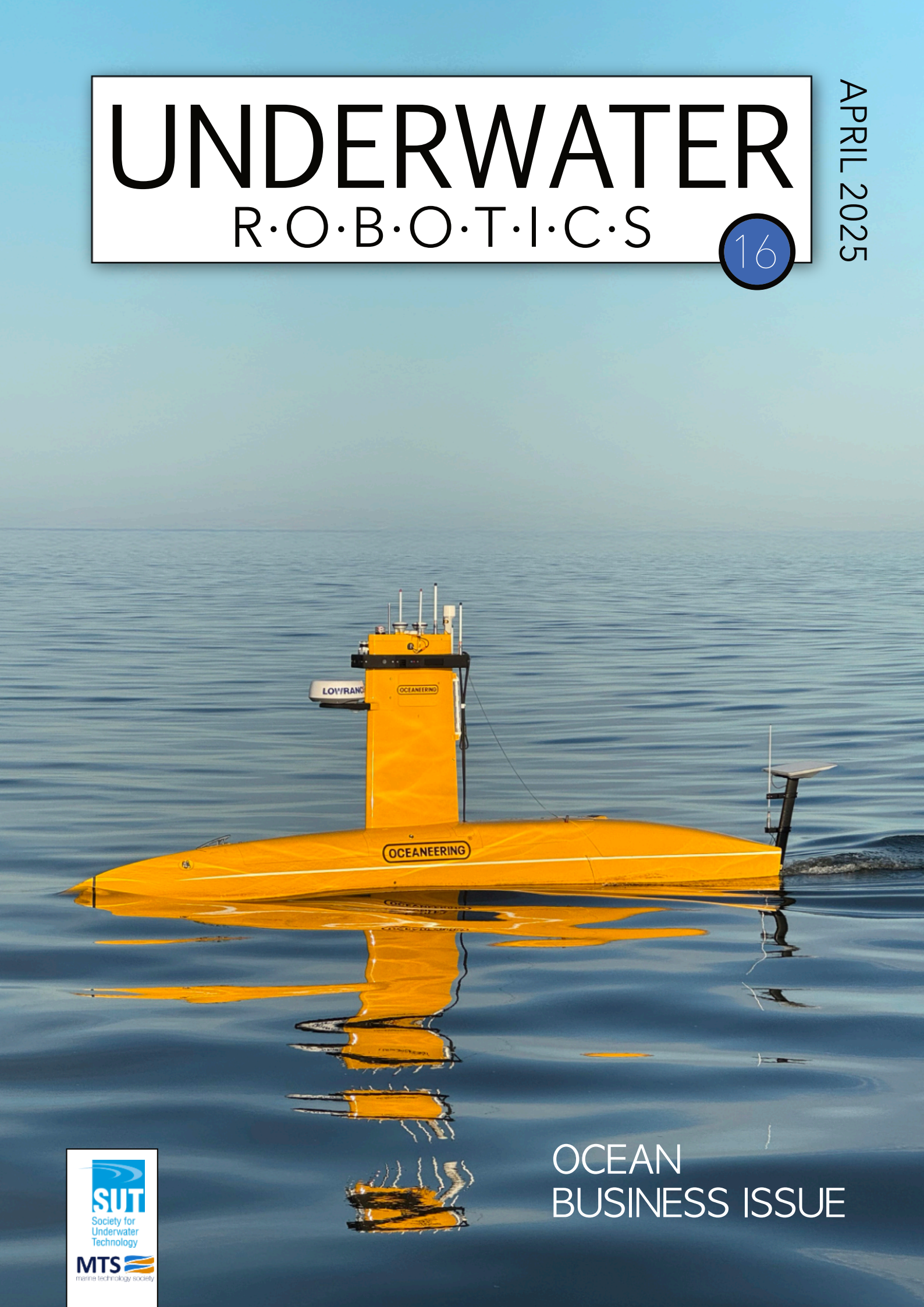
APRIL 2025



OCEAN
BUSINESS ISSUE

SUT
Society for
Underwater
Technology

MTS
marine technology society

Oceaneering's DriX USV conducting survey operations

CONTENTS

TAKEOVERS AND ACQUISITIONS

SAIPEM / SUBSEA 7

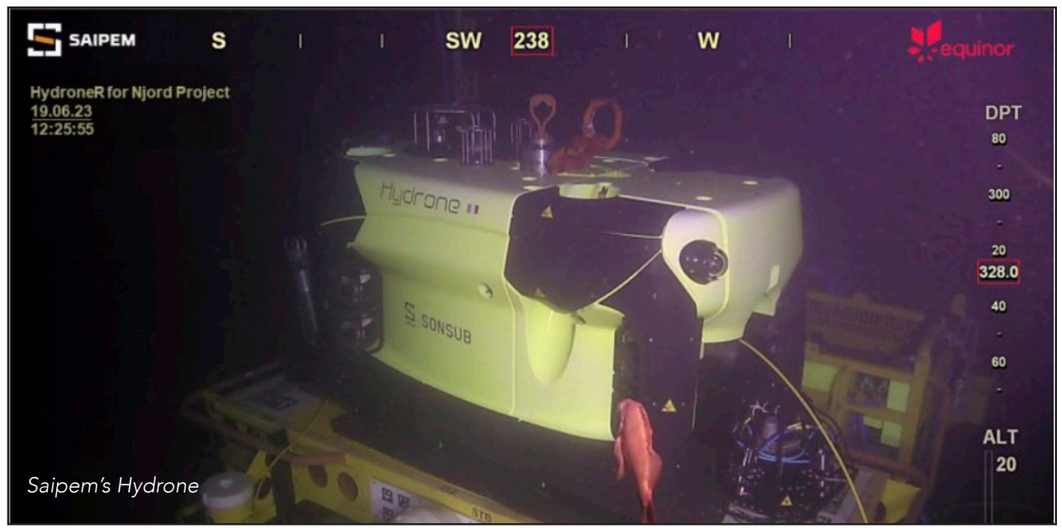
Saipem and Subsea7 have reached an agreement in principle for a possible merger. The proposed combination is expected to create a global leader in energy services.

The combination of Saipem and Subsea7, to be renamed Saipem7, will have a combined backlog of €43 billion, a revenue of €20 billion and EBITDA in excess of €2 billion The global organisation of over 45 000 people, including more than 9000 engineers and project managers

The companies have highly complementary geographical footprints, competencies and capabilities, vessel fleets and technologies that will benefit the combined company's global client base.

The Saipem and Subsea7 shareholders will own 50% each of the share capital with Subsea7 shareholders will receive 6.688 Saipem shares for each Subseal share held.

Annual synergies of approximately €300 million are expected to be achieved in the third year after completion.



Saipem's Hydrone

KRAKEN / 3D@D

Kraken Robotics has signed a definitive agreement to acquire the shares of 3D at Depth, a leading American subsea technology and services company specialising in high resolution LiDAR imaging and measurements.

Under the terms of the Agreement, Kraken will indirectly acquire 3D at Depth for US$17 million

3D at Depth employs 56 people and provides underwater LiDAR technology and services resulting in comprehensive, accurate data to enable informed decision making on underwater assets and infrastructure in a cost-effective, low risk manner.

KYSTDESIGN / EDISON CHOUEST

Kystdesign's Zeerov

The Chouest Group has acquired Kystdesign, a premier manufacturer of remotely operated vehicle (ROV) systems.

This acquisition strengthens Chouest's subsea capabilities, ensuring continued support for Kystdesign's existing clients while enhancing in-house solutions for CInnovation and ROVOP - key players within the Chouest portfolio. The first integrated ROV system under this partnership is already in development, marking the beginning of an exciting new chapter for both companies. With this integration, Kystdesign joins Chouest's global workforce approaching 20,000 employees.

This collaboration is expected to drive significant advancements in subsea technology, unlocking new possibilities in deepwater operations and design.

Kystdesign has achieved tremendous growth in recent years - including doubling its workforce, projected 2024 turnover approaching NOK 500 million, and a record-high order backlog.

NAUTICUS / SEATREPID

Nauticus Robotics has signed a definitive agreement to acquire all of the assets and business of SeaTrepid International.

The company says that by integrating Nauticus' AI-driven autonomy software, ToolKITT, into SeaTrepid's existing ROV fleet, the combination will showcase unprecedented advancements in power efficiency and operational performance across the industry.

The ability of ROVs and Aquanaut to seamlessly communicate at depth unlocks new service opportunities, enabling two autonomous systems to collaborate in delivering cutting-edge underwater solutions.

KOIL / SUBSEADESIGN

US-based KOIL Energy Solutions and the Norwegian SubseaDesign have formed a strategic alliance to accelerate advancements in subsea technology.

Both companies provide specialty products and services for subsea projects. Driven by the rising demand for innovative solutions in the global subsea industry, the two companies will collaborate within R&D and project execution.

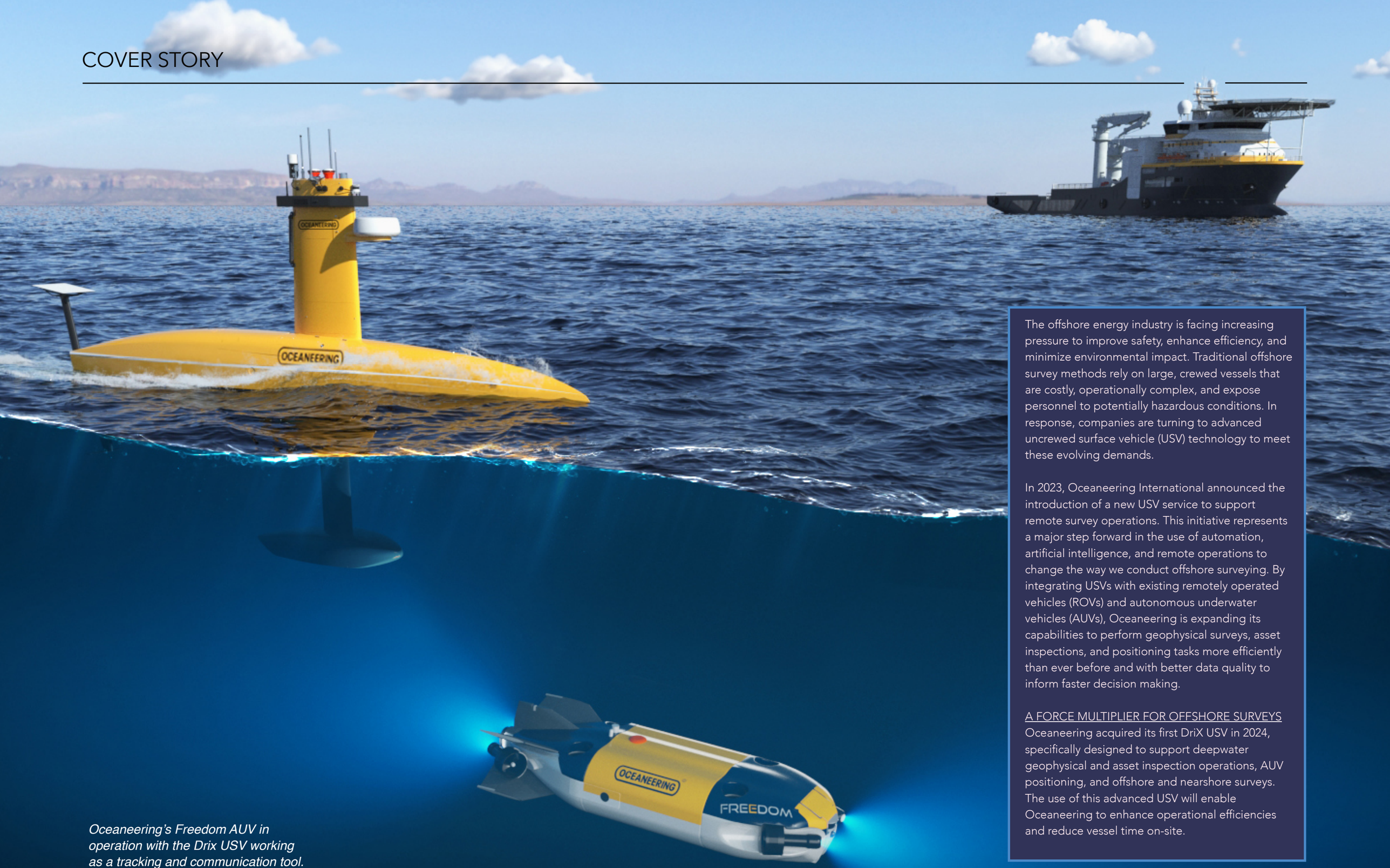
REVOLUTIONISING REMOTELY OPERATED OFFSHORE SURVEYS

Alexander Steele, Subsea Robotics Products and Services Lead, Oceaneering

Bryan Keller, Subsea Robotics Product Manager, Oceaneering

Tyler Whitener, Project Manager AUV and Geoscience, Oceaneering

The DriX USV performing subsea scanning as part of its survey capabilities



Oceaneering's Freedom AUV in operation with the Drix USV working as a tracking and communication tool.

The offshore energy industry is facing increasing pressure to improve safety, enhance efficiency, and minimize environmental impact. Traditional offshore survey methods rely on large, crewed vessels that are costly, operationally complex, and expose personnel to potentially hazardous conditions. In response, companies are turning to advanced uncrewed surface vehicle (USV) technology to meet these evolving demands.

In 2023, Oceaneering International announced the introduction of a new USV service to support remote survey operations. This initiative represents a major step forward in the use of automation, artificial intelligence, and remote operations to change the way we conduct offshore surveying. By integrating USVs with existing remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), Oceaneering is expanding its capabilities to perform geophysical surveys, asset inspections, and positioning tasks more efficiently than ever before and with better data quality to inform faster decision making.

A FORCE MULTIPLIER FOR OFFSHORE SURVEYS

Oceaneering acquired its first DriX USV in 2024, specifically designed to support deepwater geophysical and asset inspection operations, AUV positioning, and offshore and nearshore surveys. The use of this advanced USV will enable Oceaneering to enhance operational efficiencies and reduce vessel time on-site.

The DriX USV operating in adverse weather conditions due to the dual positional redundancy provided by Oceaneering C-Nav Positioning Solutions.

DriX USV works in tandem with Oceaneering's fleet of AUVs, such as the HUGIN Superior and Freedom hybrid ROV/AUV vehicle system.

By leveraging the USV as a tracking and communication tool, functions traditionally performed by large, crewed vessels, Oceaneering can maximize the Geoscience data production output of its dedicated multi-service vessels (MSVs).

The DriX USV operates with an exceptionally low fuel consumption rate of only two liters per hour, reducing carbon emissions when compared to traditional survey vessels, making it a more sustainable solution for offshore operations.

PROVEN TECHNOLOGY WITH A STRONG OPERATIONAL TRACK RECORD

The DriX USV has accumulated thousands of operational hours since its introduction in 2016. It features AI-powered CortiX software and state-of-the-art sensors, allowing it to conduct over-the-horizon supervised autonomous operations.

The USV's robust stability enables it to operate in rough offshore conditions up to sea state 5 without compromising data quality. Its high-speed and efficient surveying capabilities reduce transit downtime and enable nearshore surveys to be conducted swiftly while maintaining optimal data quality.

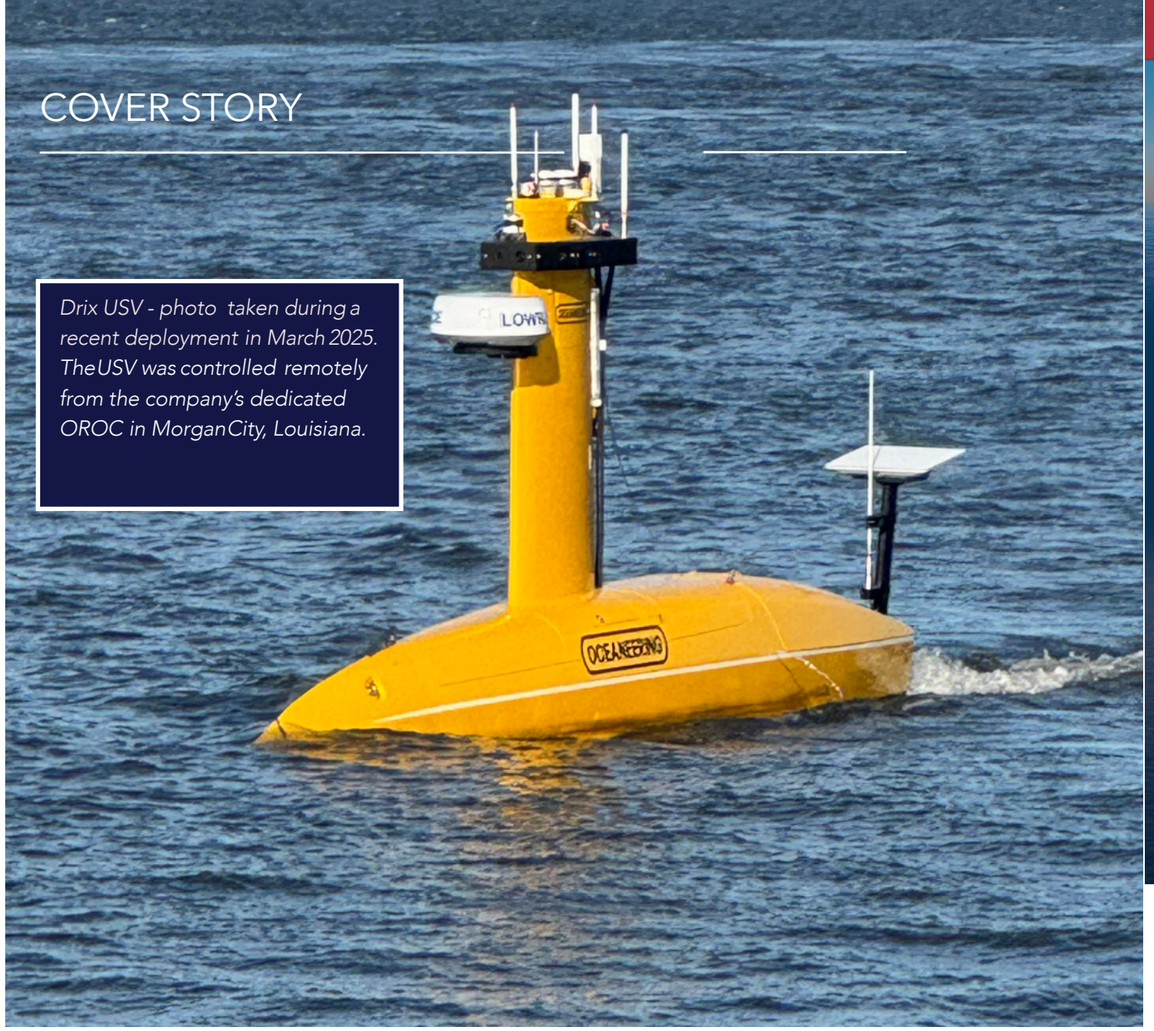
TRUE, DUAL REDUNDANCY

Oceaneering's USV services set a new standard by incorporating true, dual positional redundancy for guaranteed continuity of service. This will be achieved through the use of two fully independent positioning correction services from Oceaneering's C-NAV group, ensuring uninterrupted operations and significantly improving reliability.

The C-NAV positioning technology enables the USV to maintain precise and consistent positioning even in challenging offshore environments. Launched in early 2023, C-NAV LEO is a satellite-based correction service delivered exclusively via the Iridium Short Burst Data service. The Iridium network provides truly global coverage, featuring 66 satellites in six polar orbits, along with 15 in-orbit spares for built-in redundancy.

Unlike traditional GEO satellite positioning correction services that are positioned 35,000 km from Earth and have blind spots, the C-NAV® LEO correction service provides continuous, overlapping signals, even in remote regions. Iridium satellites function effectively even in adverse weather conditions. They move quickly, ensuring any temporary blockage in coverage does not affect correction accuracy.

This capability is critical for offshore survey operations where consistent and accurate positioning is essential. The integration of C-NAV technology into Oceaneering's USV service reinforces the company's commitment to delivering the most reliable and efficient offshore survey solutions. By ensuring seamless,



Drix USV - photo taken during a recent deployment in March 2025. The USV was controlled remotely from the company's dedicated OROC in Morgan City, Louisiana.

high-accuracy positioning even in the most remote offshore locations, the C-NAV technology enhances the performance of the USV and AUV fleets, further solidifying Oceaneering's leadership in autonomous and remote offshore operations.

A BREAKTHROUGH IN REMOTE SURVEYING

In March 2025, Oceaneering conducted the first deployment of a DriX USV in a survey role, controlled remotely from the company's dedicated Onshore Remote Operations Center (OROC) located in Morgan City, Louisiana.

The project demonstrated the potential of remote-controlled USVs to efficiently carry out offshore operations. During the project, the USV successfully surveyed 372 kilometers of seabed. Over 33 hours of uninterrupted over-the-horizon piloting was conducted, with full control of the DriX maintained remotely.

The project demonstrated that the DriX USV can conduct comprehensive block and pipeline route surveys using multibeam sonar and sub-bottom profiler (SBP) data, allowing for high-resolution imaging and precise mapping of subsea infrastructure.

Additionally, near real-time data analysis was performed by expert teams in Brazil and Morgan City, ensuring swift decision-making and improving the overall efficiency of the operation.
The deployment reinforced the expectation that USV offshore surveys can improve safety by keeping surveyors onshore thereby minimizing offshore exposure risks.

It also enables simultaneous operations (SIMOPS) w, which allows Oceaneering to maximize the Geoscience data production output of its dedicated MSVs.

A FUTURE-READY APPROACH TO OFFSHORE SURVEYS

Oceaneering has been a pioneer in both remotely operated vehicles and remote operations. The company established its first dedicated OROC in 2015 in Stavanger, Norway. Since then, the company has logged over 100,000 hours of remote piloting and has transitioned more than 9,000 personnel days from offshore to onshore operations through its Remotely Operated Survey initiatives.

Oceaneering's USV service is a natural progression of our extensive remote operations experience. Combining USVs with Oceaneering's existing ROV and AUV fleets and onshore remote operations centers delivers significant opportunities to scale operations and drive greater efficiencies.

The DriX USV allows us to remotely gather the same high-quality data at a lower operational impact, without the need for an offshore-based crew. This reduces health, safety, and environmental risks while freeing up MSVs to complete other tasks.

Looking ahead, the USV service will continue to evolve, supporting cost-effective growth in the offshore renewables market. Future plans include deploying larger USVs for towing sensors and creating a platform for remotely launching and recovering ROVs.

Customers will be able to complete AUV inspection and survey scopes that are combined with conventional survey, asset inspection, or remediation and reduce the risk of downtime associated with weather conditions. By integrating the latest in autonomous technology, Oceaneering is set to redefine how we explore and manage the world's oceans.

GAPS M3

Exail has secured its first sale of the Gaps M3 compact USBL (Ultra-Short Baseline) positioning system to a major offshore construction group in Asia. The system will be deployed for a subsea cable laying project, providing precise underwater positioning in a dynamic coastal environment.

The Gaps M3 was specifically selected for its ability to deliver high-precision subsea tracking while remaining cost-effective.

Integrated with a vessel's existing attitude and heading reference system, the Gaps M3 will provide the same accuracy as Exail's high-end Gaps USBL models, offering an ideal solution for operations that require reliable subsea navigation at a lower cost.

Gaps M3

Designed for both permanent and opportunistic installations, the Gaps M3 excels in coastal and nearshore projects, where space, budget, and operational flexibility are crucial.

Its ability to track targets at high elevations makes it particularly well-suited for dynamic offshore environments, such as subsea cable laying, pipeline installation, and marine construction.

SPRINT-Nav U

Sonardyne has launched the SPRINT-Nav U, the world's smallest hybrid acoustic-inertial navigator. It is designed specifically for compact marine robotic platforms.

SPRINT-Nav U

This groundbreaking technology delivers the proven performance of Sonardyne's industry-leading SPRINT-Nav family in a package measuring just 135 mm tall by 114 mm in diameter and weighing only 600 grams in water.

This represents a significant advancement for operators of small ROVs, AUVs, towfish, and USVs, who can now access survey-grade navigation capabilities previously available only to larger platforms.

The system combines four critical instruments—AHRS, DVL, INS, and pressure sensor—into a single unit with one connector and one cable, dramatically simplifying integration while optimising size, weight, and power consumption.

ALARS for KATFISH

Kraken Robotics has completed demonstrations for its new Autonomous Launch and Recovery System (ALARS) for KATFISH towed synthetic aperture sonar (SAS). The Company performed demonstrations for more than 40 naval customers and partners.

The new ALARS was built to fit a 20-foot ISO container footprint to increase interoperability with different vessels, allowing for rapid mobilisation and demobilisation on multi-role platforms. The system enables autonomous launch and recovery of KATFISH up to Sea State 5.

During the demonstrations, participants were able to view the KATFISH SAS data live-streaming onboard the vessel, detecting, classifying, and identifying various seafloor contacts in real-time, including high-resolution imagery of the Governor Cornwallis shipwreck.

High-resolution SAS data and command and control information were also streamed wirelessly back to shore and displayed to the attendees of Canadian Naval Mine Countermeasures Symposium taking place at *HMCS Scotian* in Halifax, Nova Scotia the same week.

“The ability to stream live, high-resolution seafloor data to analysts and mine warfare officers in real-time, from both manned and unmanned platforms, is a critical enabler for modern navies,” said David Shea, Executive Vice President and CTO of Kraken.

“Kraken was excited to be able to provide a live demo simultaneously in-person and for a remote audience, showing how remote operation and intelligent autonomy helps get humans out of the minefield.”

Kraken’s new ALARS will be delivered to an Asia-Pacific naval customer by the end of the year

$5.36M BAYONET CONTRACT

Greensea IQ has been awarded a $5.36 million contract through the Defense Logistics Agency (DLA) and Darley of Itasca, IL for the delivery of customized Bayonet 250 Amphibious Underwater Ground Vehicle (AUGV) for the U.S. Marine Corps' Littoral Explosive Ordnance Neutralization (LEON) project.

The Bayonet 250, part of Greensea IQ's Bayonet series of amphibious underwater ground vehicles, exceeds the stringent mission criteria of the LEON project, which focuses on advanced explosive ordnance disposal capabilities in littoral environments.

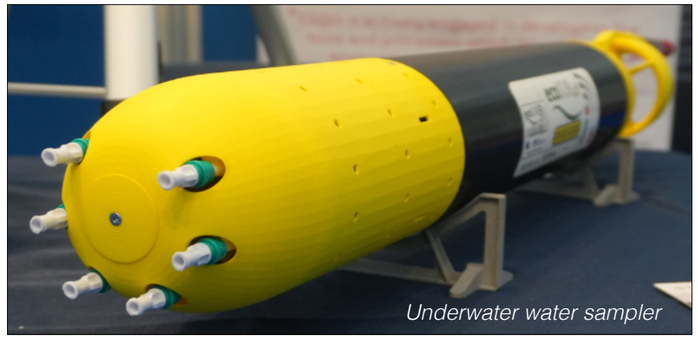
Designed for robust operations in both shallow water and surf zones, the Bayonet 250 provides autonomous capabilities for mine and explosive threat neutralisation, supporting the Marine Corps' modernisation efforts for safer and more effective EOD operations.

The Littoral Explosive Ordnance Neutralization project is a critical component of the Marine Corps' robotic revolution strategy for operating in global littorals, enhancing safety for personnel while increasing operational efficiency.

"This award reinforces Greensea IQ's commitment to supporting the U.S. Marine Corps with cutting-edge robotic solutions for complex and hazardous environments," said Paco Santana, VP of Business Development, Defense of Greensea IQ. "The customized Bayonet 250 will provide a versatile, autonomous platform for explosive ordnance disposal in challenging littoral zones."

The contract was awarded under the Defense Logistics Agency's procurement framework and facilitated by Darley, a trusted supplier for defense solutions. Greensea IQ continues to expand its portfolio of autonomous technologies designed to support defense, maritime, and commercial applications.

ECOSUB SAMPLER


Underwater water sampler

The University of Southampton has announced a partnership with marine science technology specialists ecoSUB Robotics to bring an innovative underwater water sampler into commercial use.

Developed by researchers at the University with support by engineers from ecoSUB Robotics, the advanced water sampler autonomously collects discrete volumes of water for later analysis, even at great depths.

This new capability provides marine researchers, environmental agencies and others, with the unprecedented ability to retrieve water at up to 2500m below the surface, without the need for human interaction. The versatile sampler, available in multiple configurations, can be seamlessly integrated with any of ecoSUB's autonomous underwater vehicles (AUVs).

The University of Southampton and ecoSUB Robotics have now signed a licensing agreement to bring the sampler onto the market.

Traditional underwater data collection has relied heavily on manual collection of samples which are taken to laboratories for analysis – looking at specific water parameters such as nutrients (eg nitrate, phosphate), heavy metals, oil pollution, and environmental DNA. Sample collection is manually intensive, and often requires the use of expensive ships when operating at sea.

The new device overcomes this limitation by using an automated system, mounted on ecoSUB's small easily-deployable robot submarines to retrieve samples without manual intervention.

The sampler, which was originally conceived as part of a student project, opens new avenues for applications, including environmental monitoring, marine biogeochemistry, oceanography, and offshore operations – where detailed water quality data is essential.

This will help provide a richer and more detailed picture of underwater environments and an insight into anything from pollution problems to the health of sea creatures.

Dr Adrian Nightingale, from the School of Engineering at the University of Southampton, commented on the significance of this achievement: "This is a significant step forward, giving researchers, regulators, and industry a new tool to quantify water quality.

It strengthens a productive relationship between the university and marine business and is part of a wider move to increase marine autonomy for smarter, cost-effective and less carbon-intensive environmental science."

PATHFINDER SOFTWARE

Deep technology company Beam and SMD are mobilising autonomous vehicles in harsh offshore environments using Beam's Pathfinder software.

Having purchased SMD's Quantum EV, Beam plans to mount its innovative subsea perception system, SubSLAM - running their Pathfinder software - to the vehicle, enabling AI-driven autonomous piloting in deeper, harsher waters.

By combining SubSLAM's localisation, AI and mapping technology with Quantum EV's exceptional high-current performance, vital progress will be made towards improving the efficiency of offshore wind farm maintenance.

SubSLAM'S real-time 3D mapping, data collection, and image capture capabilities represent a huge step towards fully autonomous ROV operations. When mounted to a powerful, steady vehicle like the Quantum EV, these capabilities are unlocked in even deeper waters.

Discussing the importance of this partnership, Simon Adams, programme director at Beam, said: "Our work with SMD underscores our commitment to leveraging cutting-edge technology to deliver superior services and drive the growth of renewable energy worldwide. By moving towards autonomous vehicles for inspection and maintenance missions, we cut operational costs and improve overall efficiency. These inspections also require less manpower, which is critical in an industry facing a workforce shortage."

SMD's Quantum EV

"With SMD's Quantum EV offering superior stability and position-keeping during high-current operations, we can now take our Pathfinder software and SubSLAM to even harsher environments, autonomously servicing a wider range of offshore wind farms."

VO:X BARENTSZ

VO:X Barentsz, Van Oord's first USV designed for challenging offshore conditions such as supporting dredging, offshore wind and maritime infrastructure projects, has secured a certificate of registry in the Netherlands, becoming the first uncrewed seagoing vessel to fly the Dutch flag.

Barentsz is an evolution of the four previous USVs, building upon the same hardware and software USV platform system and expanding with new technologies and more functionalities for offshore operations.

Barentsz USV

FREEDOM AUV INNOVATION AWARD

Oceaneering International's Freedom AUV has won the Innovation Award at TotalEnergies' 2024 Supplier Day.

The award recognises Freedom's contribution to advancing subsea robotics and fostering industry best practices to improve operational efficiency, including by reducing carbon emissions.

This award celebrates a decade-long collaboration among Oceaneering, TotalEnergies, and other energy industry operators to develop an advanced, resident-capable underwater robotic

Freedom AUV

solution that can be tailored for use across industries, including energy and defence.

The collaboration ensured that the Freedom vehicle and its autonomous behaviors would meet customer specifications and requirements.

The Freedom AUV, which has been commercialised since 2023, showcases innovative autonomous behaviours and operational excellence in subsea operations, including undocking, docking, obstacle avoidance, precision payload placement, survey, inspections, and transit.

In October 2024, Oceaneering was awarded a contract from the Defence Innovation Unit (DIU) of the U.S. Department of Defense to build a Freedom AUV, enabling Oceaneering to deliver commercial technology driven by energy industry needs to address subsea security needs.

In May 2024, Freedom completed a pipeline inspection industrial pilot with TotalEnergies, demonstrating its ability to deliver high-quality commercial pipeline inspections in less time and with reduced emissions as compared to existing methods..

DEEPOCEAN

DeepOcean will use its dedicated survey remotely operated vehicle (SROV) to carry out geophysical seabed surveys of the export and inter-array cable seabed corridors.

This will be carried out on the Polish wind development Bałtyk 2 and 3 which are jointly developed by Equinor and Polenergia. Polish company MEWO will serve as a subcontractor to DeepOcean.

The work scope also includes surveys to map the seabed for potential unexploded ordnances (UXO).

DeepOcean's flagship survey

DeepOcean SROV

vessel, Edda Flora, will be mobilised for the main scope. The Polish survey company MEWO will serve as a subcontractor for UXO surveys, utilising the vessel, Amber Cecilia.

The Bałtyk 2 and 3 offshore wind developments ar will have a total combined capacity of 1.44 GW enough to power more than two million households. These projects play a crucial role in achieving Poland's updated energy strategy.

DeepOcean's Superior SROV has surveyed thousands of kilometres of subsea survey annually.

ARGUS

Inspector ROV

An Argus Inspector ROV has been successfully delivered to Adriatic Commercial Diving LTD in Croatia.

The 600m-rated ROV is delivered with a pilot chair featuring integrated joystick controls, an Argus electric manipulator, a tether, an Argus winch, and the Sonardyne Micro-Ranger 2 USBL positioning system.

DEEP SURVEY

Recently, Teledyne Marine joined forces with Maritime Robotics and DEEP to survey DEEP's quarry lake, sometimes referred to as Loch Lyr in the Wye Valley.

Loch Lyr serves as the centre of DEEP Campus, a facility developed by the visionary company DEEP. Spanning 50 acres, this former National Dive Centre offers an unparalleled environment for testing subsea equipment, developing methodologies, and training in controlled conditions.

The loch itself stretches 500m in length, up to 125m in width, and plunges to an impressive 80m of depth. Its water quality is maintained by measures such as perimeter curtains designed to limit debris from entering.

Upon arrival, the team underwent rigorous security protocols, site safety briefings, and was equipped with appropriate PPE. From the top of the site, the full extent of the water was hidden from view, with access options limited to a 10-story scaffold staircase or a ride in the site's crane.To safeguard the loch's exceptional water quality, only electric vessels are permitted to operate.

SURVEYING

The team deployed the latest survey equipment, including a Teledyne RESON SeaBat T51 (800 kHz) multibeam sonar with integrated inertial navigation, paired with a Teledyne Valeport SWiFT profiler. Mounted on a Maritime Robotics Otter Pro vessel, these technologies represent the forefront of hydrographic mapping.

The SeaBat T51's controls were tailored for autonomous operations to map the quarry, while the SWiFT profiler complemented the system by providing critical environmental data – such as temperature, sound velocity, and depth – to correct multibeam readings.

An onboard winch enabled remote deployment, and near real-time profiler data was accessible via smartphone for immediate quality control.

The electric Otter Pro vessel, launched via crane, operated seamlessly both locally and remotely.

During surveyor breaks, operators in Norway controlled the vessel through satellite communications, leveraging its onboard cameras and collision avoidance radar to navigate autonomously with precision.

The survey produced high-quality data, covering nearly the entire body of water in a single pass.

DEEP'S VISION: PERMANENT UNDERWATER HABITATS

DEEP's aspirations extend far beyond surveying. Their flagship product, Sentinel, is a modular subsea habitat capable of sustaining human life and operations at depths of 200m for up to a month.

These habitats could be the underwater equivalent of the International Space Station, enabling a permanent human presence beneath the ocean surface.

Applications for Sentinel range from ocean research to the excavation of historical shipwrecks. These habitats are being built using Wire Arc Additive Manufacturing (WAAM) – a state-of-the-art 3D printing process that uses an electric arc to melt a metal wire feedstock. WAAM enables the rapid production of complex, large-scale structures (up to 6.2 diameter x 3.2 m) with good quality.

EVO III LAUNCH

FET'S NEW WORKCLASS ROV

In recent years the Evo II has been Forum's standard heavy-duty work class ROV. The design, however has now been superseded by the Evo III. This new generation Ultra-Heavy-Duty subsea vehicle technology is engineered to undertake a broad spectrum of underwater tasks. It is equipped with larger 420 diameter thrusters for increased through-water performance and an improved buoyancy package.

It has been built at the firm's UK manufacturing facility at Kirkbymoorside in Yorkshire and supported by organisation's global network of bases.

"The ROV has a newly-designed, CNC-machined frame which gives us a number of advantages including an a larger payload of up to 500kg," said Commercial Manager Chris Buckle, "and that's after all the standard tooling, sensors and cameras and lights are installed. All the changes to the frame design gives us through-frame lift of 4tons, a rise of over 30% from the EVO II.

" We started the project between six and twelve months ago and if an Evo II is ordered today, what will be delivered will be an Evo 3.

"Despite the overall physical improvements, one of the main features of Evo III is our latest control software called ICE Unity, We have designed it from scratch to carry remote operations. It's got a streamlined set of controls which we will eventually roll out across the range. The intention is that all our ROVs will operate on the same software. This will be particularly good for training and commonality.

Evo III

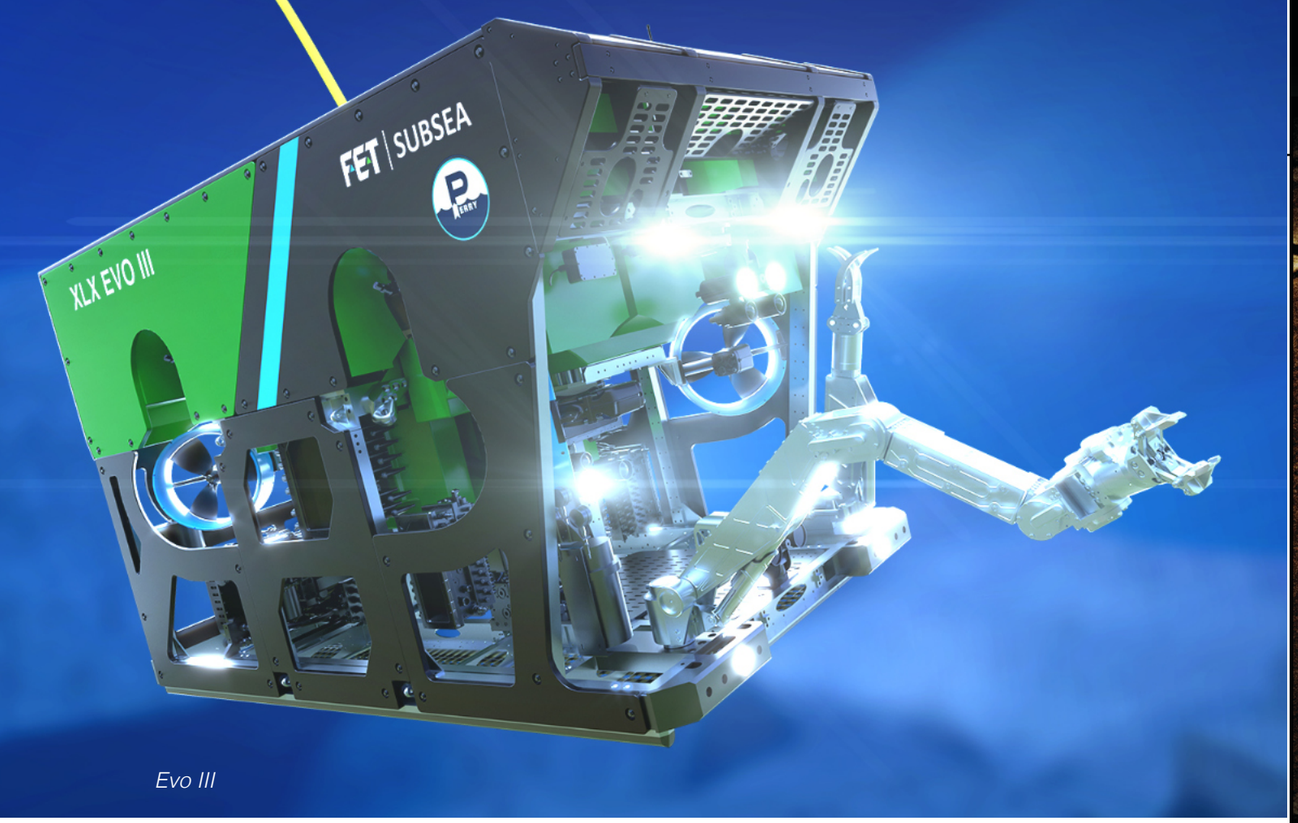
"An interesting feature is its ability to log everything the vehicle does. So for example, the thruster has a turns counter which will be logged. We will be able to analyse this data to see if a thruster is slowing down compared to the other thrusters alongside it. We will be able to use machine learning more to look at maintenance and predictive maintenance."

Within the industry, many work class ROV companies are looking to electric thrusters. Weren't you tempted to produce an electric version?

"We're we are looking actively at both electric and hydraulics," said Buckle. " At the inspection class level, we've got a range of electric ROVs but at the work class end, we slightly bias towards the hydraulic systems, mainly because the tooling is still primarily hydraulic.

"Nevertheless, we have pretty much completed a range of electric thrusters for the work class, so we could produce an electric version if required. The latest Petrobras specifications request electric thrusters so we are keen to adapt the design for this.

"At the moment, around 4000V travels down the



Evo III

umbilical to the, drive the motor for the hydraulic pump which converts it to hydraulic power.

With the electric ROVs, we would need a to reduce the 4000V to something much more manageable on the subsea end - 600 volt DC to the thrusters. It requires transformers instead of HPUs. So we're probably three quarters of the way through this process. At present, we h So this is the two vehicles now in the work class, the XLX Evo 3 and the XXLX DAF C, which is the compact.

FRAME

“An electric version would have the same new frame. It is still aluminium alloy but previously, it was welded and every single time there were subtle differences, maybe only millimetres could cause assembly difficulties.

“The new frame composed of CNC sections result in amazingly tight tolerances. Every single frame ends up being exactly the same. So it's easier to maintain, it's easier to build, it's stronger.machined. When they're welded together, they're the same every single time.”

SPECIFICATIONS

Depth: 3000 m / 4000 m
Power: 200 hp (150 kW)
Dimensions: (L/W/H) mm: 3600 / 1900 / 2200
ROV Weight in Air: 5500 kg Frame
SWL: 10000 kg
Frame Guidelines: DNV, Lloyd's Register
Payload Capacity: 500 kg Total
(300 kg Fwd, 200 kg aft)
Through Frame Lift: 4000 kg Fwd Upper
Load Thrusters Horizontal: 4 x @420 mm
Thrusters Vertical: 4 x 0300 mm
Forward Bollard Pull: 1200 kgf
Lateral Bollard Pull: 1200 kgf
Vertical Bollard Pull: 940 kgf

Hydraulic System
Main Hydraulic System: 320 L/min @ 240 bar
Valve Pack B 10-Station 12 L/min,
Electrical System
Core Junction Box 12 x SD Camera
Ports (up to 4 HD upgradeable)
6 x Light Ports
12 x RS232 / RS485

IKM Subsea Emissions Report

IKM Subsea isa more sustainable choice for subsea and offshore operations, according to a study validated by Avito and Terravera. This report highlights the company's commitment to reducing carbon emissions and advancing sustainable practices within the offshore industry.

With the deployment of electric Remotely Operated Vehicles (ROVs), IKM Subsea has made significant strides in emission reductions compared to hydraulic ROVs. Depending on the type of operation and vessel/rig, the electric ROV achieves between 32%-35% emissions savings. This is approximately 100-600 kg for every 24 hours of operation. IKM Subsea proudly holds the largest and longest operational track record for electric WROV fleets globally, affirming its leadership in sustainable offshore technology.

The company is leading the charge in optimising onshore operations as well. The implementation of Onshore Control Centers (OCC), such as the one in Bryne (Norway), eliminates the need for personnel to travel to offshore platforms, resulting in a 96% reduction in emissions per employee per rotation. The difference in emissions from the onshore control room in Bryne and the Offshore Rig (Snorre B) is a significant 294 kg CO2.

Combining the efficiencies of OCC with electric WROV technology amplifies emissions reductions even further, establishing a comprehensive strategy for minimizing environmental impact across all operations.

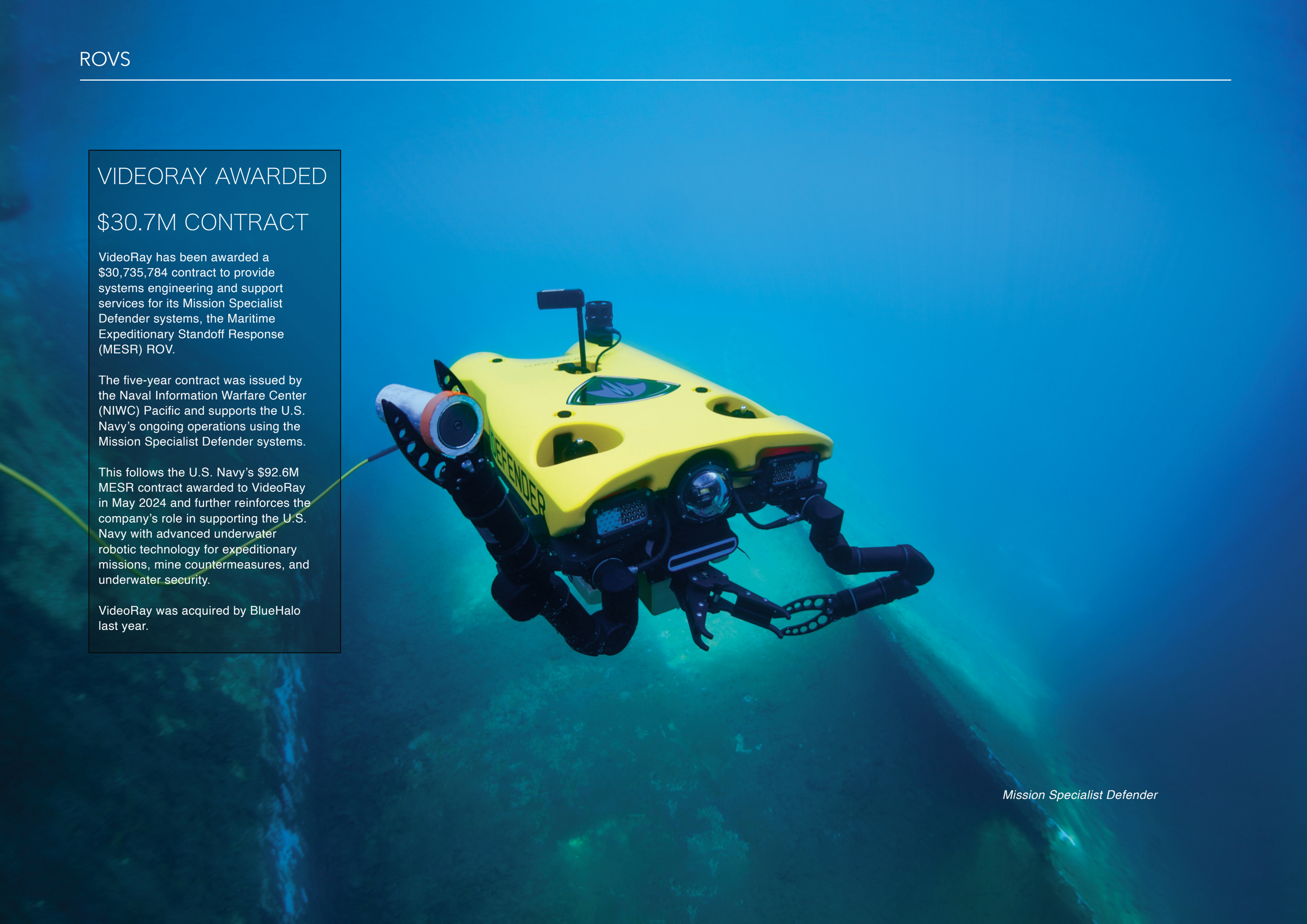
VIDEORAY AWARDED $30.7M CONTRACT

VideoRay has been awarded a $30,735,784 contract to provide systems engineering and support services for its Mission Specialist Defender systems, the Maritime Expeditionary Standoff Response (MESR) ROV.

The five-year contract was issued by the Naval Information Warfare Center (NIWC) Pacific and supports the U.S. Navy's ongoing operations using the Mission Specialist Defender systems.

This follows the U.S. Navy's $92.6M MESR contract awarded to VideoRay in May 2024 and further reinforces the company's role in supporting the U.S. Navy with advanced underwater robotic technology for expeditionary missions, mine countermeasures, and underwater security.

VideoRay was acquired by BlueHalo last year.



Mission Specialist Defender

KYSTDESIGN CONTRACT WITH NIOZ

Kystdesign is proud to announce the signing of a contract with the Royal Netherlands Institute for Sea Research (NIOZ) for the construction of the advanced Remotely Operated Vehicle (ROV), the Supporter 6000. The contract was signed this week by NIOZ Director Han Dolman and Kystdesign Director Tore Nedland. The Supporter 6000 will be delivered in June 2026 and will serve the entire Dutch marine research community.

The Supporter 6000 is designed for ultra-deepwater operations, capable of reaching depths of up to 6,000 meters. This state-of-the-art ROV combines unique flexibility and capabilities. It is equipped with six high-resolution cameras and 41 electrical connectors for interfacing external equipment such as tooling, survey sensors, and cameras. It also accommodates 24 hydraulic functions, all proportionally controlled. The ROV control system is prepared for a variety of auto functions like AutoPOS and AutoTRACK capabilities, in addition to over-the-horizon control from a Remote Operation Center (ROC) onshore.

"We currently don't have anything like it available for the Dutch scientific community," explains Gert-Jan Reichart, head of the NIOZ Ocean Systems department. "The robot is equipped to take over the work of humans at great water depths. With its six high-resolution cameras and strong gripping arms, it forms our eyes and arms underwater. One of them can rotate along seven different axes. That's more than a human arm can move."

The ROV will be assigned a role aboard the RV Anna Weber-van Bosse, the future flagship of the Dutch research fleet. It has been financed by a grant from the Large-Scale Scientific Infrastructure fund.

Supporter 6000

LARGEST CONTRACT

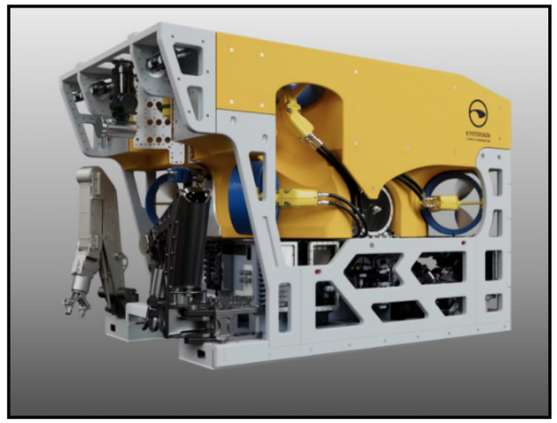
Kystdesign has announced its largest contract to date with a new international client, undisclosed for the time being.

This significant agreement involves the supply of four Work Class ROVs, including Constructor and Constructor Compact models, along with Launch and Recovery systems (LARS), Remote Operating Centres (ROC), additional spares and extra equipment.

These comprehensive ROV solutions will support two Construction Support Vessels (CSV´s) in the client's fleet.

These four off Work Class ROV spreads along with LARS and ROC´s are scheduled for delivery in Q4 2025.

This partnership marks the beginning of a promising collaboration, opening opportunities for future projects and strengthening our presence in the worldwide subsea industry. This contract positions Kystdesign for significant growth and increased marked shares in the coming years.



Constructor Compact

FET ROV to ACSM

The Forum Energy Technology (FET) Subsea product line has secured a contract to provide a work class remotely operated vehicle (ROV) system and a Dynacon Launch and Recovery System (LARS) to ACSM, the Spanish-headquartered global maritime survey and ROV services operator.

Building on a long-term relationship, the FET Perry XLX EVO II will be delivered in the third Quarter 2025 to support construction, drilling, pipeline and platform inspection, survey, salvage, cleaning and dredging.

FET's XLX EVO II ROV system represents the latest evolution in the highly successful Perry XLX series and is equipped with the latest ICE Unity Control System, incorporating remote operations and machine learning. It features significantly enhanced performance across the full range of demanding intervention and survey tasks without compromise to the outstanding reliability for which FET vehicles are renowned throughout the world.

The ROV is being manufactured at FET's UK facility at Kirkbymoorside, North Yorkshire. FET ROVs are used globally to support underwater industry applications, including in defence, traditional and sustainable energy, telecommunications, mining, aquaculture and academia.

OPERATING ROVS IN STRONG CURRENTS

Strong currents can present unique challenges when operating ROVs. Not all underwater vehicles are designed for high-current environments and so selecting the correct equipment and procedures can become key factors in mission success.

By understanding local factors and employing suitable piloting techniques, underwater robotic systems can perform effectively, even in these demanding situations.

VideoRay has compiled a number of determinants that should be considered when operating in such high-energy environments.

TETHER

Strong prevailing currents – typically anything exceeding two knots – can be enough to make navigation and stability difficult. In these conditions, managing the tether (that provides power and control to the vehicle) can sometimes be particularly critical.

"The tether can act like a drogue sail in the water, increasing total drag and making manoeuvrability problematic," said Brad Clause, Global Account Manager at VideoRay. "By deploying only the minimum necessary length of tether, therefore, we can reduce this effect, allowing the ROV to move more freely.

"Another strategy we often use involves attaching small clump weights to the tether, using carabiners. This stabilises the vehicle by reducing surface and midwater drag.

Distributing the weight ensures that the tether hangs straight in the water column, preventing unnecessary strain on the vehicle. Adjusting weight increments carefully allows operators to maintain balance and control without impeding manoeuvrability.

"At all times, clear and continuous communication between team members is vital. The pilot and tether handler must coordinate their actions to ensure precise adjustments during tether deployment. Regular updates – typically every five minutes – allow for real-time adjustments based on the ROV's positioning and external conditions.

"Monitoring tether twists and torque is another factor that can impact manoeuvrability," said Clause. "Excessive twisting can confer strain on the system, making control more difficult. Awareness of tether rotation enables the user to better understand vehicle movement and make necessary corrections."

VESSEL DEPLOYMENT

When being launched from a vessel, it is essential to prevent the line from becoming entangled in propellers, rudders or other obstacles. Rough seas further increase the risk of entanglement.

"In some cases, live boating (deploying the robot from an unanchored vessel) may be a preferred option," said Clause. "In currents exceeding three knots, the boat should be turned to face upstream while the robot is deployed downstream. Pilots can then use the current to their advantage by manoeuvring *with* it rather than *against* or *across* it.

Live boating, however, introduces additional risks as the vessel movement can be unpredictable."

When operating from shore, natural current breaks such as ship hulls, bridge footers, underwater structures and even debris, can provide shelter from strong currents. A thorough understanding of the local environment, therefore, is useful before deployment.

SHORE

Factors such as water depth, current strength, visibility and potential obstacles all impact mission success. Even in familiar locations, conditions can change quickly and unexpected hazards may arise. Conducting pre-mission assessments, including sonar scans, particularly simultaneous localisation and mapping (SLAM), is useful in allowing operators to map the environment in real time, improving navigation and reducing risks associated with unknown obstacles.

When navigating to a target, taking a diagonal approach and "crabbing" across the current

CHOOSING THE RIGHT TETHER

One important factor is to select the appropriate tether type as different tethers offer varying levels of strength, buoyancy, and power transmission.

Choosing the right tether depends on the specific mission parameters, including depth, current strength, and distance.

"Thinner tethers reduce drag but may have lower power capacity. Neutral buoyancy tethers, conversely, are slightly buoyant in saltwater and provide a balance between handling and pertormance.

Negative buoyancy tethers, which sink, offer increased power transmission over longer distances but can weigh down the robot it too much is deployed.

ROVS

can sometimes be more effective than attempting a direct path. Starting upstream and moving downstream with a short tether can provide better control of the ROV's movement.

ROV THRUSTERS

A robot operating in strong currents must have sufficient power to counteract water movement. As a general rule, a system should have approximately twice the thrust of its mass to maintain stability and manoeuvre effectively.

“Lateral thrust capabilities, combined with an auto-heading feature, improves responsiveness and allows the robot to maintain direction more effectively," explained Brandon Turner, VideoRay Global Account Manager.

"Auto-heading technology also enhances operational control by maintaining a consistent heading without requiring constant manual adjustments.

“When engaged, the system automatically applies horizontal thrust to compensate for changes in direction, ensuring stability in fluctuating conditions.”

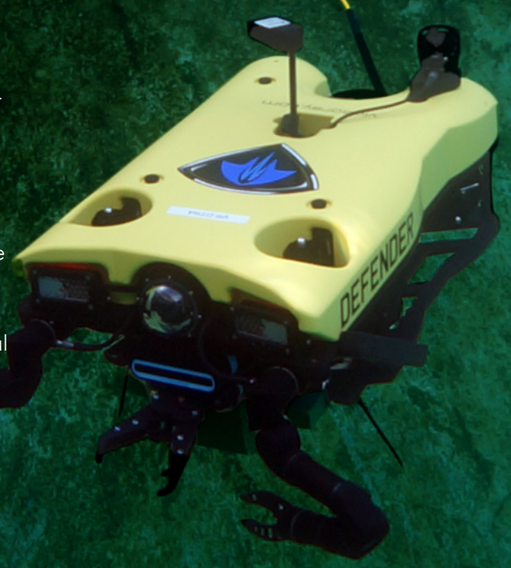
Good mission planning is another critical aspect. While real-time adaptations may be necessary, having a detailed plan – including one or more backup strategies – always improves the chances of a successful outcome.

"Understanding tidal patterns can be particularly beneficial," said Turner. Slack tides occurring when the tide is neither rising nor falling) provide the best window for operations due to the reduced current.

The minimised resistance can improve manoeuvrability.

"Awareness of spring and neap tides is invaluable.” he said. “Spring tides, occurring during full and new moons, result in stronger currents due to increased gravitational pull. In contrast, neap tides, occurring a week later, produce weaker currents.

"Factoring these tidal cycles into planning can significantly extend the operational window, allowing more time for mission execution. Importantly, however, tidal conditions can vary based on location, and tide tables even from nearby ports may not be entirely accurate. "



TIDES

TETHYS ONE

Last year, Zurich-based Tethys Robotics launched its Tethys One underwater robotic vehicle as an advanced compact solution for automated investigations, particularly in challenging environments.

At 35kg, the Tethys One is designed for rapid deployment, requiring just ten minutes to be operational without the need for additional equipment. This compact form, however, belies a robust construction, allowing it to operate at depths reaching 300 meters.

“One of the main features of the Tethys One is its dual-mode functionality,” said CEO Jonas Wüst. It can seamlessly transition between remote-operated vehicle (ROV) mode, where a pilot exercises control, and autonomous underwater vehicle (AUV) mode, enabling it to conduct missions independently. This versatility ensures that the Tethys One can adapt to a wide array of underwater tasks, from detailed inspections to extensive explorations.”

“Navigating the often unpredictable underwater currents is a formidable challenge for many submersible devices. The Tethys One, however, is adept at maintaining its position even in currents up to 3.5 kts. This capability is crucial for stationary inspections in dynamic aquatic environments, ensuring stability and precision during operations.

“The drone's propulsion system facilitates omnidirectional movement, granting it unparalleled manoeuvrability in confined or complex underwater terrains.”

The vehicle is equipped with advanced georeferenced localisation technology, and thus offers precise navigation and mapping capabilities. Its suite of sensors provides 360-degree terrain awareness, incorporating Doppler Velocity Logs (DVL), side- and front-facing sonar systems, and obstacle avoidance mechanisms. This comprehensive sensory array ensures that the drone can effectively navigate and map areas with poor visibility, a common challenge in underwater operations

Tethys One

ROV

Modularity is at the core of the Tethys One's design philosophy," said Wüst. "It supports a diverse range of payloads, including high-definition cameras, acoustic sensors, metal detectors, and various environmental sensors.

"This adaptability allows operators to customise the drone for specific missions, whether it's environmental monitoring, industrial inspection, or search and rescue operations. The inclusion of a 4-axis manipulator enhances the drone's capability to interact with its environment, enabling tasks such as object retrieval or infrastructure manipulation."

Data collection and reporting are streamlined through the Tethys One's integrated systems. It supports live recording and reporting during missions, facilitating real-time decision-making. Post-mission, the data can be processed to create detailed 3D models through photogrammetry and acoustic mapping techniques.

This level of detail is invaluable for assessments in industries such as offshore oil and gas, where precise structural analyses are paramount.

"The Tethys One's applications span multiple sectors," said Wüst. "In the offshore wind industry, it can perform autonomous inspections of submerged structures, ensuring the integrity and longevity of installations. In search and rescue missions, its ability to operate in turbid waters and maintain stability in strong currents makes it an indispensable tool for locating and identifying objects or individuals.

"The drone's capacity to integrate environmental sensors also positions it as a vital instrument for scientific research, allowing for the collection of data on water quality, temperature, and other critical parameters.

"Safety and efficiency are paramount in underwater operations, and the Tethys One addresses these concerns adeptly. By automating inspections and reducing the reliance on human divers, it minimises exposure to hazardous conditions. Its rapid deployment capability ensures that time-sensitive missions can commence without delay, a critical factor in scenarios like search and rescue or emergency infrastructure assessments.

Tethys One

"Tethys One's user interface is designed for intuitive operation. A user-friendly control system, complete with a mini-map and the ability to place points of interest, allows operators to manage missions effectively.

"The drone's autonomous features, such as position and orientation hold, depth and distance lock, and repeatable area coverage, further simplify the operational process, reducing the learning curve for new operators. In terms of endurance, the Tethys One boasts a runtime of up to four hours, supported by hot-swappable batteries that allow for extended missions without significant downtime. Its wired operating range extends up to 2km, with options for extension, providing ample reach for various underwater tasks.

"The launch of the Tethys One marks a significant milestone in underwater robotics. Its combination of advanced features, modular design, and operational versatility positions it as a leading solution for underwater inspections and explorations. As industries continue to seek efficient and safe methods for subaqueous operations, the Tethys One offers a compelling answer, embodying the future of underwater drone technology," said Wüst.

Depth rating	300 m
Weight in air	35 kg, (neutral buoyancy)
Dimensions	60.5 x 59 x 33.5 cm
Setup time	10 min
Vehicle Power	
Speed	3.5 knots
Runtime	4h
Batteries	Hot swappable
Thrust	480 N
Lift capacity	Fully equipped diver
Orientation	360° roll, pitch & yaw
Turning rate	180°
Safety	Low voltage
GNSS	Yes
Waypoint follow	Autonomous
Spatial aware	360° (acoustic)
Topography	Real time
Communication	Fiber Optics Tether
Tether length	2000 m
Diameter	3.5 mm
Breaking strength	750 lb / 340 kg
Management	Manual cable reel
Buoyancy	Neutral
Cameras	
Resolution	1080p (full HD)
Sensitivity	0.01 Lux
View angle	150°
Tilt range	160°
Lighting	
Brightness	Up to 16'000 lm
Nr. of light LEDs	4 pcs (dimmable)
Pressure, Temperature Sensing	
Range	30 bar, -10 - 80 °C
Sensitivity	0.15%, 1%
IMU & Magnetometer	
Roll / pitch	0.5° RMS
Yaw / heading	2° RMS
Gyro bias stability	40 ug
Op frequency	1.2 MHz / 2.1 MHz
DVL (Doppler Velocity Log)	
Acoustic frequency	500 kHz.
Range (bottom track)	0.3m - 175 m
Current profiling	Yes
Grabber	Nr. of axes 4 DoF

NOC DEVELOPING MULTI-PARAMETER MINIATURE SENSOR FOR UNDERWATER PLATFORMS

A project to create a multi-parameter miniature sensor to help boost the range of measurements single underwater robotic platforms can take has won UK funding.

Experts in the National Oceanography Centre's (NOC) Ocean Technology and Engineering group will develop and then test the new SixSense package on autonomous underwater vehicles, including Autosub Long Range (ALR) and Slocum Glider platforms.

The new miniature sensor will be capable of measuring six key parameters covering biogeochemical, physical and environmental measurements – all of which support Essential Ocean and Climate Variables.

Having them in this small package will help free up space for other instruments in underwater vehicles and provide greater sensing capability for smaller underwater platforms, such as low-power micro-submersibles and profiling floats.

Increasing how much data these platforms can gather, on their own or in swarms, will help scientists to better understand the ocean and how it's changing.

Dr Andrew Morris, project lead, says, "Sampling our world's ocean is a formidable challenge, yet understanding more about the marine environment is critical for understanding a wide range of issues that can have local but also global impacts."

"Marine autonomy is a way to monitor more locations for longer than has previously been possible. As the platform technology advances so must the sensors available to them to make best use of new capabilities to deliver more data."

The funding, totalling £390,000, from the Natural Environment Research Council's Future Marine Research Infrastructure (FMRI) programme, will cover sensor development, platform integration and testing.

The sensors – conductivity, temperature, dissolved oxygen, pressure, pH and Eh – will all be solid-state, low-power and not require reagents, making them simple to deploy and with no moving parts to maintain.

During testing, three sensors will be deployed on a single ALR, all mounted in different locations – inside, on the outside and in-line with pumped sample lines – alongside traditional instruments, for verification. Others will be deployed in the science bays of gliders.

The vehicles are part of the UK's National Marine Facilities' National Marine Equipment Pool, operated by NOC.

Slocum Glider

GLIDERMAN

Steve Woodward is responsible for gliders within the Marine Autonomous and Robotics Systems group at the National Oceanography Centre in Southampton (NOCS).

Currently, the group maintains around 24 Slocum Gliders and 7 Seagliders, as part of the UK's National Marine Equipment Pool, available for use by the UK scientific community.

In addition, NOCS runs the European Slocum Glider Service Centre for service and repair. Teledyne's clients can call upon the facilities rather than having return their gliders to United States.

Steve discusses aspects of modern glider design and operation.

GLIDERS

Gliders have come a long way since the first were developed in the 1960s. In the early days, scientists were delighted if they got data – or indeed, their vehicle – back after a month or two. Today, it is not even remarkable for multiple vehicles from different manufacturers to interact with each other using acoustic communications.

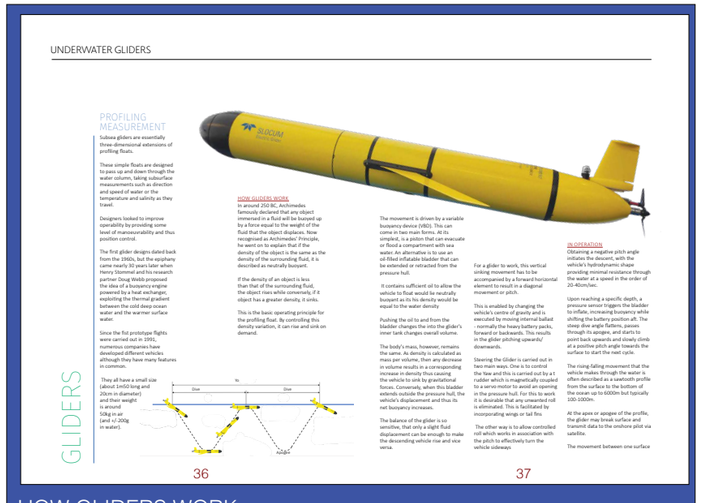
There is also a greater mix of vehicles in general. Gliders, AUVs, subsea vehicles and surface vessels can all cooperate on the same project to afford a more complete picture of the environment.

“Modern gliders can carry more sensors to produce more data,” said Woodward. “While increasing onboard processing reduces overall endurance, we have looked for ways to improve operability. Our longest mission is now 240 days (although the longest we know about is greater than 400 days). Deployments of around 6-10 months are not uncommon and we are close to reaching the one-year mission mark.”

Most gliders are long torpedo-shaped vehicles often incorporating wings and/or a tail for steering and stability. They all operate, however, using a similar buoyancy mechanism to travel across the water in the same classic saw-tooth motion. After diving to the target depth, a change in buoyancy and movement of an internal mass (a battery pack) causes the vehicle to rise to the surface with the nose tipped upwards .

Close to the surface, the nose is tipped down again, and once the tail breaks the water, it can transmit accumulated data to a satellite. It then repeats this cycle, all the time expending remarkably little energy.

Array of Gliders in storage


UNDERWATER GLIDERS

PROFILING MEASUREMENT

Subsea gliders are essentially three-dimensional extensions of profiling floats.

These simple floats are designed to pass up and down through the water column, taking subsurface measurements such as direction and speed of water or the temperature and salinity as they travel.

Designers looked to improve operability by providing some level of manoeuvrability and thus position control.

The first glider designs dated back from the 1960s, but the epiphany came nearly 30 years later when Henry Stommel and his research partner Doug Webb proposed that a buoyancy engine powered by ocean currents exploiting the thermal gradient between the cold deep ocean water and the warmer surface water.

Since the fist prototype flights were carried out in 1991, numerous companies have developed different vehicles although they have many features in common.

They all have a small size (about 1m50 long and 20cm in diameter) and their weight is around 50kg in air (and +/-200g in water).

HOW GLIDERS WORK

In around 250 BC, Archimedes famously declared that any object immersed in a fluid will be buoyed up by a force equal to the weight of the fluid that the object displaces. Now recognised as Archimedes' Principle, he went on to explain that if the density of the object is the same as the density of the surrounding fluid, it is described as neutrally buoyant.

If the density of an object is less than that of the surrounding fluid, the object rises while conversely, if it is greater density, it sinks.

This is the basic operating principle for the profiling float. By controlling this density variation, it can rise and sink on demand.

The movement is driven by a variable buoyancy device (VBD). This can come in two main forms. At its simplest, is a piston that can evacuate or flood a compartment with sea water. An alternative is to use an oil-filled inflatable bladder that can be extended or retracted from the pressure hull.

It contains sufficient oil to allow the vehicle to float would be neutrally buoyant as its his density would be equal to the water density.

Pushing the oil to and from the bladder changes the into the glider's inner tank changes overall volume.

The body's mass, however, remains the same. As density is calculated as mass per volume, then any decrease in volume results in a corresponding increase in density thus causing the vehicle to sink by gravitational forces. Conversely, when this bladder extends outside the pressure hull, the vehicle's displacement and thus its net buoyancy increases.

The balance of the glider is so sensitive, that only a slight fluid displacement can be enough to make the descending vehicle rise and vice versa.

For a glider to work, this vertical sinking movement has to be accompanied by a forward horizontal element to result in a diagonal movement or pitch.

This is enabled by changing the vehicle's centre of gravity and is executed by moving internal ballast - normally the heavy battery packs, forward or backwards. This results in the glider pitching upwards/ downwards.

Steering the Glider is carried out in two main ways. One is to control the fore and this is carried out by a t rudder which is magnetically coupled to a servo-motor to avoid an opening in the pressure hull. For this to work it is desirable that any unwanted roll is eliminated. This is facilitated by incorporating wings or tail fins

The other way is to allow controlled roll which works in association with the pitch to effectively turn the vehicle sideways

IN OPERATION

Obtaining a negative pitch angle initiates the descent, with the vehicle's hydrodynamic shape providing minimal resistance through the water at a speed in the order of 20-40cm/sec.

Upon reaching a specific depth, a pressure sensor triggers the bladder to inflate, increasing buoyancy while shifting the battery position aft. The steep dive angle flattens, passes through its apogee, and starts to point back upwards and slowly climb at a positive pitch angle towards the surface to start the next cycle.

The rising-falling movement that the vehicle makes through the water is often described as a sawtooth profile from the surface to the bottom of the ocean up to 6000m but typically 100-1000m.

At the apex or apogee of the profile, the glider may break surface and transmit data to the onshore pilot via satellite.

The movement between one surface

GLIDERS

36 37

HOW GLIDERS WORK

A previous issue, explaining how gliders operate, can be seen here.

ANATOMY OF A GLIDER

In some designs, to aid recovery, the nose (fabricated from syntactic foam within a tough external skin) is remotely released to act like a drogue anchor. A 10 metre trailing line can then be snagged by a grapnel, allowing the glider to be recovered to the recovery vessel.

Inside the nose is an altimeter to measure the vehicle position with regards to the seabed.

GLIDERS

On some gliders the buoyancy engine lies immediately behind the nose. This is responsible for changing the glider's ballast – making it dive or surface – and thus essential for maintaining its motion through the water.

There are two basic types.

Those rated for 1000m use oil-based arrangements where an oil pump moves hydraulic fluid between an external and internal bladder – a vacuum inside the vehicle facilitating the oil entering but requiring a pump to push the oil back out.

Shallow versions designed for nearer 200m, however, often employ a piston pump analogous with a syringe. These designs push water out faster but can't cope with the pressure associated with deeper waters.

Glider tail showing weights to achieve the desired balance

SENSING AND CONTROL
Every glider has a conductivity temperature depth (CTD) package which provides water density information.

“We've had just over two years of continuous operations for the UK Met Office taking temperature and conductivity measurements to validate their supercomputer climate models, as there are parts of the ocean where the model is not as accurate as others.

The data gets fed back and assimilated daily.

“They can run two versions of the model, one using the glider data and one ‘control version’ without, to assess the benefit of the extra in-situ data source. In the first year, our gliders took 35 million data points for temperature and 35 million for conductivity.

However, the central module houses the glider’s interchangeable payload that can be modified according to the project needs.

“One recent project has been to look at carbon cycle organisms in the water column,” said Woodward. “In deep waters, we employed optical sensors able to detect backscatter to see how much light of a certain wavelength was reflected. Other sensors measure light and oxygen levels from the top of the water column down to full depth.”

HYBRID
Some manufacturers advertise gliders as being Hybrid Capable. This translates as them having a rear propeller.

“We try to never use thrusters for propulsion, instead solely relying on the more efficient buoyancy engine,” said Woodward.

“It can be useful, however, in areas featuring strong currents and tides or freshwater lenses near the surface, as these make it hard for the buoyancy glider to pass through without stalling. In such cases, therefore, the glider can be set up in such a way that it will autonomously engage the propeller for extra thrust.

“Our ascent speed is typically 0.1m/sec, so we might set the thruster to engage if the speed drops below0.05 m/sec as it approaches the surface.

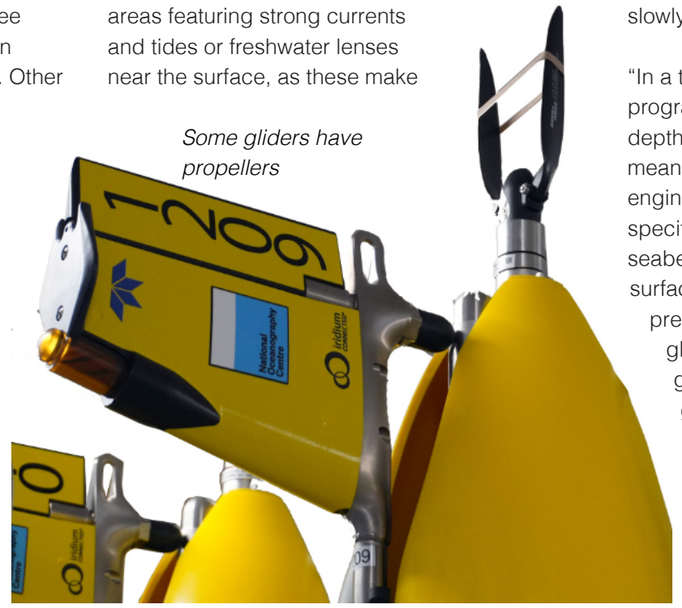
AUTONOMY
“Glider autonomy is still limited. Currently, the vehicles are only able to make decisions based on a limited number of parameters, such as if they reach a particular depth or suddenly detect the seabed and need to turnaround. This is slowly changing.

“In a typical mission, the glider is pre-programmed to follow a path to a specific depth and start to begin the turn. This means pre-programming the buoyancy engine to change once it reaches a specific depth or altitude above the seabed. When the glider reaches to the surface, the operators will have preprogrammed how much data the glider will send and what actions the glider should take when something goes wrong.

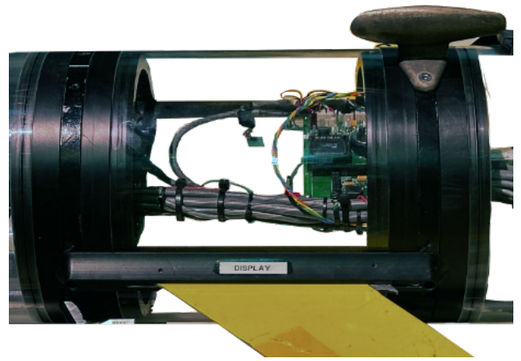
“We have some development projects ongoing that could improve the way we operate,” said Woodward. “At present, the Slocum glider has two processors. The main flight processor is used for navigation and control while the science processor controls all of the payload sensors and data.” The group are now adding a third processor, a backseat driver.

“It can effectively take inputs from the other two and conducts some internal processing before relaying information back to the onboard flight processor to modify the way the glider behaves underwater. This occurs without receiving

Payload



Some gliders have propellers



Central payload section

Shallow vs Deep Water

What are the differences between shallow water and deep water glider designs?

“One factor is the type of pump and how the vehicle is set up to achieve a balance between speed and operation,” said Woodward.

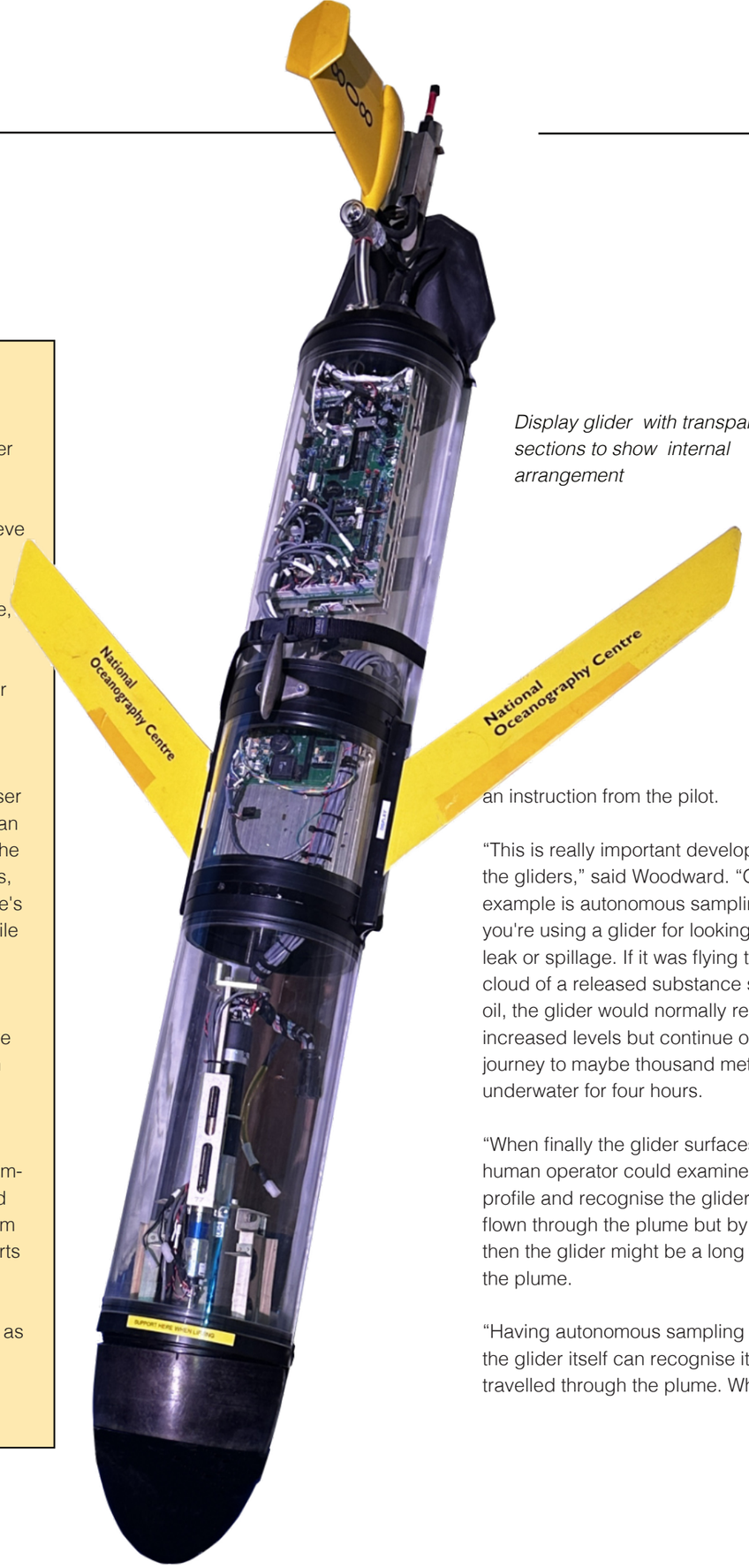
“In shallow water, you don't need a pump that can cope with pressure, but you do need one that can run quickly. That is because a proportionally greater amount of time is spent making the turn at apogee, so you need to be able to have a pump that makes the glider turn quickly and get back to stable flight where we can collect good data.

“Regardless of the depth rating, gliders are always more efficient closer to their maximum depth: a 1000m glider is more efficient at 1000m than it is at 500m. This means, that in theory, it would be possible to tune the engine to the exact maximum depth simply by changing gearing. This, however, disregards the fact that when operating in 200m water, there's a pretty good chance that you're going to be operating for quite a while in 100m of water, for example when making transects back and forth across a slope.

“Instead, the designers offer a range of pumps. As operators, we have to look at the science requests and understand the locations in which they want to operate. That will determine whether we buy deep or shallow pumps.

“NOC has a range of 1000m and 200m-rated gliders as well as a 350m-rated glider. In theory, we could also buy even shallower pumps rated to 100m, but that would mean that the only people who could use them are those interested in studying water shallower than 100 meters - parts of the North Sea, for example.

“As such, we try and keep as much modularity as we can in the fleet, as we don't really know what the science drivers will be in three or four years' time.”



Display glider with transparent sections to show internal arrangement

an instruction from the pilot.

“This is really important development for the gliders,” said Woodward. “One example is autonomous sampling. Say you're using a glider for looking at an oil leak or spillage. If it was flying through a cloud of a released substance such as oil, the glider would normally recognise increased levels but continue on its journey to maybe thousand meters underwater for four hours.

“When finally the glider surfaces, a human operator could examine the profile and recognise the glider had flown through the plume but by then, then the glider might be a long way from the plume.

“Having autonomous sampling means the glider itself can recognise it has travelled through the plume. When it

BATTERIES

Today, we use more rechargeable batteries than we have previously,” said Woodward. “Of course the downside of rechargeables is that the endurance reduces quite considerably.”

The research vessels are typically away at sea for four to seven weeks. The endurance for a glider with secondary batteries is about six weeks, but they can be recharged on the host vessel. An underwater station that can employ wireless charging systems can be used for larger AUVs, but gliders are not particularly manoeuvrable and this is not currently an option.

There is still a call for primary Lithium batteries, as these greatly increase the endurance, but this comes at a financial cost. They may, however, be the only answer for inaccessible operations such as those under ice, etc.

reaches the surface, or even before, rather than waiting for new instructions from the pilot, it can instruct the flight computer to turn around, fly back towards the plume, resolve its extent and possibly return to the surface instead of continuing down to the seabed. It becomes a really useful tool for science, as well as commercial applications.

“We could also use adaptive sampling, where, if it detects (for example) temperature changes that might indicate an ocean front, the glider can either start sampling in that area or follow that body of water.

This, therefore, does some of the pilot’s work for them and means it is not necessary for the operator to wait - potentially hours - until the glider surfaces to instruct the glider to follow the temperature change.

“Another benefit of autonomy is when working under ice. The glider will want to climb to the surface, but sometimes ice cover prevents this and can damage the vehicle. It also cannot receive new instructions. We need to add extra processes so that the glider can also detect what’s above it such as an ice sheet and automatically know to turn around or change heading.

“A backseat driver allows for processing that extra information. Is there ice above the glider? What's the water temperature? What's the salinity of the water above? Is the glider likely to be able to get to the surface? In such case, the vehicle can turn 20m, maybe, 30m below where it perceives ice is, and then start to dive again, possibly changing heading, and steering somewhere else.

“One of the projects we are currently working on, and intending to start trials in the spring, is to use acoustic underwater navigation to keep the glider within a certain area without ever going to the surface.

“When combining the extended endurance of the glider with the ability to operate under ice, it might be able to carry out the sort of work that is currently the domain of much larger vehicles. Being able to use these vehicles, instead of larger autonomous vehicles, also reduces the transportation and logistics issues involved in moving these types of vehicles around.”

VEHICLE REPAIR

What are the most common reasons to bring gliders in for repair?

“Corrosion is an issue for everyone working subsea, especially around connectors,” said Woodward. “One of the unusual things about gliders is that they're deployed for such a relatively long time. When anything is immersed in water for six months, damage does happen and even a small scratch on the anodising can invite corrosion. After six months, that corrosion can be extensive.

“Failure on a connector or a cable can result in a short circuit, but in general component failures are uncommon.

“Biofouling is a well-known issue, especially in shallow waters and in the tropics. Biofouling is very easy to clean off but can affect navigation and the ability to steer.

Broken wings during a mission can be another problem. This sometimes occurs from impact with the seabed and results in quite distinct changes in the flight characteristics. The glider tends to spiral when it dives although when it climbs, it does get back on track. Some gliders may need O-ring seals changing more than others and this makes them more prone to leaks, while in others, it is much easier to spot faults early with more early warning systems.”

Inside the NOCS workshop

MICRO-UUV FOR LAKE APPLICATIONS

UNLOCKING NEW POTENTIAL FOR SHALLOW WATER SURVEY

Uncrewed Underwater Vehicles (UUV) have significantly transformed ocean research and engineering operations over the past few decades.

In contrast, lakes and reservoirs, despite being critical ecosystems and vital water resources, have seen minimal impact from this technological revolution, except in all but the largest examples, such as the Great Lakes.

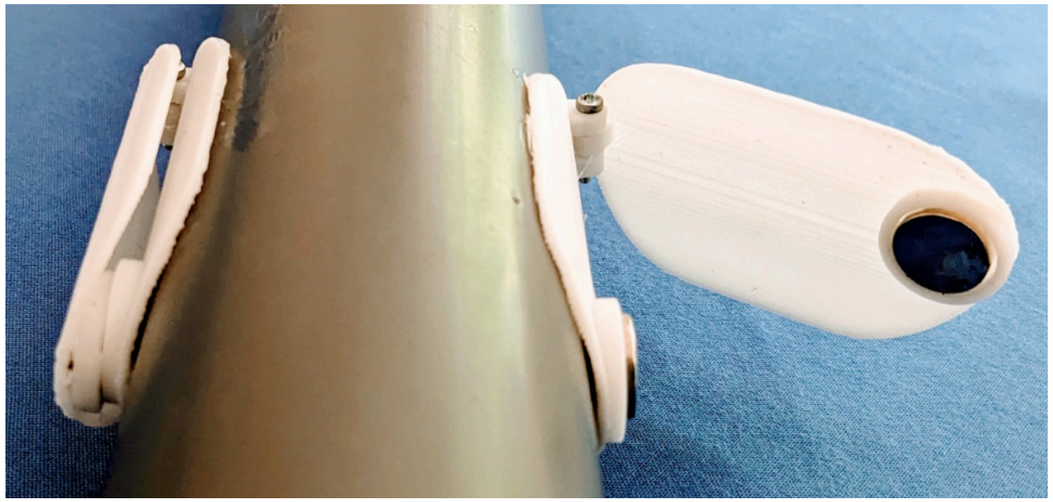
Whilst Uncrewed Surface Vehicles (USV) are starting to be trialled by water utility companies, monitoring and sampling of lake water quality tends to be currently done by either a fixed automated process (data buoys, inlet monitoring, etc) or using manually deployed instrumentation from the shore or from boats.

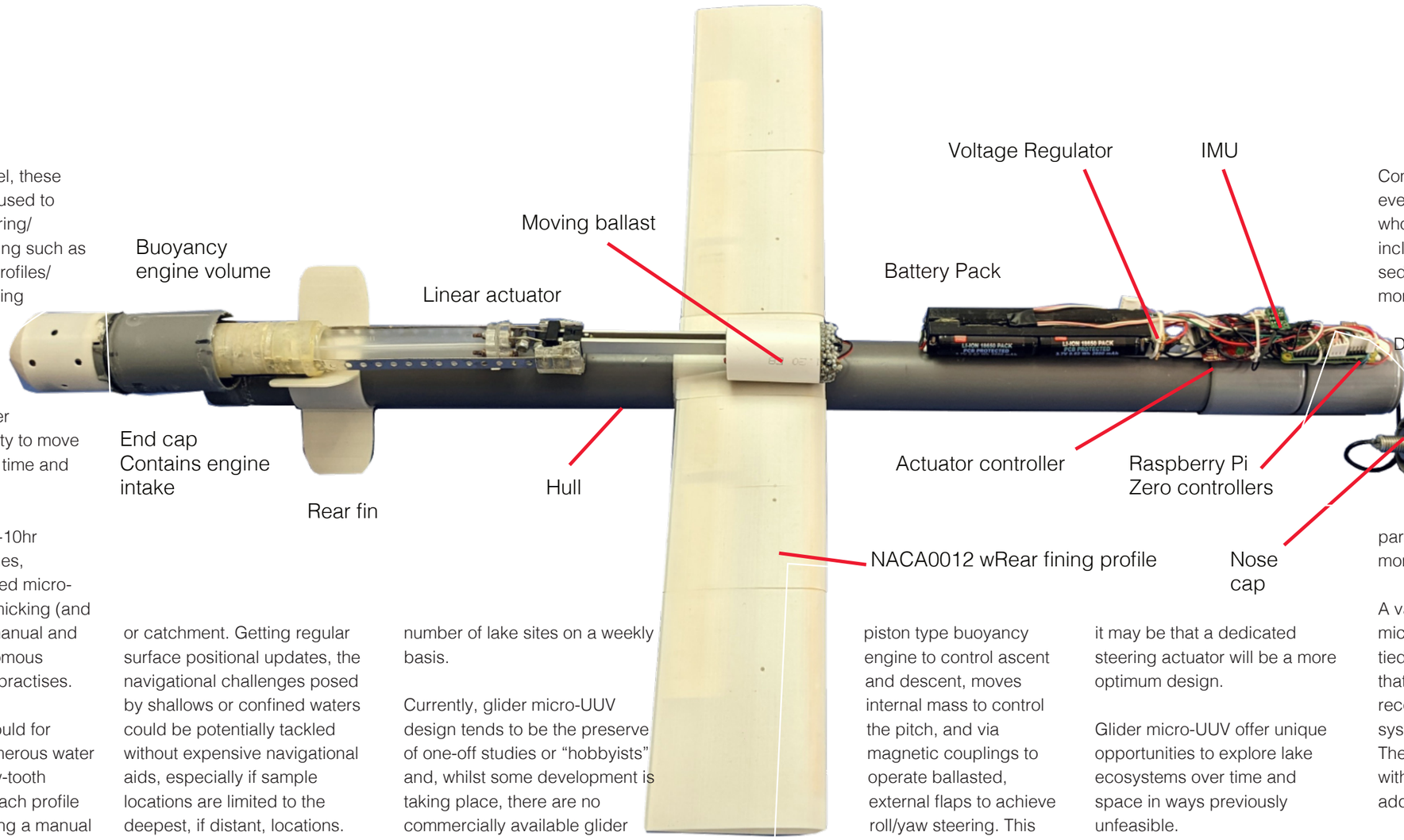
The reasons why UUV have not been adopted by lake monitoring organisations include the prohibitive cost, suitability (size and weight) of commercially available UUV and that, unlike oceans, lakes are very constrained bodies of water in all dimensions posing significant autonomous navigational challenges.

To be attractive to lake scientists and reservoir utility companies (and assuming that going underwater provides sufficient advantages compared to an USV), a UUV would need to be of the micro variety, meaning readily portable, relatively cheap, simple to operate, and single person deployable.

Coupled with sonar altimeters, active navigation/collision avoidance technology, or a baseline acoustic localisation/ navigation system such micro-UUV could meet lake research needs. Conventional micro-UUV (propellor driven mini submarines) such as the Planet Ocean's ecoSUB, Seaber's YUKO, and RTSYS's Nemosens are currently available and would appear broadly suitable for what is needed in a lake suitable micro-UUV.

There are 2 broad types of micro-UUV, conventional and underwater gliders and each type is suited and fulfils a particular research/monitoring niche. Due to their more controllable propulsion and steering, conventionally powered micro-UUV will be more suited to shallower and more navigationally challenging lakes where accurate manoeuvrability will be critical. Glider micro-UUV can be exploited for long duration and long distance lake research.





At the most basic level, these micro-UUV could be used to mimic current monitoring/ research data gathering such as taking water quality profiles/ transects and mimicking data buoys by acting as virtual moorings. However the greater general potential, especially of the glider micro-UUV, is its ability to move and gather data over time and space.

With approximately 6-10hr maximum mission times, conventionally powered micro-UUV are ideal for mimicking (and enhancing) current manual and many types of autonomous monitoring/sampling practises.

Such a micro-UUV could for example perform numerous water quality vertical or saw-tooth profiles every hour (each profile potentially representing a manual instrument deployment or a virtual mooring of instrumentation).

Repeatedly sampling a lake over a day or deployed in many different lakes per day, this could provide a vast amount of regular information concerning the water quality and process within a lake or catchment. Getting regular surface positional updates, the navigational challenges posed by shallows or confined waters could be potentially tackled without expensive navigational aids, especially if sample locations are limited to the deepest, if distant, locations.

With conventionally powered micro-UUV, the limit is the endurance of the mission but the advantage is directness, and preciseness of travel. A single, conventional micro-UUV could be a very attractive monitoring tool for organisations that are required to monitor a large number of lake sites on a weekly basis.

Currently, glider micro-UUV design tends to be the preserve of one-off studies or “hobbyists” and, whilst some development is taking place, there are no commercially available glider micro-UUV.

Work at the University of Bath has been looking at modelling and developing low cost gliders through reducing component count by the use of a single actuator.

The single actuator controls a piston type buoyancy engine to control ascent and descent, moves internal mass to control the pitch, and via magnetic couplings to operate ballasted, external flaps to achieve roll/yaw steering. This prototype (shown above) approach has reduced complexity, cost, weight, and size whilst retaining sufficient battery capacity to sustain weeks of operation are achievable.

Prototype manoeuvring has not been fully explored to date and, it may be that a dedicated steering actuator will be a more optimum design.

Glider micro-UUV offer unique opportunities to explore lake ecosystems over time and space in ways previously unfeasible.

Their ability to maintain slow ascent and descent rates, combined with minimal energy consumption, allows for extended missions that can map from daily processes to seasonal changes over an entire lake (assuming shallow water does not prevent operations).

Combine with an ability to park (and even sleep) on the bottom, the whole water lake depth profile including interactions at/in the sediment water interface could be monitored.

Drifting both at surface, sub surface and even at the bottom following contours of constant densities or temperatures could be a particular energy efficient monitoring strategy.

A valid concern by owners about a micro-UUV is the amount of money tied up in an underwater vehicle that could easily be lost, so a recovery to surface and locator system of some description is vital. The issues of theft and interactions with lake leisure users are additional unexplored challenges.

With budgetary pressures to the fore, micro-UUV (and USV) tailored to lakes could dramatically enhance our understanding and management of these vital freshwater systems whilst reducing long term costs. However, until the technology is commercially developed, this remains an aspiration.

NAUTILUS

In their free time, students from a number of leading Swiss universities have been building and developing an autonomous underwater glider suitable for polar under ice exploration. Working under the banner Akademische Raumfahrt Initiative Schweiz (ARIS) the novel glider, called Nautilus, is currently undergoing its second design iteration.
Luca Dofing, project manager explained the development to delegates at the recent MATS conference in Southampton

The work started in 2002 and the testing program followed in 2023, in various pools near the universities.

"We tested the first iteration Lake Kuipen with the help of the local diving shop, but our mission is to go under ice in the polar regions with missions up to 30 days and a depth of 1000m.

PEOPLE

FINLAY JOHNSTON

Trendsetter Vulcan Offshore (TVO), a developer of solutions for the offshore industry, has engaged Finlay Johnston, through 4C Global Consultancy, to lead business development efforts for TVO in the UK.

“There is a long-term need for expert subsea support services in the UK, and by engaging a local representative, we are strengthening our commitment to the region, providing an avenue for North Sea operators to access our proven solutions,” said TVO President Jim Maher.

The company has also appointed Russell Collins as Country Manager, Australia, to head up

RUSSELL COLLINS

the company’s newly opened office in Perth.

“As more demand arises for TVO services in Australia and Southeast Asia, we are investing to make it easier for companies in the region to get in touch with our team and access our solutions,” says Maher.

With a Bachelor of Engineering degree from the University of Western Australia and more than three decades spent in the offshore oil and gas sector, Collins has extensive commercial and corporate leadership experience, from engineering design to executive management roles.

ALEXANDER GRAVERT

MacArtney Germany has appointed Alexander Gravert as Sales Manager to strengthen regional connectivity initiatives. He joined the MacArtney team in March to enhance and develop connectivity initiatives aligned with corporate strategy.

Located at the Kiel, he will help drive connectivity efforts in the DACH region, which includes Germany, Austria, and Switzerland. Alexander will focus on ocean science, marine and offshore, and naval industries, with the primary objective of improving customer support, increasing customer engagement, and facilitating closer collaboration.

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