UNDERWATER
R·O·B·O·T·I·C·S

ISSUE 7

SUT Society for Underwater Technology

MTS marine technology society

UNDERWATER R·O·B·O·T·I·C·S

THE MAGAZINE OF THE SUT's
UNDERWATER ROBOTICS GROUP

Cover: NOC's latest Autosub

Editor: John Howes
John@ut-2.com
+44 7859905550

Editorial Assistant:
Jenny Séqua

Production:
Sue Denham

Advertising:
Zinat Hassan
UT3subsea@gmail.com

Tel: +44 (0) 845 6522 483
Mobile: +44 (0) 781 1200 483

MANTAS

Subsea Europe Services has launched a rental service for its next-generation Uncrewed Surface Vehicle (USV) MANTAS T12.

Built by Florida-based USV manufacturer MARTAC Systems, with deep integration of the Subsea Europe Services integrated Hydroacoustic Survey System (iHSS), the MANTAS T12 is a uniquely lightweight, fast and agile vehicle, able to be deployed from any vessel with even the smallest deck crane. The performance optimises marine data acquisition and enables pro-active, hydrographic survey business models.

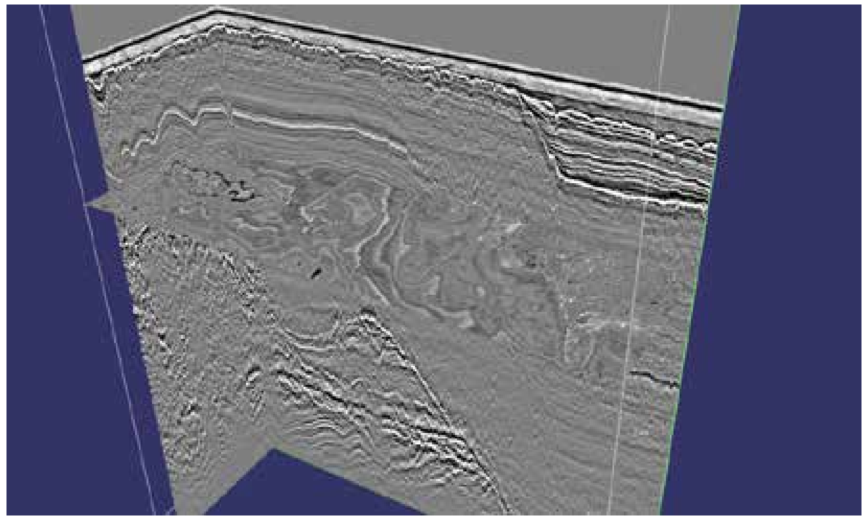
At 12 ft long, with a draft of just seven inches and a clean, powerful all-electric motor and propulsion system – the MANTAS T12 performance exceeds many current platforms that have the ability to conduct hydrographic surveys to s-44 exclusive order standards, even under the harshest conditions and strong currents.

In comparison to the process of mobilising a crewed and expert staffed survey vessel (which may not always be ready to go), the speed and operational flexibility of the MANTAS T12 can significantly reduce the costs of marine data acquisition and allow for higher utilisation.

Autonomy upgrades and new hydroacoustic technologies will unlock a new phase of efficiencies over the next few years. Forthcoming multibeam systems will allow high-precision data to be collected at speeds in the region of 16kts while advances in AI will allow the MANTAS T12 to adjust its own survey plan according to the real-time data it receives from the hydroacoustic and positioning systems.

The cost per data package can be reduced further still when using a 'swarm' of MANTAS T12 USVs. MARTAC has already successfully demonstrated hydrographic USV 'swarms' in multiple exercises, showing that synchronised unmanned platforms can survey an area of the seafloor many times faster than a single manned platform.

SEISWIND 3D



3DUUHR seismic data

Fugro has successfully completed a series of trials and testing configurations for its new SeisWind 3D ultra ultra high resolution (UUHR) seismic system off the coast of the Netherlands.

SeisWind 3D is designed to offer an efficient data acquisition footprint with the highest resolution to enable detailed ground modelling and interpretation of near surface geology for the safe development of offshore projects.

With the ability to acquire precise data in shorter periods, SeisWind 3D improves project development schedules, lowers HSSE risk for offshore crew by reducing operational exposure hours and mitigates potential project risks.

SeisWind 3D is an evolution of Fugro's UUHR seismic service that consists of eight solid custom specification digital streamers, with proprietary sources and decimetre accuracy in-sea positioning systems. Data is processed by in-house experts, utilising the latest Fugro developments in UUHR seismic imaging, for the creation of detailed ground models for offshore asset installation planning.

GREENSEA AND SEEBYTE COLLABORATE FOR ROV AUTONOMY

In response to the growing demand for true ROV autonomy within the field of maritime Explosive Ordnance Disposal (EOD) robotics, Greensea Systems, creator of the open architecture platform OPENSEA and autonomy and automatic target recognition (ATR) developer, SeeByte, have announced an ongoing collaboration.

The two companies have previously operated as competitors, both fielding software for ROVs, but recently recognised that to satisfy the emerging needs of key maritime robotics consumers such as the US Navy, pooling intellect and experience through collaboration is the way forward.

As a result, for the first time, their complementary skill sets are to be put to work together under a DoD OTA (Other Transaction Agreement) led by the Defense Innovation Unit valued at $1.2 million with a potential value of $4.2 million.

"Autonomy is the right solution for the war fighter trying to use robots," said Ben Kinnaman, Greensea CEO.

True ROV autonomy for EOD robotics requiring advanced technology (over-the-horizon control, intervention autonomy, and automatic target recognition) will only happen at the pace customers demand through collaboration."

"It is relatively rare that two small companies start out as competitors in one area and progress to being partners for the benefit of the end user," said Leverett Bezanson, SeeByte Engineering Manager.

REACH ROBOTICS

In 2019, the Bristol-based consumer robotics company Reach Robotics finally closed down its business. Now, the Australian-based company Blueprint Labs, famous for its advanced robotic arm solutions, have reached out with both manipulator arms and grabbed the name.

The decision to change the corporate name to Reach Robotics, according to the company, was spurred by a need to better communicate the company's robotic arm.

"The name 'Reach Robotics' provides greater clarity to the market about the company's core technologies and better captures our team's vision", says Anders Ridley-Smith, Commercial Director. "We have secured commercial trademark rights to the 'Reach Robotics' name and are excited to operate on this basis in our key markets.

"We have grown a lot in the five years since the company was founded and, whilst we have a subsea pedigree, we are moving rapidly into harsh environments in all domains. Now is the right time to align our name with the full scope of what we do", says Paul Phillips, Managing Director.

"We have the same vision – to extend human reach into harsh environments – but have expanded our scope, including designing intervention solutions for land and space domains and increasing global market penetration."

Blueprint Lab was established in late 2016 with the aim of revolutionising robotics for harsh environments, removing people from harm and increasing the productivity of remote systems. Since then, the company has grown considerably to 40+ staff, a global sales and support footprint, and a strong research and development capability.

Reach Robotics arms

GAPS

Seaforth Geosurveys recently acquired iXblue's new Gaps M5 USBL system to support data acquisition for marine geophysical survey projects. This includes one in the Canadian Arctic as well as multiple other projects such as support of sidescan sonar operations during lost and abandoned fishing gear (Ghost Gear) identification and retrieval efforts.

The latest addition to iXblue's USBL product range, Gaps M5 has already been adopted by many companies worldwide. It offers accurate positioning and tracking of subsea assets and provides horizontal tracking capabilities and high-precision geo-referenced positioning, especially in shallow waters where it has shown accuracy better than 0.5% up to 995m water depths.

With no calibration required, it can be easily deployed and operated from any vessel of opportunity. Free of export, the new Gaps M5 is quick and easy to ship anywhere in the world, saving even more operational time and offering efficiency on the field.

IxBlue's GAPS

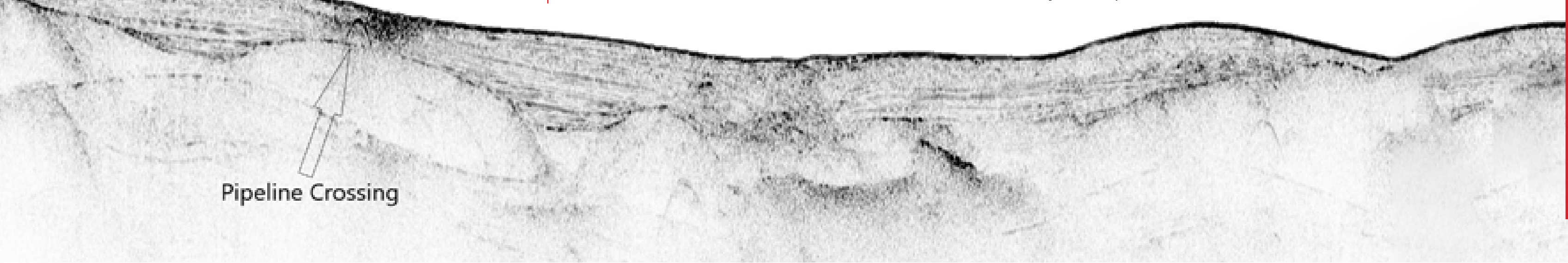
PIPE SURVEY

EdgeTech has recently added a new feature to the popular 2050-DSS combined sub-bottom profiling and side scan sonar system. The new Pipeline Survey Mode provides the ability to select a smaller hydrophone sub-array enabling a larger fore-aft beamwidth and faster transmission rate and hence increasing pipeline detection when running crosslines.

The 2050-DSS systems use a flat multi-channel Polyvinylidene Fluoride (PVDF) hydrophone array to generate high resolution images of the sub-bottom stratigraphy in oceans, lakes, and rivers and provides excellent penetration in various bottom types.

The sub-bottom receiver array is segmented for standard sub-bottom profiling surveys or pipeline survey mode for optimal location of pipelines or cables and measurement of depth burial.

The 2050-DSS also boast a tri-frequency side scan sonar, where any two frequencies can be operated simultaneously. The 2050-DSS comes complete with a combined side scan and sub-bottom towfish with built in depth, heading and altitude sensors, digital telemetry over a single coax cable, ROV interface, a 19-inch rackmount topside, EdgeTech's DISCOVER acquisition software and optional magnetometer interface.



EdgeTech's new Pipeline Survey Mode

STARFISH

Earlier this year, Sarcos Technology and Robotics Corporation acquired RE Squared and with it, the Sapien family of robotic arms including autonomy software. Since then, the company has announced that it has achieved a significant technical milestone with its Strong Tactile mARitime hand for Feeling, Inspecting, Sensing and Handling (STARFISH).

STARFISH is an underwater end-of-arm tooling (EOAT) project being funded through the U.S Navy's Office of Naval Research (ONR). It is essentially an advanced gripper that uses tactile feedback, enabling the grippers' fingertips to "feel" and interact with objects.

The tactile feedback is seen as useful for mine countermeasures and explosive ordnance disposal (EOD). With this technical milestone, the company has successfully assembled and lab-tested a complete STARFISH gripper.

The gripper uses an advanced array of visual and underwater sensors to orient itself to its environment. It will operate in hazardous underwater environments that would typically damage end effectors, including turbidity, ocean swells, and other dynamic underwater conditions.

Data collected from the hand's interactions within the environment will be sent back to the operator control unit (OCU), allowing the operator to perform complex manipulation tasks from a remote location.

During lab testing, the STARFISH prototype used three tactile-sensing fingers to successfully achieve a variety of fine- and large-gripping skills, including squeezing a pair of tweezers and grasping larger objects. Each finger conforms to the shape it is grasping, enabling it to securely hold objects upon contact.

STARFISH underwater end-of-arm tooling

COLOUR SUBSEA CAMERA WITH LIGHT RING

Underwater technology supplier OceanTools has added to its extensive range of high specification subsea cameras with the launch of its new C7 colour camera.

Differing from its sister products, the OceanTools C7 multipurpose subsea camera has an integral high intensity controllable light ring to illuminate the underwater environment, providing clear video footage at depths down to 6000m.

The compact C7 subsea observation camera offers an impressive 800 TVL resolution composite video output with a Wide Dynamic Range providing superb video quality under all lighting conditions.

The integral light ring has 12LEDs that can provide light output of up to 2250 lumens.

The unique design is manufactured from Grade 5 Titanium and features separate Sapphire windows for the camera and light ring, to eliminate reflected light.

Brian Hector, Technical Sales Manager, OceanTools said "The C7 has been designed with specific customers' requirements in mind and utilises the latest CMOS sensor camera technology and high efficiency ultra-bright LED's in a very small 6000m package.

"We believe the C7 is the smallest camera currently on the market to be able to offer very high-resolution SD video and integrated LED lamps making it truly versatile".

The C7 product announcement follows a series of releases for OceanTools including the high performance C6 Colour Zoom camera producing advanced video imagery at resolutions up to 1080p, launched earlier this year.

C7 colour camera.

POLAR AUV GUIDE

Over the past 50 years, a number of operations using AUVs have been undertaken in ice-covered waters. While the actual operation of the vehicle may be little different than in open water, the manner in which the mission is planned and executed can vary substantially. This has prompted the SUT to launch a website http://wsprdaemon.org/polar providing a guide to AUVs in polar regions and bringing together a number of resources that may be of help to those contemplating polar AUV missions.

Gwyn Griffiths, Principal, Autonomous Analytics explains

There are few underwater sub-system technologies that face greater challenges than when operating in Polar regions.

Many components can be strongly affected by the ice. This has required the industry to both consider risk management techniques and to develop new processes for implementation in such sub-zero environments.

HOMING AND GUIDANCE

Normally, it is only in special circumstances such as when trying to locate a subsea docking station, that a civil AUV operating in ice-free waters includes a homing and guidance system. In polar regions, however, an effective homing and guidance system is often necessary for several modes of operation, including:

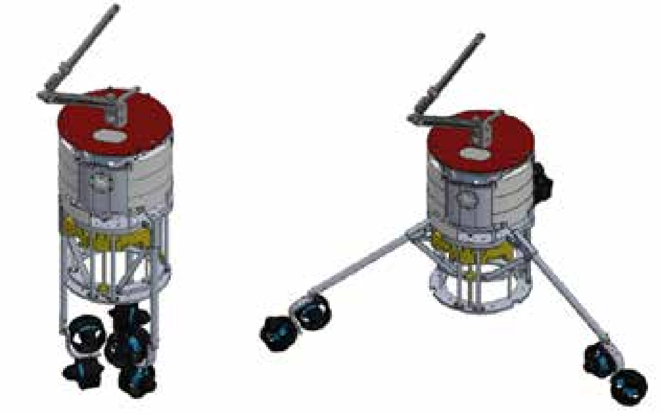
• Reaching the end of a mission (or a monitoring waypoint) at an ice camp that may be drifting, where the exact position could not be known when the mission started.

• Requiring open water at the end of a mission for recovery to a ship at a location prone to sea ice, where the ice conditions might be uncertain eg, due to changes in wind force and direction.

COLLISION AVOIDANCE

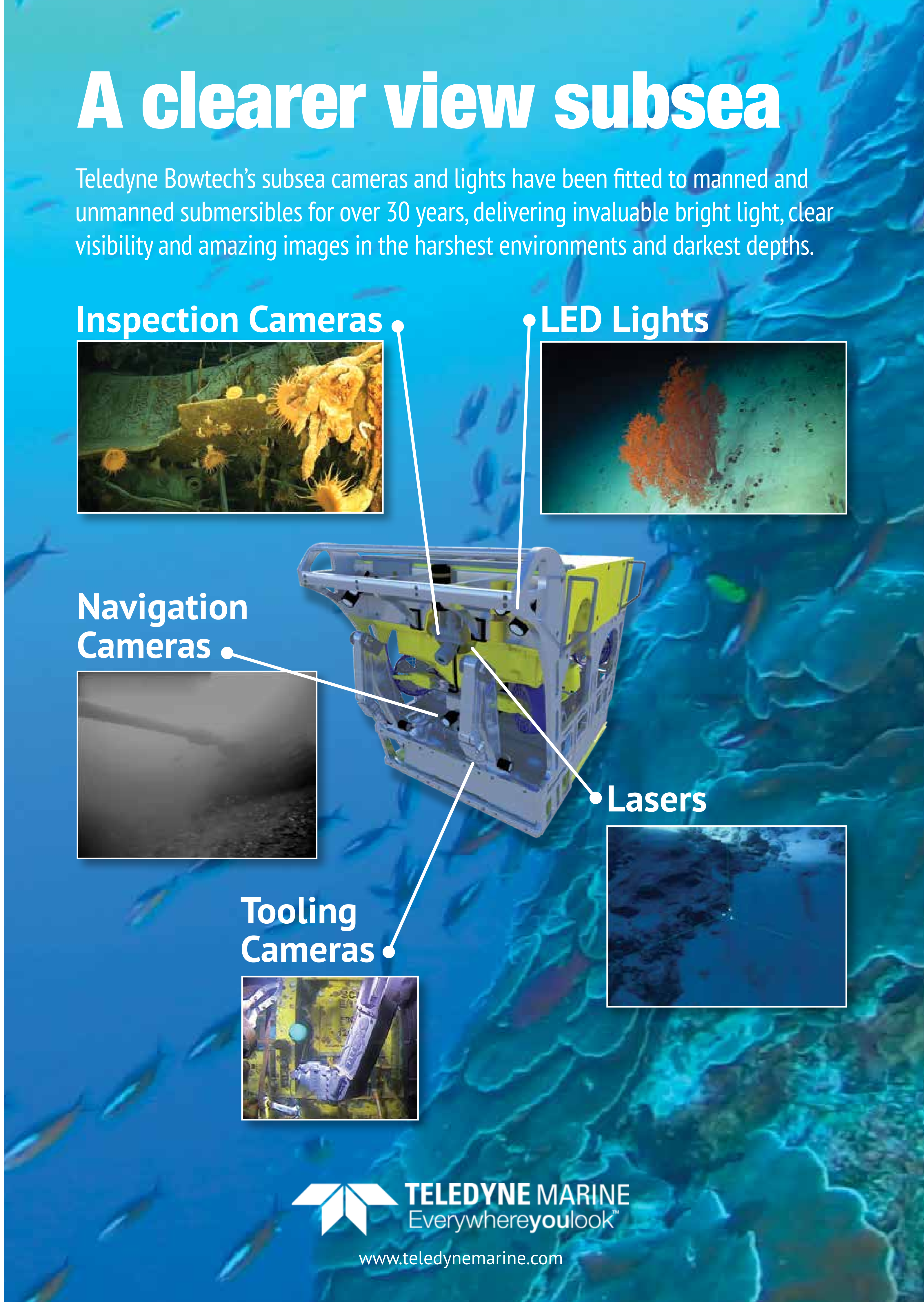
The under ice environment can be a complex 3D world of obstacles that may scatter or specularly reflect sound. The challenges for collision avoidance hardware (inevitably sonar) are difficult enough, but the real challenge comes in the real-time interpretation of what may be sparse data on an environment where preconceived notions and ideas may be quite wrong.

Features include strudel scour on the seabed and under ice features such as ice keels tens of metres deep. There may be chasms hundreds of metres deep, floating glacier tongue and scattered icebergs. These pose multiple difficulties for AUV collision avoidance systems not seen in open water. Practical solutions have ranged from collections of sonars with single or several beams to systems with tens of beams aiming to cover the full four-pi steradian solid angle.



A CAD model of the pantograph-based AUV with arms folded (left), and with the arms stretched out(right). It is also equipped with a stereo-inertial system for visual localisation.

One group proposed an idea maintaining a safe distance from the under side of sea ice using an articulated pantograph. It is specifically aimed at sampling and measurement under thin, relatively flat, young Antarctic ice. Their pantograph provides a constant contact with the ice's undersurface



COMMUNICATIONS AND TELEMETRY

Regular surfacing for satellite or terrestrial radio communications and telemetry is more difficult and risky in a region with sea ice compared with open water, and indeed may be impossible when under fast ice or an area with 10/10ths ice cover.

Current techniques for radio communications are not suitable at all for under ice shelf environments, but an innovative systems-approach may hold some promise.

Acoustic communications and telemetry in the Polar regions may be strongly influenced by strong vertical gradients of sound speed especially if the upper layers comprise cold, fresh melt water. Physical obstacles such as ice keels that scatter sound, or give rise to shadow zones may also affect acoustic communications range and reliability.

Communications and telemetry play an important role not only in the regular conduct of missions but also in locating a missing vehicle, especially when it may be under ice, and special adaptations may be needed to ensure an adequate communications range under those circumstances.

From the early days of AUV surveys there have been sound theoretical and practical grounds to use multiple small vehicles rather than one large vehicle.

If a fleet of small vehicles is deployed in a common area a problem with acoustic interference may result if using conventional transmission methods.

One group have developed transmission techniques called MultiUser Chirp Spread Spectrum (MU-CSS) that are straightforward to decode and resilient against interference from other users on the same channel. Importantly for use with moving AUVs, the method is also tolerant of Doppler shift.

Another group have proposed autonomously moveable radio towers to act as communications gateways between AUVs in the Arctic and shore bases

The APOGEE (Autonomous Polar Geophysical Explorer) project

BUOYANCY CONTROL

Achieving an appropriate buoyancy can be a difficult task for an AUV operating in the Polar Regions, where large differences in density (temperature, salinity) can occur either in the vertical or the horizontal.

Some vehicles adopt a strategy of determining a suitable static buoyancy before launch and rely on the forward motion of the AUV and the dive planes and the depth-control algorithms to maintain the required depth despite changes in water density. This can come at the cost of additional energy consumption from the vehicle body taking up an angle of attack that incurs additional drag.

This has been the approach with the Autosub series of AUVs on under ice missions.

Other vehicles have used an active buoyancy (or ballast) control system, most notably for an under ice AUV – that used on the ISE Theseus for its Arctic cable-laying missions. Not only did the system have to cope with water density changes (estimated to result in a buoyancy change of 400 lbs) but also the change in displacement as the fibre optic cable was deployed onto the seabed.

An arrangement of pumps and valves let water in, or pumped water out, of toroidal tanks in the free-flooding bow and tail while maintaining trim.

One group have been looking at a variable buoyancy long endurance vehicle for sub-Ice Shelf research.

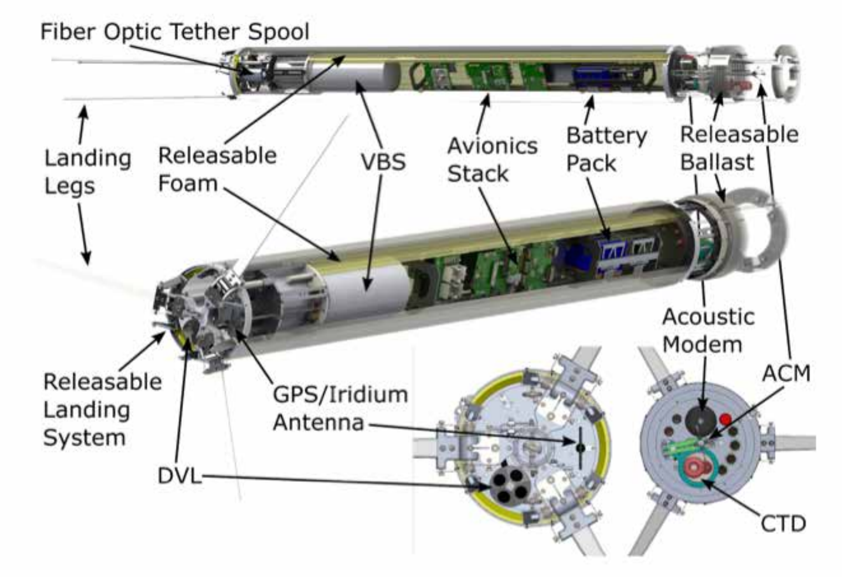
IceNode is a variable buoyancy drifter with extensive situational awareness specifically designed for year long deployments under ice shelves. In part resembling a profiling float, the concept is that the vehicle, deployed at the ice front, descends, and finds / rides a current that takes it under the ice shelf.

When under the shelf it may profile from seabed to the underside of the ice, eg, for CTD+ before autonomously finding a suitable site on the underside of the ice for long-term emplacement and its task of ice-melt measurement. At the end of the mission, it detaches from the ice, descends and finds a current to head into open water before telemetering its data. Emplacement may also be through a ~0.25 m hole drilled through the ice.

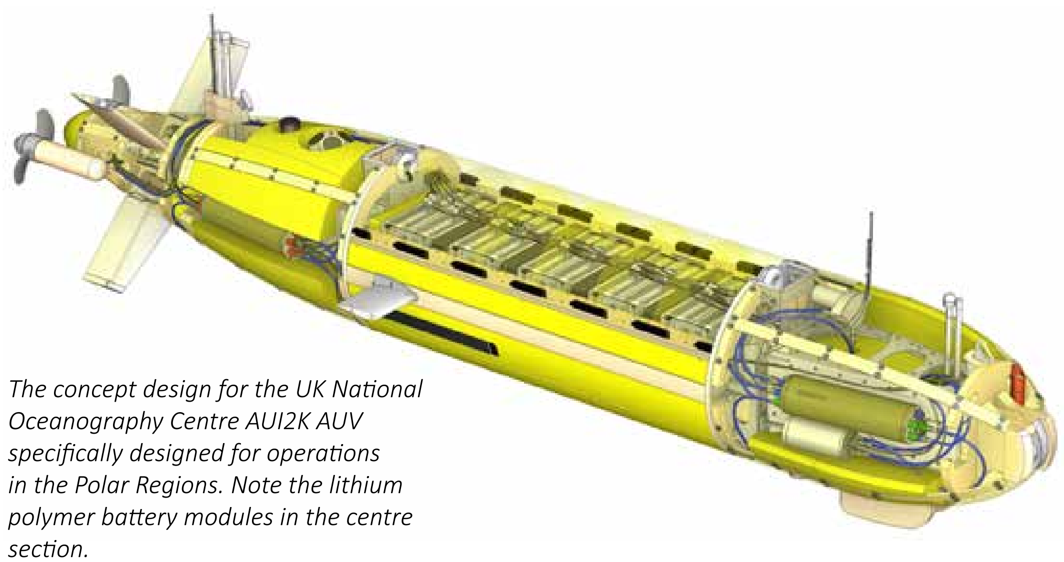
The concept includes acoustic sources near the ice front to provide a position-fixing capability.

ENERGY STORAGE

A good knowledge of the energy system performance in cold temperatures should be a prerequisite for effective mission planning. A realistic model of the energy system performance with load and temperature can help. In temperate regions it can be a problem for an AUV energy system to avoid reaching too high a temperature, and the hardware design may need to incorporate cooling devices.



Outline diagram of IceNode, a variable buoyancy system proposed for year-long observations of basal melting of ice shelves. In operation the vehicle travels vertically, drifting in and out on sub-ice shelf currents, emplacing itself under the ice when making its measurement



The concept design for the UK National Oceanography Centre AUI2K AUV specifically designed for operations in the Polar Regions. Note the lithium polymer battery modules in the centre section.

In Polar Regions, the AUV is likely to face the problem of conserving self-generated heat to maintain a high enough working temperature for efficient energy conversion. Solutions include choice of energy source technology, insulation and pre-heating the energy source before deployment.

A design feature of the Autosub 2000 Under Ice (AUI2K) AUV is the vehicle's lithium ion energy storage system. It includes four modules, each comprising 28 Kokam 12Ah pouch cells in a 2P14S configuration, forming a 4.97 kWh battery, housed in oil-filled bespoke polyethylene boxes.

These pressure-tolerant lithium polymer battery packs are surrounded by syntactic foam, rated to 2000m.

INSTRUMENTS, SENSORS AND SAMPLERS

There may be some missions for which an instrument or sensor specific to the Polar Regions will be needed, but more often, an instrument or sensor commonly used in temperate regions may suffice, albeit with modifications.

Some modifications may initially seem trivial, such as turning a swath bathymetry transducer array through 180˚ to image the under side of ice rather than the seabed. These, however, may end up exposing hidden complexities and assumptions that cause unforeseen problems.

Icing on deck may cause problems for some sensors and samplers that have internal water-containing cavities or tubes, low temperature may affect calibration, for instance in the backscatter measurement from scientific echo sounders.

Supercooled frazil ice may result in false measurements, eg, false echoes from an echo sounder. Alternatively, it may coat or clog temperature and conductivity sensor surfaces.

AUV operations in Polar Regions offer great scope for innovative underway sensors, such as to measure the amount of algae growing on the underside of sea ice.

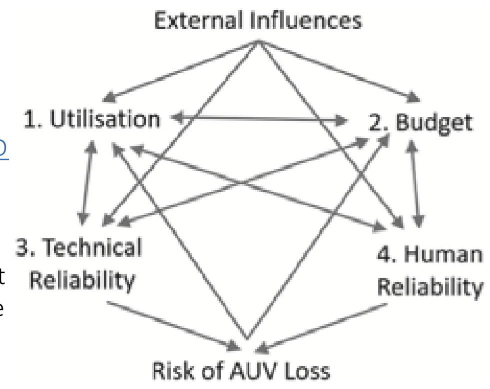
RISK MANAGEMENT: SYSTEMS AND PROCESSES

Many, if not most, AUV operators practice informal methods of risk management, perhaps thought about as "good engineering practice". Some groups thought about replicate and redundant sub-systems or sensors.

It was not until after the openly-shared report of the investigation into the loss of the Autosub2 AUV under the Fimbul Ice Shelf in 2005, however, that ideas on formal risk management systems tuned to the needs of AUVs were published in the peer reviewed literature. Some of the ideas were controversial.

Several researchers considered that only through the methods of classical probability, testing many of the same sub-system modules and obtaining reliability statistics, could the reliability of an AUV be assessed. Ideas centred on subjective (or personalist) probability and formal expert judgment were considered anathema by some.

Nevertheless, a number of AUV groups operating vehicles in Polar Regions have taken up, and implemented formal risk management strategies. Some groups are using formal expert judgment to assess and improve the likely outcomes, a key example being the team from Natural Resources Canada, DRDC and ISE, guided by the University of Southampton, with the Explorer AUV's Arctic



Overview of the causal loop diagram for the nupiri muka AUV programme.

NAVIGATION

There are two main aspects where operating in the Polar Regions give rise to additional and unique challenges, eg.

Positioning

AUVs take positioning information from several external sources, eg GPS satellites, acoustic beacons or may match its current position to a previously known location. It may have the position estimated and updated from a remote location, eg, a surface ship using USBL.

In the Polar Regions sea or shelf ice, it may be that an AUV cannot surface for GPS position fixes and an operator may face the substantial challenges of installing and using a long range acoustic navigation system.

Dead Reckoning
Using speed and heading (ideally referenced over ground and to true North respectively) can obtain an estimate of current position in the absence of position fixes.

Measuring heading poses particular problems in the Polar Regions, with the proximity of the magnetic poles affecting magnetic techniques and gyroscopic errors grow as the secant of latitude. Researchers have developed a number of concepts specifically for polar navigation.

Low frequency EM
One study has involved the use of Extremely Low Frequency (ELF) radio waves for AUV localisation especially in areas where acoustic propagation would prove difficult.

Terrain Aided Navigation
Very low spatial resolution of bathymetric maps have suggested employing a terrain-aided navigation approach, combining the sparse bathymetry with a model of its uncertainty with a numerical model of Arctic Ocean currents and a detailed model of the errors of the heading sensor.

Under Ice Navigation Buoys
The concept of a network of free-drifting buoys to aid under-ice navigation envisages each buoy carrying an above-water Global Navigation and Satellite System (GNSS) to obtain position fixes and a two-way underwater acoustic modem for bidirectional communication with one or more AUVs.

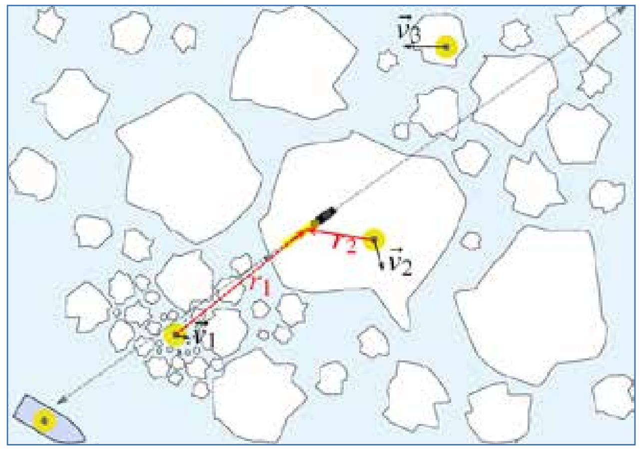
Communication to a support ship would be via short-range VHF radio but also via Iridium satellites. Buoys would be deployed along the planned route of the vehicle(s), either as a transect or in an operating area, for example in support of a grid survey.

Navigation of AUVs beneath moving sea ice
One proposed method, which has been tested with simulations, uses two or more satellite navigation beacons on the ice surface together with the navigation sensors on the AUV, e.g, upward DVL, and support ship in an extended Kalman Filter. One area of uncertainty the authors highlight is that of the actual path of sound between source and receiver- they have assumed straight paths – while acknowledging that refraction could occur and would add to distance sensor noise

Minimising external inputs on gliders
One group have looked at various topics including Intelligent power management, leading to energy savings, e.g, through only using essential sensors when on transits.

• Hybrid buoyancy engine and propeller propulsion together with an adaptive velocity control using a multi-factor objective optimisation approach. The propeller option allows the glider to make headway even in the presence of adverse currents.

• Dynamic depth band selection, not just the saw-tooth profile constrained by a buoyancy engine alone. This capability can benefit scientific sampling and improve energy efficiency for shallow profiling with a deep glider.



A foreseen AUV operation using the under-ice navigation buoys. The red lines show range measurement between buoys and AUV. Solid line indicates valid measurement, while dashed line indicate that measurement may be beyond maximum range. The buoys may or may not be drifting, and not necessarily with the same speed or direction (as indicated by the black arrows). The long grey line shows the AUVs planned transect.

ICE

According to the web site, AUVs can be affected by a number of ice types.
WHAT! You mean that there is more than one type of Ice? Who Knew that?

SEA ICE

• Frazil: Fine spicules or plates of ice, suspended in water. Possibly a potential hazard to AUV CTD sensors pumped through a sample tube.

• Grease: A later stage of freezing than frazil ice when the crystals have coagulated to form a soupy layer on the surface. Grease ice reflects little light, giving the surface a matt appearance.

• Nilas: A thin elastic crust of ice, easily bending on waves and swell and under pressure, thrusting in a pattern of interlocking "fingers" (finger rafting). Has a matt surface and is up to 10cm

• Pancakes: Predominantly circular pieces of ice from 30 cm- 3m in diameter, and up to 10 cm in thickness with raised rims due to the pieces striking against one another. Certainly a hazard for appendages on an AUV and to sighting a surfaced vehicle.

• Young ice: Ice in the transition stage between nilas and first-year ice, 10-30 cm in thickness. May be subdivided into grey ice and grey-white ice. May be detected by upward-looking sonar.

• First year ice: Sea ice of not more than one winter's growth, developing from young ice; thickness (typically) 30 cm- 2m. May be subdivided into thin first-year ice/white ice, medium first-year ice and thick first-year ice.

• Multi-year ice: Old ice up to 3 m or more thick, which has survived at least two summers' melt. May form in Hummocks (hillocks of broken ice that have been forced up by pressure) Almost salt-free. .

• Fast ice: Sea ice which forms and remains fast along the coast, where it is attached to the shore, to an ice wall, to an ice front, between shoals or grounded icebergs. Vertical fluctuations may be observed during changes of sea-level. Fast ice may be formed in situ from sea water or by freezing of pack ice of any age to the shore, and it may extend a few metres or several hundred kilometres from the coast.

Multi-year fast ice may be impenetrable for a support vessel, and recovery of an AUV stranded under multi-year fast ice at a distance from the ice edge may not be feasible.

• Brash ice: Accumulations of floating ice made up of fragments not more than 2 m across; the wreckage of other forms of ice.

LAND DERIVED ICE

• Ice shelf: A floating ice sheet of considerable thickness showing 2-50 m or more above sea-level, attached to the coast. Usually of great horizontal extent and with a level or gently undulating surface.

Nourished by annual snow accumulation and often also by the seaward extension of land glaciers. Limited areas may be aground. The seaward edge is termed an ice front.

• Glacier tongue: Projecting seaward extension of a glacier, usually afloat. In the Antarctic, glacier tongues may extend over many tens of kilometers. A similar hazard to beneath an ice shelf.

• Iceberg: A massive piece of ice of greatly varying shape, more than 5 m above sea-level, which has broken away from a glacier (or an ice shelf), and which may be afloat or aground. Icebergs may be described as tabular, dome-shaped, sloping, pinnacled, weathered or glacier bergs (an irregularly shaped iceberg).

As icebergs drift, they are a transient hazard. AUV missions may involve deliberate transects under icebergs, in which case temporary or extended stranding may be possible, especially if icebergs have areas of rough bottom topography.

• Bergy bit: A large piece of glacial ice generally showing less than 5m above sea-level but more than 1m and normally 100-300 square metres in area.

OPEN WATER

• Lead: Any fracture or passage-way through sea ice which is navigable by surface vessels.

• Polynya: Any non-linear shaped opening enclosed in ice. Polynyas may contain brash ice and/or be covered with new ice, nilas or young ice; submariners refer to these as skylights. Sometimes the polynya is limited on one side by the coast and is called a shore polynya or by fast ice and is called a flaw polynya. If it recurs in the same position every year, it is called a recurring polynya.

Leads and polynyas offer opportunities for AUV launch and recovery within ice-covered areas.

SNAKEHEAD REPRIEVED

Earlier this year, the US Navy formally christened the Snakehead LDUUV [Large Displacement Unmanned Undersea Vehicle] prototype vessel. Soon after, however, the Navy made an announcement indicating that they wanted to cancel the unmanned undersea drone research programme for financial reasons.

The project however, may soon get a reprieve.

Snakehead was planned as a large undersea vehicle that could be deployed from a submarine to carry out a variety of operations. So far, the Navy has invested at least $200 million in developing the vehicle.

The development was to follow a two-stage approach with the government investing in up-front research and then industry competing to fabricate the vehicle.

The long-endurance, multi-mission vehicle was designed as the largest UUV able to be hosted and deployed through submarine tubes.

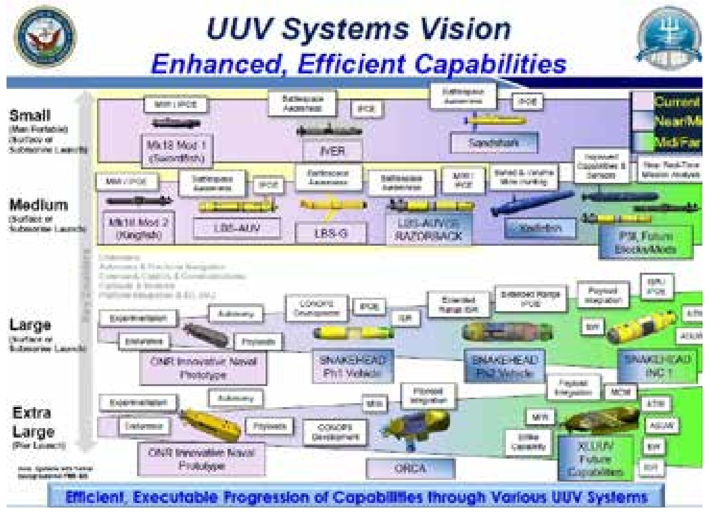
"The vehicles were originally designed to be launched and recovered from nuclear-powered submarines," said a source. "The idea was that they could fly ahead of the submarine, gathering intelligence and monitoring areas of interest, a task otherwise known as 'Intelligence Preparation of the Operational Environment' roles, or IPOE.

EQUIPMENT

The Navy said that because Snakehead is designed with a modular, open architecture, new systems or payloads can be rapidly integrated in the future, to even further expand its capabilities. The system incorporates the Navy's Unmanned Maritime Autonomy Architecture (UMAA) and Common Control System (CCS) for mission planning and execution, as well as monitoring.

Snakehead launch

Snakehead in the water



Vehicles in the UUV Systems programme

The current iteration uses a number of side-scan sonar and bathymetric instruments for the obstacle identification and seafloor mapping operations, allowing it to identify potential dangers for the host vessel. In addition, the acoustic instruments can map the area to provide intelligence for future operations.

The LDUUV is part of a family of underwater systems- the third largest in a group of four. These range from the small Sandshark and Swordfish , through to medium-sized vehicles such as the Kingfish, Razorback and Knifefish. The largest in the family is the Extra Large vehicles including the Orca.

The Navy contends that while cancelling the Snakehead would generate a gap, it could be filled with others in the range. Doing so would save a considerable amount of money – maybe $500 million over the next 5 years– that they need to allocate on other projects.

RESCUE

Its rescue may come in the form of the Senate Armed Services Committee.

In general ,Congress is always reluctant to cancel ongoing programmes that are being developed and built. Once active, they say, it could prove to have an important capability to the fleet. In saying this, they allocated $100 million dollars for next year to fund more research on the programme.

Sen. Jim Inhofe said "Underwater drones have potential. The Pentagon just needs sound systems engineering and a little creativity."

The Snakehead prototype recently carried out trials at the Narragansett Bay Test Facility. The AUV conducted a long distance ingress, performed a sonar survey box and then egressed back to the test facility, demonstrating a new milestone in total sortie endurance.

The sortie, conducted with the Draper Laboratory-developed Maritime Open Architecture Autonomy, successfully collected sonar data using technology from the Pennsylvania State University Applied Research Laboratory.

"The accomplishment of this mission in the system’s intended operational environment was a big step for the programme to gain confidence in the vehicle software and hardware systems, as the team pushes toward extended endurance operations and layering additional system capability," said Chris DelMastro, head of the Undersea Warfare Platforms and Payload Integration Department.

"The IPOE mission is a critical step toward understanding an area of interest and feeds into planning a relevant course of action to support the warfighter.

"To date, Snakehead has conducted 155 in-water sorties and more than 78 hours of runtime utilising a government-owned and controlled modular open system architecture to include vehicle controller software; autonomy software; and command, control, and communications software – TopsideC3 – for mission planning, operations and analysis."

Since last year, the team conducted up to 190 hours of simulations using full-up vehicle hardware-in-the-loop and software-in-the-loop simulation tools.

These simulated missions ensure the software operates as intended and that mission parameters are set correctly and confirmed by the vehicle.

HUGIN

Kongsberg Maritime’s Sensor and Robotics division has secured over NOK 450M in contracts for HUGIN AUV in Q2 2022.

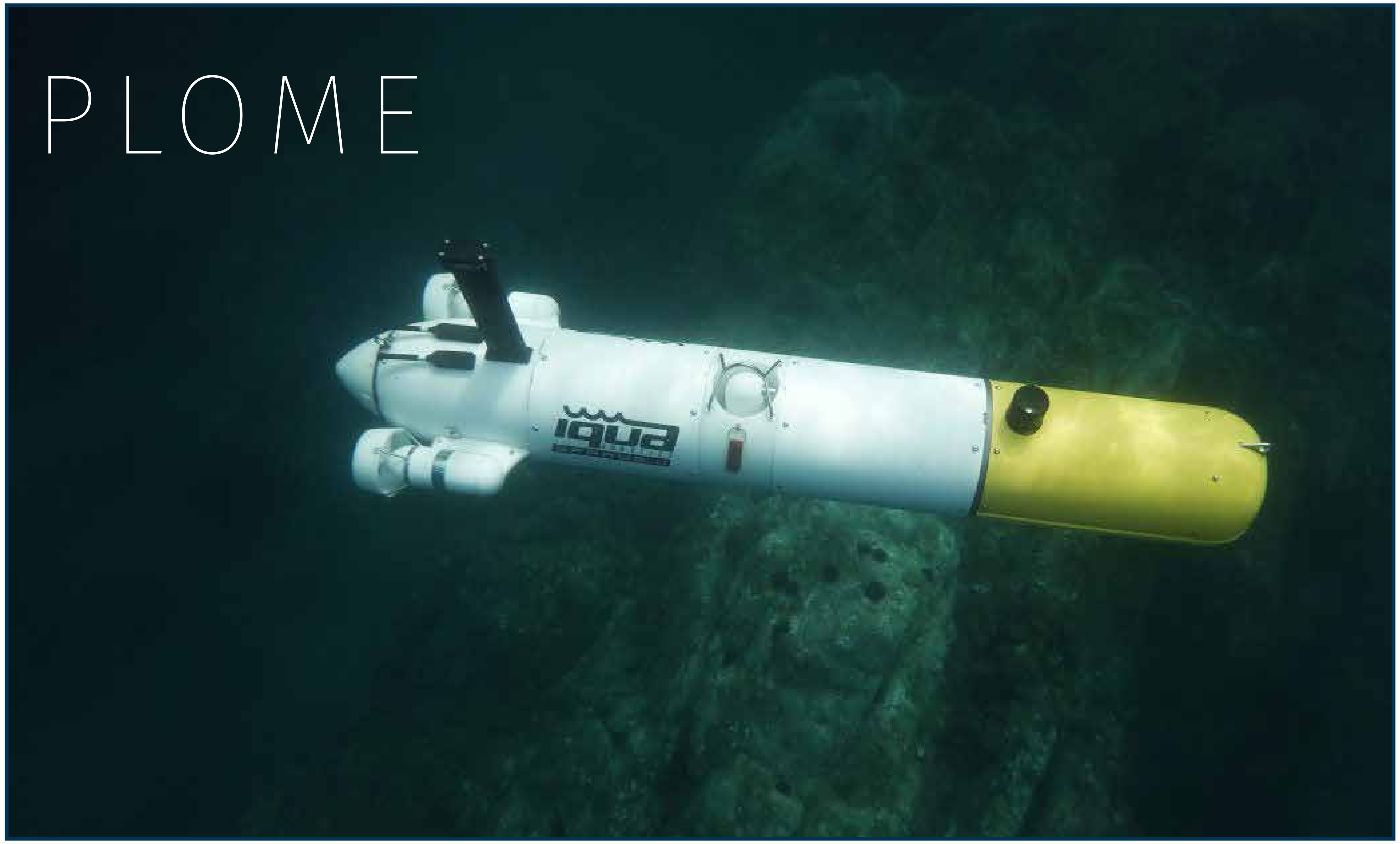
The order income consists of a mix of recurring business with existing customers and new customers that will use the HUGIN platform in their operations.

Since the first dive of the iconic HUGIN autonomous underwater vehicle (AUV) prototype in March 1993, Kongsberg Maritime has been spearheading the development of the sector, and with the latest release of HUGIN Edge, Kongsberg Maritime offers complementary AUV solutions for the rising AUV Market.

The HUGIN range of autonomous underwater vehicles is characterised by great manoeuvrability and high accuracy of stabilisation.

Hydrodynamic shape, accurate instruments and high battery capacity means these AUVs can be optimised for a variety of industries from oil and gas and renewables to defence and research.

HUGIN AUV range



A scientific team led by the University of Girona (UdG) will develop an underwater platform to intelligently monitor marine ecosystems in real time.

The project is called **Platform for Long-lasting Observation of Marine Ecosystems** (PLOME) and is carried out jointly with the Universitat Politècnica de Catalunya · BarcelonaTech (UPC), the Universitat de les Illes Balears (UIB), the Universitat Politècnica de Madrid (UPM), the Institut de Ciències del Mar (ICM-CSIC) and the company Iqua Robotics. The project has a budget of €1.5 million from funds from the Spanish Research Agency and the European funds Next Generation.

Over the course of three years, PLOME will design a non-invasive, modular platform to collect essential data so that the scientific community can better monitor, supervise and manage marine ecosystems.

Specifically, the project proposes to develop a set of independent systems consisting of fixed stations that remain on the seabed, submarine vehicles and surface vehicles that work together and autonomously to collect data.

All systems have batteries and communication systems. Underwater vehicles can be parked to charge batteries and surface vehicles can work by extracting energy from the environment.

The set of systems constitutes a platform that can monitor an area for several weeks, and up to a month, without the need for human intervention. Once collected, the systems are maintained, data is extracted, batteries are charged, and the platform can be deployed again so that monitoring can continue in another area.

The project aims to advance the current methodology in which, for the most part, data is only extracted while there is a human team conducting an oceanographic campaign.

Since the systems are working for many days, artificial intelligence is used to detect species and adapt and optimize seabed monitoring according to the detections. Researchers will also receive a summary of the detections in real time, so they can understand what is happening and be able to change the parameters they want to make better use of the rest of the days when the platform will still be collecting information.

During the three years of the project, three experiments will be carried out in different places on the Catalan coast. The first will take place in 2023 on the coast of Sant Feliu de Guíxols. It will be the first time that the technologies developed will work together to obtain data from the seabed.

During 2024, two final experiments of the project will be carried out. The first will consist of a deep validation, between 300 and 500 meters, in a protected area of real fishing near the city of Barcelona, by means of an oceanographic boat. In this experiment the monitoring systems will be validated in real conditions for several days, supervising and operating the systems from the ship.

The second experiment will be carried out on the coast of Vilanova i la Geltrú, and will consist of validating all the systems at shallow depth over a week without interruption. The platform will be connected to the OBSEA marine observatory, and this will allow real-time monitoring of all systems to verify that they are working properly.

The Centre de Desenvolupament de Sistemes d'Adquisició Remota i Tractament de la Informació (SARTI-UPC) will contribute to the design of fixed seabed observation stations. This group deals with the design of landers, stations that will host instrumentation such as cameras and sensors, devices for communication with the surface and the recovery elements of the platforms.

JAIABOT

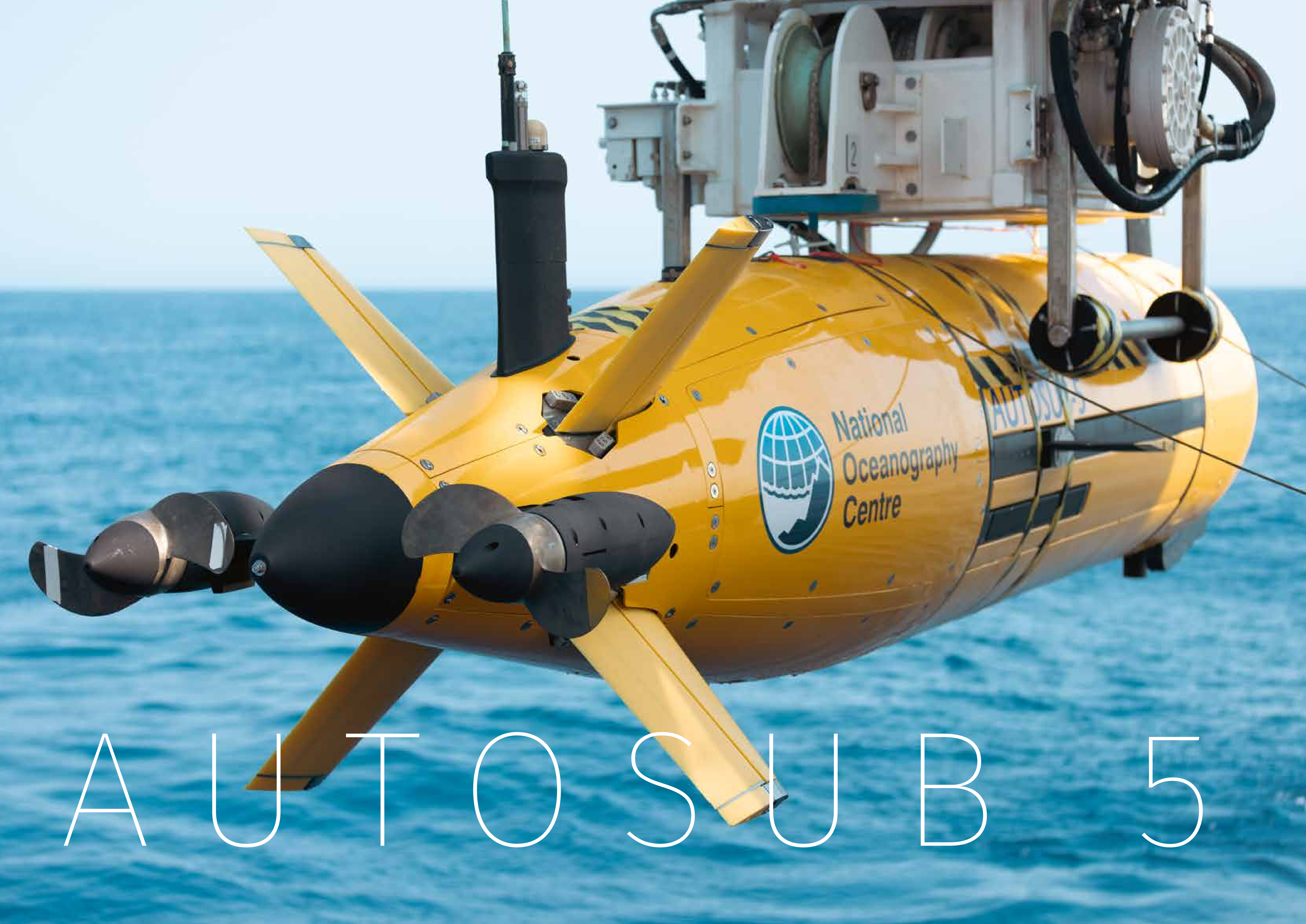
Aquatic robotics group Jaia Robotics, a company specialising in the development of micro-sized, high-speed, autonomous underwater vehicles (AUVs), has announced that it has raised over $1 million in seed funding.

They see an increased focus on Blue Tech as a key to accelerating their growth. The focus of their plan is a unique micro-sized, high-speed, aquatic data collection robots called JaiaBots

JaiaBots are micro sized hybrid autonomous surface and subsurface vehicles. They are rugged and reliable, designed for shore or manned or unmanned vessel launched operations. Their design simplicity and intuitive user interface provides a system that needs minimal training time to become fully proficient.

JaiaBots can be operated individually or in multi-vehicle pods in depths of 1m to 100m and in a wide variety of marine environments including offshore, surf zones, estuaries, rivers, and lakes, representing a significant advancement in affordable robots.

A U T O S U B 5



THE LATEST OCEANID

A RETURN TO COLD WATER

The dance card of the débutante Autosub 5 vehicle has been filling rapidly following on from the successful conclusion of deepwater sea trials in late July.

At present, it is busy on its inaugural scientific operation at the Whittard Canyon and promises to provide the scientific sector with the ability to carry out complex surveys around the world, particularly in harsh Polar conditions.

This AUV is the latest of a line of Autosub designs developed by the National Oceanography Centre (NOC).

"There have been 4 previous incarnations of Autosub “said Dr Dan Roper NOC’s AUV Operations Group Engineering Manager.

"Polar work is extremely challenging, Autosub 2 and the data it carried was lost under the Pine Island Glacier in 2005 whilst attempting highly ambitious and high-risk survey deep under over a kilometre-thick Ice. Its replacement, Autosub 3 went on to be applied in the very successful Autosub under-ice program which saw it deployed under a number of glacial ice shelves in both the Arctic and Antarctic. This pioneering vehicle successfully introduced a number of important scientific capabilities including having one of the first upward-looking multibeams, to look at ice-shelf basal morphology

"By the time the 4th iteration of Autosub was being planned, it was considered that the ability to work in deeper waters was becoming

an important developmental goal and the result was a vehicle capable of working at 6000m. This was therefore reflected in the vehicles name- Autosub 6000."

In 2016 the team at the NOC began work on the all-new Autosub 5 – not a gradual design iteration of Autosub 6000 but a completely new concept that not only allows the deep-water operations of its predecessor, but opens up new types of science in places previously inaccessible.

The new 5.5m long, 0.9m diameter vehicle will be able to get considerably closer to the ice and further into the critical zone

Nose section of the Autosub 5
Left: Preparing the Autosub for operations

OCEANIDS

The NOC operates the National Marine Equipment Pool on behalf of the National Science Research Council (NERC) for the wider UK science community.

This pool contains a diverse fleet of commercial and NOC-developed vehicles from an ROV for precise, manually-directed tasks to a large fleet of long duration deployment ocean-going gliders.

"An important function of this pool is to satisfy the demand for bespoke scientific platforms. The NOC provided underwater vehicles when marine autonomy was in its infancy," said Dr Kristian Thaller, Programme Director for the Net Zero Oceanographic Capability (NZOC), "and even when the market began to be satisfied by commercial vehicles, there is still a demand for vehicles to be deployed in harsh and hazardous environments that the commercial sector would consider too niche."

Oceanids is a long-term investment by the NERC to develop new and improved autonomous capabilities to enable the UK science community to undertake world leading science within a low carbon research environment. The programme has funded new platforms, innovative marine sensors and interactive command-control and data management systems.

“Marine autonomy was originally conceived to open up new areas of science that couldn't be carried out by ships, but the use of networked fleets of battery powered vehicles also supports the drive to net zero by 2040,” said Dr Thaller.

where the melted sea ice begins to mix with the salt water. Its cutting-edge navigation and full systems redundancy mean that it will also be able to get physically nearer the critical glacial calving point and monitor what happens prior to where the ice 'calves' or breaks off the main glacier.

TESTING

The vehicle was designed and built in Southampton, carrying out repeated tests along the way. The project timetable was delayed by Covid but once the final in-house testing was complete, the next step was to conduct commissioning trials.

"Between 2021 and early 2022 we conducted a series of harbour acceptance tests in Loch Ness, which offered the opportunity to observe how Autosub 5 worked in deep waters and fairly rugged terrain, all whilst working from the relative safety of inland waters and shore launch and recovery," said Roper. After seeing the vehicle behave as planned, the next stage was to launch it off the back of a ship in open sea conditions.

"For the final phase, which we termed the 'sea acceptance test,' we loaded Autosub 5 onto *RRS Discovery* (99.7m long, 5954 gross tonnes) in early July, and took it to a place that we have been to many times before-Haig Fras, an area located in the south west approaches, past Cornwall and Scilly Isles and then out (around 10hrs sailing time) to the Whittard Canon, lying in the narrow strip between the Irish and French economic zones. Here, the water depth is just over 100m.

"One of the reasons we selected that location was that there is a repeat survey site at a depth of only 100m that we've been to with previous Autosub incarnations. This means we can benchmark the results, comparing them with previous submarines whilst also contributing to continual long-term monitoring in an area of scientific interest."

"It was there that we carried out the Autosub 5's first ever real piece of science, conducting full run lines using the Edge Tech 2205 410kHz sonar. We ran four lines of 5km by 800m. Whilst at that location we also completed a repeat of a multibeam bathymetry survey, and on the final night a repeat of a 20km long camera survey, 3m above the floor, which collected 25,000 photos.

"All in all, we found that the data compared very well with previous surveys. One notable improvement was in the navigation and positioning. The project also afforded

AUTOSUB LONG RANGE

By the time the first Autosub 6000 was commissioned to support deep water research in around 2009, it had become evident that the demand for autonomous vehicles was falling into two categories.

One was for a large vehicle able to carry numerous large sensors. These come with a relatively high-power budget to both move the vehicle and power the sensors.

Due to their power consumption, these platforms don't operate for long, maybe a week, and then the batteries have to be recharged or placed. However, they do have the capacity to carry quite powerful sonar and observation equipment.

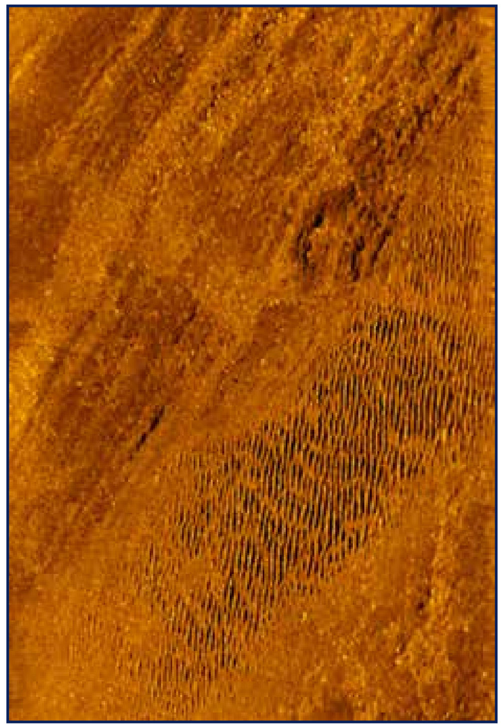
In parallel there has been the emergence of long range, lower power vehicles. The sensors in these are far more limited, but can operate for many weeks or even months. This was the basis of the by the Autosub Long Range design, popularly known as Boaty McBoatface.

"The ability for a platform to independently travel long distances to a region of scientific interest is increasingly important. Instead of taking a ship out to launch and recover the vehicle, which is a carbon intensive activity, such vehicles could be shore launched, said Dr Thaller.

"This would not only reduce the carbon cost associated with oceanographic research but would also mean that scientists would no longer be restricted by the limited availability of the UK's three global class research ships,"

The Oceanids programme expanded the existing fleet of three 6000m-rated ALRs by developing a 2000m-rated version that can carry more batteries and thus has a longer range. Future development will continue to expand its performance envelope to support the transition to a net zero research infrastructure.


AUTOSUB-5



Sidescan sonar data of the rock striations at Haig Fras marine protected area as recorded from the Autosub5

the opportunity to see how it behaved in rolling waves as opposed to the flat calm of Loch Ness.

"The next stage of the work was to sail to the much deeper Whittard Canyon to see how it behaved in 4000m of water.

Submarine canyons often support increase diversity in habitats and species and this allowed scientists to map these deep areas in high resolution.

"Deepwater AUV operation comes with its own challenges," continued Roper, " and whilst we had been able to test individual components at pressure, this was the first time we had the opportunity to test the systems response as a whole to the immense pressures found deep in the ocean. We were very pleased to achieve a full depth dive on only the second attempt. Following this we conducted a second dive to 4000m in this area, building complexity, to a full high resolution multibeam lawnmower at 4000m.

"As well as measuring dive rates we were able to test our acoustic signalling and demonstrate we were able to multibeam conduct surveys. CEFAS had originally collected data on its vessel mounted multibeam and we were able to superimpose data from Autosub 5 to provide greater clarity.

"The final stage of the expedition was spent on a 14-hr task undertaking 50km of multi beam and side scan survey mapping the South of Whittard Canyon. This was the deepest dive yet in 4197.48m. It then moved on to its first science expedition, JC237. "

JC237

Expedition JC237 is contributing to sustained ocean observations as part of the NERC-funded Climate Linked Atlantic Sector Science (CLASS) programme.

Conducted with the RRS James Cook, this meant a return to the same location at Whittard Canyon and pushing further out to the Atlantic Ocean for low altitude surveys using a camera system developed as part of a project called Autonomous Ecological Surveying of the Abyss (AESA).

This is used to identify species from the imagery, study the populations of various species and their biodiversity.

POWER

The Autosub 5 incorporates significant improvements over previous versions. It has a cruise speed of 1.2–1.4m/s with a navigation accuracy of 0.01% or less than 0.1m per kilometre.

In order to achieve a 400km range, the original Autosub 3 was powered by 5000 non-rechargeable alkaline D-Cells. The Autosub 5, however, has an updated version of the Autosub 6000 NOC designed pressure tolerant rechargeable lithium iron battery. Each battery unit has 4 x 1.25kWhr sub modules, giving a total of 5kW hrs per battery with a maximum 30A discharge.

The entire AUV has 12such batteries giving a total output of 58kW hrs. The batteries, weighing only 8kg each in water, can be located in one area or be distributed more around the vehicle.

One new tool in the underwater biologist's armoury is eDNA sampling.

Autosub 5 is currently fitted with a prototype sampler developed by the Ocean Technology and Engineering group at the NOC, which allows water to be filtered through a mesh which can then be processed for DNA sampling.

By coupling the eDNA sampling with the other sensor payloads available on Autosub 5, such as the AESA cameras and oceanographic measurements such as current profile and temperature and salinity, its hoped that a greater understanding of population distributions can be achieved.

REDUNDANCY IN DESIGN

In the design of the Autosub 5, the front section of the vehicle, contains the potential for upward and downward-pointing multi beam, cameras, Conductivity Temperature Depth (CTD) sensors and the obstacle avoidance system.

The rear, however, includes the Edgetech 2205 sidescan with sub bottom profiler, primary gyrocompass and spare pressure sensor. There is the ADCP/Doppler velocity log up.

One important feature of the design is to maximise reliability. As such, the design features considerable hardware redundancy with payload items containing complementary tools. In the event of damage to one part of the AUV, it may be possible to derive data from sensors in another part.

This means that if the front half of the vehicle is damaged and the obstacle avoidance were to stop working, the vehicle could revert to using ADCP to prevent contact with the ice or seabed.

Conversely, if damage to the rear prevented the ADCP's to work, the forward-facing obstacle avoidance system has a wide enough range that it can see the ice above and the seabed below to prevent collisions.

Similarly, if the primary navigation system at the back of were to be affected, the spare gyro and depth sensor in the CTD can be used for navigation.

The vehicle propulsion is also dually redundant. It is possible to lose one thruster and its actuator and the Autosub 5 could still return.

The communications satellite, GPS and Wi-Fi systems are also dually redundant. There is an acoustic control beacon along with a back-up standalone acoustic beacon, light flashes and Iridium beacons.

THE OCEAN EXPLORATION TRUST

SEAFLOOR MAPPING

During the 24-day Lu'uaeaahikiikawawāapalaoa expedition, The Ocean Exploration Trust teamed up with the University of New Hampshire Center for Coastal and Ocean Mapping / NOAA-UNH Joint Hydrographic Center.

The mission was to test how ship-based seafloormapping can be supplemented with new mapping technologies to expand the types of habitats and how to best gather data from and boost the efficiency of future expeditions.

Together E/V *Nautilus* and Uncrewed Surface Vehicle DriX collected bathymetry readings across over 20,000 km2 from near coastal to deepocean habitats near NihoaIs land in Papahānaumokuākea Marine National Monument.

New seafloor maps will equip monument managers with a better understanding of the formation of deep-water and shallow-water terrain of the Northwestern HawaiianIslands, contribute to high-resolution nautical charts, and improve safe navigation in the area. Every chance to work together improves operational planning and coordination of new technologies.

This work also contributes to the National Ocean Mapping, Exploration, and Characterization Council and GEBCO Seabed 2030 seafloor mapping campaigns. Both efforts to build complete maps of the seafloor require dedicated surveying efforts, particularly in remote areas to meet these goals within the next decade.

SHIBUYA FALCON

Shibuya recently selected the Seaeye Falcon as the best robot for supporting its floating wind turbine operations in Japan.

"As a diving company, underwater robotic vehicles can be a vital resource for extending operational capability," said Shibuya. "To find the best vehicle for our specific circumstances, we assessed the market and found that the Seaeye Falcon was the most widely used robot in the offshore power generation business with the longest proven reliability record."

Shibuya will mainly deploy its Falcon for floating turbine work as, in a crowded and mountainous country, the search for sites in Japan is trending offshore with floating turbines becoming the favoured option in the deep waters off the rugged coast.

The company has accumulated 10 years' experience in offshore wind power generation, being early to trial robots for the emerging use of floating turbines for power generation. It recognises that robots are best placed to advance the use of floating turbines by confirming the stability of deep mooring anchorages and for carrying out periodic inspections of the floating structures.

Success in the floating offshore wind power generation business has extended Shibuya's operations into tidal power generation and ocean current power generation.

For Shibuya, the Falcon's multi-tasking capability with easy role change makes it a good choice. It is also easy to use, highly manoeuvrable and able to master turbulent waters and strong currents and remain stable whilst undertaking robust or precision tasks.

DIVER SAFETY

The company says that the Falcon plays a vital safety role by undertaking missions too hazardous for divers, particularly where the depth of water and strength of current are dangerous for divers to operate. This includes surveying fishing grounds and fishing reefs prior to turbine installation — and periodic inspection of mooring anchors and chains. The addition of the Falcon to diving operations improves diver safety and increase efficiency, Shibuya says, by pinpointing and examining locations of interest before sending down divers.

Important in Japan's development of offshore technologies for power generation is maintaining harmony with the natural environment and enabling marine ecosystems and floating turbines to co-exist and promote sustainable fishing.

ROV CONTRACT

Oceaneering International's Subsea Robotics segment has been awarded a multi-year service contract supporting Petrobras projects off the coast of Brazil. This award continues to build on the copany's success in growing its remotely operated vehicle (ROV) business in an important energy market.

Oceaneering will provide survey and ROV services for AKOFS Offshore's subsea equipment support vessel (SESV) *Aker Wayfarer*. The scope of work includes the provision of two Millennium Plus work class ROVs, complete specialised tooling packages for each ROV, ROV personnel for simultaneous operations, and survey equipment and personnel.

The contract is for four years plus options to extend. Tiago Crespo, Director for Subsea Robotics Brazil and Rest of Americas, said: "We are delighted to work with AKOFS to support Petrobras's offshore activities. With AKOFS, this will be the first time we will be providing survey services for Petrobras on an SESV."

In addition to this latest service contract, Oceaneering has been awarded work on 11 rigs offshore Brazil over the past 12 months.

FORUM ROVS TO OCEANICA

Forum Energy Technologies (FET) has reportedly delivered two work-class ROVs to Brazilian marine engineering company Oceanica Engenharia e Consultoria Limitada (Oceanica) to support its deepwater intervention operations.

These will be used to support inspection, repair, and maintenance (IRM) activities at Petrobras' oil fields.

The two ROVs in questionare a pair of Perry XLX-C work-class ROV systems to Oceanica. The systems were manufactured at FET's U.K. facility at Kirkbymoorside, North Yorkshire, and delivered in the first half of 2022.

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

EXPEDITION YACHT
RESCUE ROBOT

For expedition yacht *Dapple*, a Saab Seaeye deep-rated Falcon robot has been chosen as a standby rescue resource for emergency recovery of their manned submersible.

In addition, the 1000m-rated Falcon comes fully equipped for undertaking a wide range of scientific research and survey operations.

Dapple's dive manager, Marc Taylor, says that the Falcon is a proven commercial choice, so fits their criteria, "and it makes sense because we already have a Falcon aboard another vessel in our fleet."

Operators worldwide favour the Falcon, a small, intelligent robot with the power and task range typically found in much larger systems.

Not only can owners view underwater from aboard the yacht in high-definition images transmitted by the roaming Falcon, but the robot has many other uses.

It can examine the hull millimetre-by-millimetre, recover items from the seabed, cut ropes and cables, and clean critical fittings.

Specialist cameras, survey systems and manipulator arms can be fitted for research and survey missions.

For Dapple, the Falcon is equipped with an extensive range of technology including HDTV cameras, a multifrequency scanning sonar, multibeam sonar, laser system and an eventing suite. It also comes with both a three jaw and a five-function manipulator, each with rope cutters, along with hydraulic cable cutter and rotary cleaning brush.

Although the Falcon's key role is recovery of Dapple's submersible, for general diving safety the Falcon can survey a dive site beforehand, then watch over a diver when below and transport items back and forth during a dive. The Falcon's global success comes from being a small metre-sized, yet powerful, highly manoeuvrable, multi-tasking, easy to use vehicle, depth rated up to 1000m and enhanced with Saab Seaeye's revolutionary iCON intelligent control system.

ASSET TRACKING

TO THE POLISH NAVAL ACADEMY

iXblue and ECA Group recently demonstrated successful subsea asset tracking in shallow waters using iXblue Gaps M7 USBL (Ultra Short BaseLine) positioning system and ECA Group new R7 ROV (Remotely Operated Vehicle).

Hosted by their local partner THESTA, a Polish company providing maritime navigation services and communication systems for the defense sector, the demonstration was organized for the Polish Naval Academy and NAVSUP 2022 attendees with the aim of showing that accurate positioning of underwater targets is possible in a potentially hostile and fast-approaching environment, in coastal regions characterized by shallow waters and often limited access.

As part of the mission scenario, ECA Group's R7 ROV investigated objects and structures submerged in the shallow waters of the Baltic Sea in Gdynia harbor. iXblue Gaps M7 USBL acoustic positioning system was deployed to geolocate the R7 ROV and correct its trajectory in real time. A fixed transponder was also placed several hundreds of meters away from the vessel, at only 5 meters deep. The trials were carried out in water depths of 7 to 10 meters, surrounded by many docks and vessels causing significant acoustic echoes.

Despite challenging acoustic conditions, the positioning of the ROV and the transponder was stable and accurate. Extremely efficient in shallow waters, Gaps M7 ensured excellent horizontal tracking capabilities with omnidirectional coverage and 200° acoustic aperture. With no calibration required, it was easy to deploy and ready to use, saving precious operational time on the field.

The ROV inspection was successful despite the low visibility. Such environments make the use of traditional cameras impossible, but the HD acoustic inspection camera performed remarkably, providing high-resolution data with superior localization accuracy. The R7 combines the compactness and manoeuvrability of mini-ROVs with the performance and power of professional observation-class ROVs. It embeds a wide range of fast-equipped payloads and operates well under harsh sea conditions, making it the perfect ally of Navies for quick and efficient subsea interventions.

"The R7 ROV along with the Gaps M7 USBL acoustic positioning system is able to transmit information accurately, even in noisy and difficult acoustic environments. They both enable fast operation as well as regular and quick position updates, even in very shallow waters, which is a definite asset for the navies, given their need for a fast, clear and concise picture of the battlespace to quickly manoeuvre naval forces in the field." says Cezary Majchrowicz, Technical Director at THESTA.

The R7 ROV and GAPS M7 ready to be deployed at sea

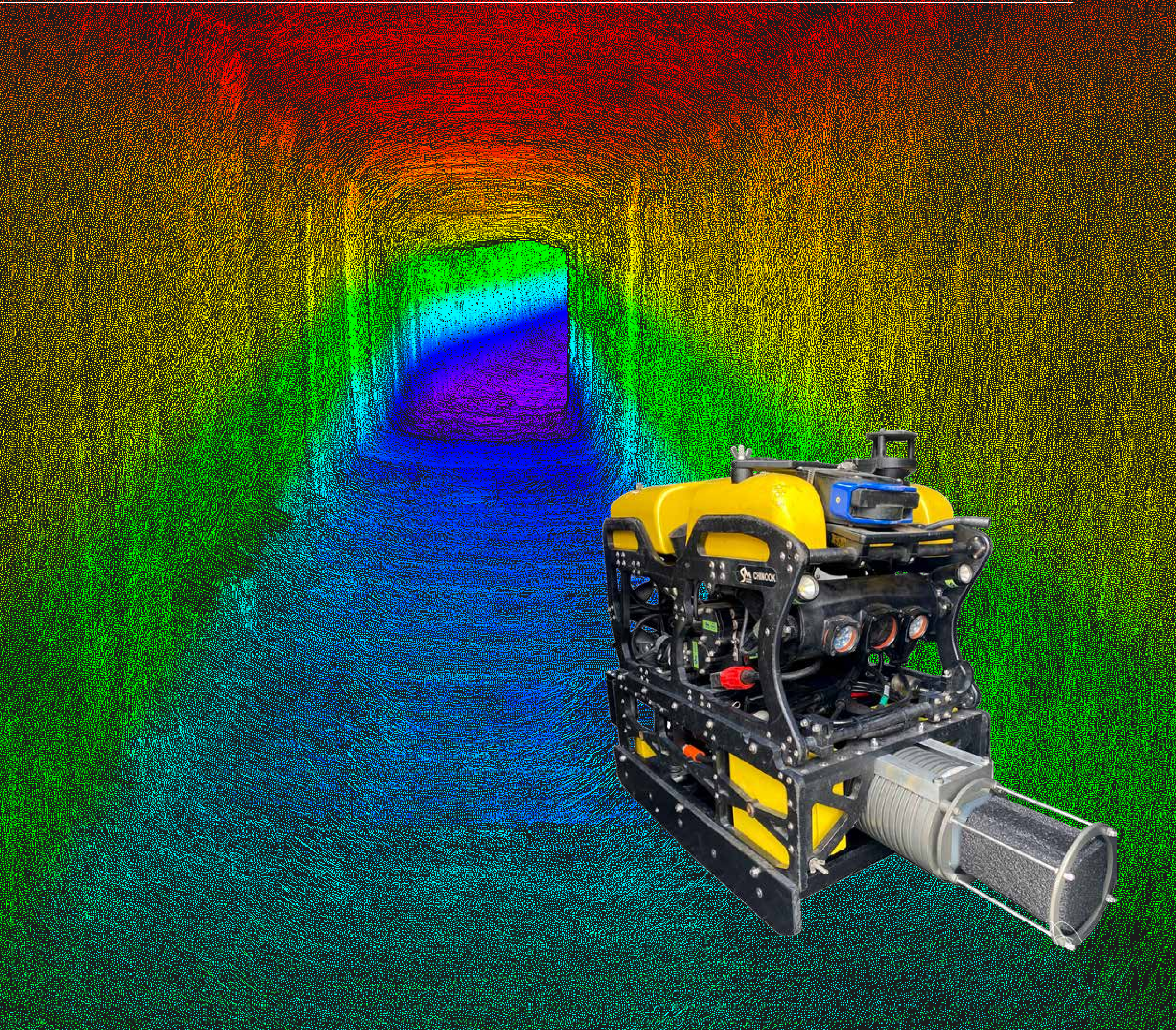
CULVERT INVESTIGATION

The Underwater Acoustics International (UAI) team just recently completed a fully flooded siphon ROV / 3D SONAR imaging investigation.

The client contracted UAI to execute an underwater condition assessment of their fully flooded Siphons as part of a large HEC-RAS modeling project. UAI was required to generate a 3D point cloud of the flooded siphon and identify any significant issues within the 10ft x10ft concrete structure.

The UA Team used a SEAMOR Chinook ROV with a 360deg Tunnel Profiling MBES Sonar (1440 Beams), iXblue Rovins Nano (INS) Inertial Navigation Sensor, Nortek (DVL) Doppler Velocity Logger and QPS-QINSy software. The fully flooded siphon was determined to be in good condition with no significant issues discovered during the investigation.

"Although very challenging at times, working in GPS denied environments are one of our team's specialties and they continue to prove their expertise every time they are in the field," said a spokesman.



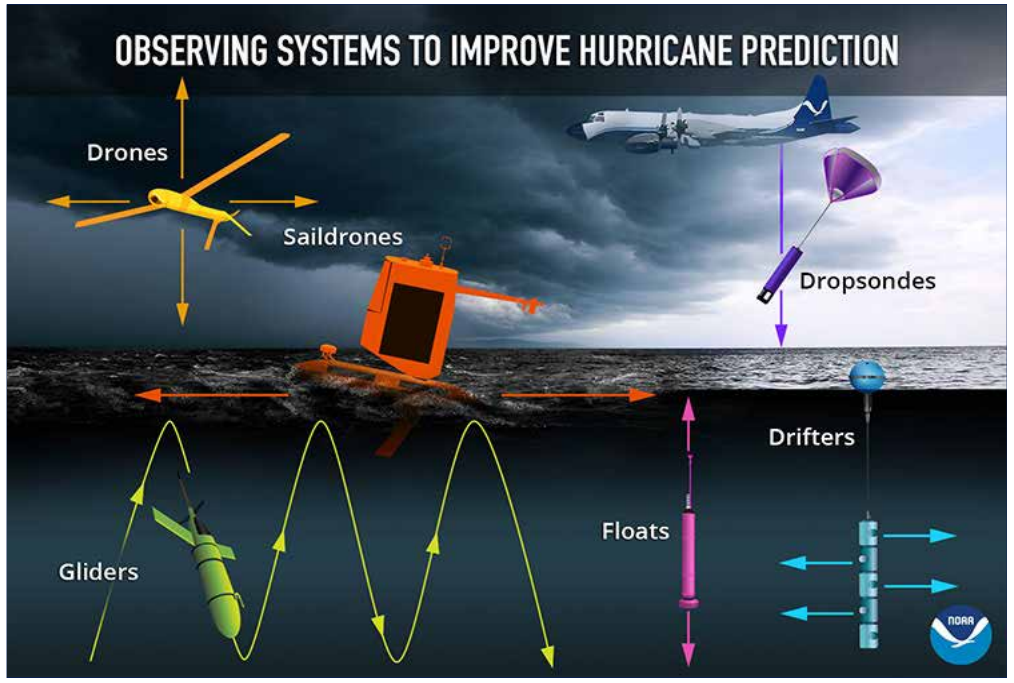
SAILING THROUGH THE EYE OF A HURRICANE

Saildrone has launched its second annual Hurricane mission, partnering with the National Oceanic and Atmospheric Administration (NOAA)'s Office of Oceanic and Atmospheric Research to send seven uncrewed surface vehicles (USVs) to brave the treacherous hurricane season, collecting more insights into how large and destructive hurricanes grow and intensify in the Atlantic Ocean and the Gulf of Mexico.

Saildrone Explorers towed out of high traffic areas. Photo: David Hall/NOAA.

The Saildrone USVs proved themselves in the Atlantic Ocean during last year's hurricane season, with SD 1045 sailing through the eyewall of Category 4 Hurricane Sam. Battling massive 100ft waves and roaring 140 mph winds, the vehicle not only survived intact but sent back the first-ever live video footage from inside the eye of the monster storm.

This year, Saildrone will collect critical data from both the Atlantic Ocean and the Gulf of Mexico expanding the potential impact of the mission. This week, one of the USVs bound for an operation area in the eastern Gulf of Mexico, SD 1032 was deployed from Saildrone's Ocean Mapping Headquarters in St. Petersburg, and another was deployed from Port Aransas, TX, for the western Gulf.



The saildrones will join an array of underwater gliders, surface drifters, profiling floats, and aerial assets

NOAA predicts an above-average 2022 hurricane season, with up to 21 named storms and three to six major hurricanes. Hurricanes don't only present a persistent threat to human safety in coastal cities, they also present a significant economic impact—hurricane damage in the US is estimated at around $54 billion annually. Understanding the physical processes of hurricanes is critical to improving forecasts of deadly storms, reducing property damage and loss of human life.

Saildrone USVs will gather key data throughout the 2022 Hurricane season. Saildrone Explorers, specifically designed to withstand the extreme conditions that occur during a hurricane weather system, are said to be the only USVs capable of collecting this type of critical data.

The Atlantic Hurricane mission aims to improve understanding and predictability of tropical cyclone intensity changes and advance knowledge of the ocean-atmosphere interactions that fuel them.

The saildrones will provide *in situ* data NOAA's Pacific Marine Environmental Laboratory (PMEL) and Atlantic Oceanographic and Meteorological Laboratory (AOML), Saildrone's scientific partners in this mission. The data will also be valuable to other government and research groups.

The saildrones will join an array of underwater gliders, surface drifters, profiling floats, and aerial assets to understand hurricane intensification.

Saildrone Explorer

ALVIN AT 58

THE WORLD'S MOST SUCCESSFUL RESEARCH SUBMERSIBLE REACHES AROUND 4 MILES, ITS DEEPEST EVER DIVE

The human-occupied submersible Alvin made history recently, when it successfully reached a depth of 6453m in the Puerto Rico Trench. This is the deepest dive ever in the 58-year history of the storied submersible.

The dive was a critical step in the process of achieving certification from the U.S. Navy to resume operations after an 18-month overhaul and upgrade that extended the sub's maximum dive rating from 4500m (14,800 feet) to its new limit of 6500m (21,325 feet). Naval Sea Systems Command (NAVSEA) requirements stipulate the certification dive be between 6,200 and 6,500 meters.

The added range puts roughly 99% of the seafloor within reach of the world's longest-operating, most active, and, by many measures, most successful human-occupied submersible program in the world.

This success comes after test dives were temporarily halted in November 2021 when a post-dive visual inspection revealed damage to several attachment points of the specialized syntactic foam used to provide buoyancy to the 43,000lb submersible.

2020-2022 Upgrades included

- Titanium variable ballast spheres and syntactic foam modules rated to 6500m
- High-quality still and 4K video imaging system
- New hydraulic manipulator arm
- More efficient, fully redundant hydraulic system
- Higher-horsepower thrusters
- New motor controllers
- Integrated command-and-control system.