Ocean Robotics Planet

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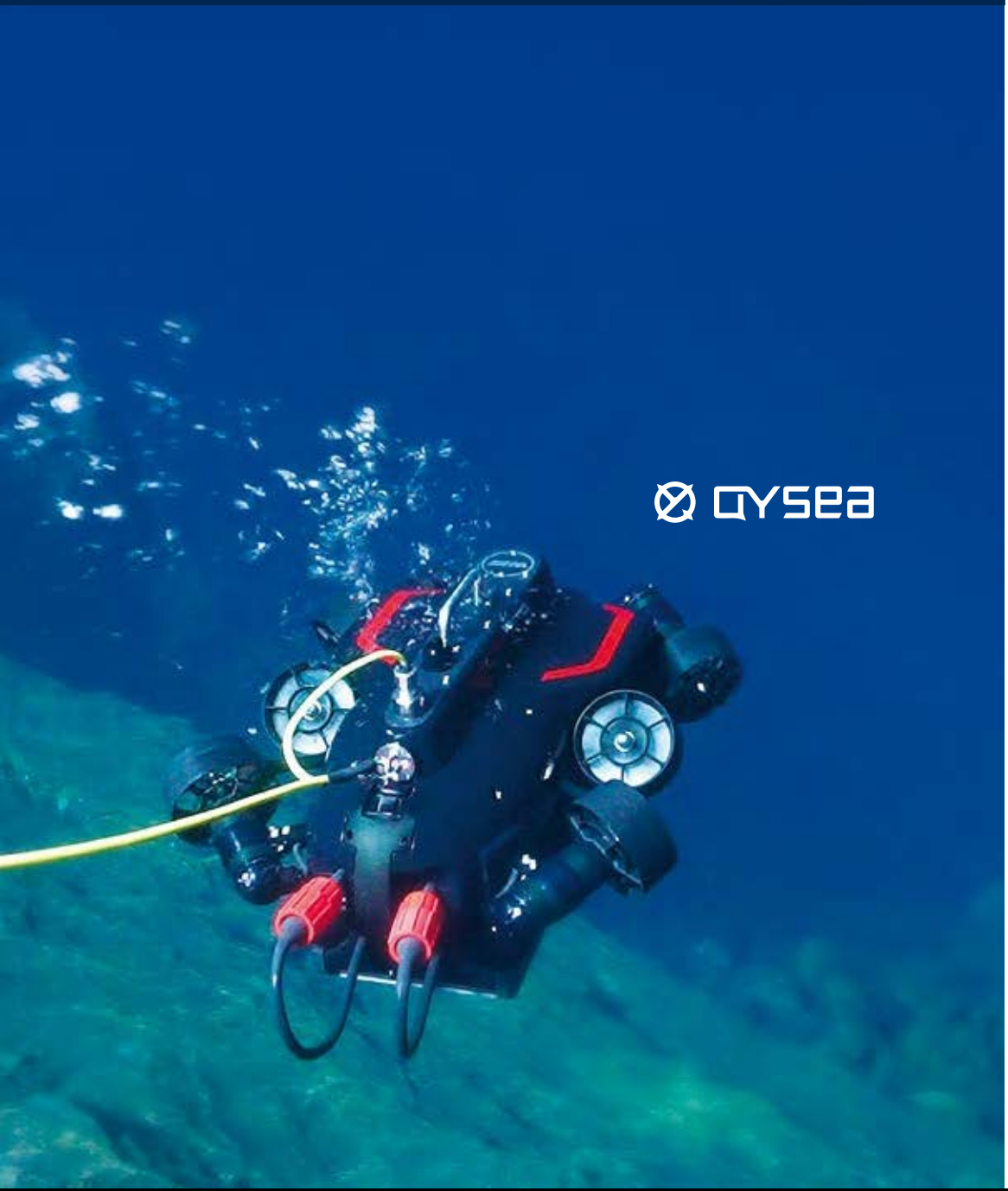
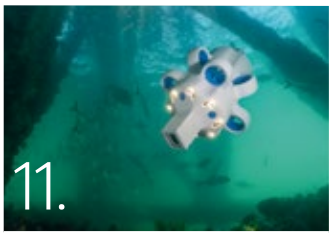


7. QYSEA's Small Sized ROVs Advance Marine Operations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23. U.S. Marine Corps Explores Using USVs

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ISSN 2634-0283 (PRINT)
ISSN 2634-0291 (ONLINE)

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EVENTS CALENDAR 2022

For more information about all events visit WWW.OCEANROBOTICSPLANET.COM

JUNE	**UNDERSEA DEFENCE TECHNOLOGY (UDT)** Rotterdam, The Netherlands (7–9 June 2022) **GLOBAL OFFSHORE WIND 2022** Manchester, UK (21–22 June 2022)
AUGUST	**ONS 2022** Stavanger, Norway (29 Aug – 1 Sept 2022)
SEPTEMBER	**WINDENERGY** Hamburg, Germany (27–30 September 2022) **UNMANNED MARITIME SYSTEMS TECHNOLOGY – USA** Arlington, VA, USA (28–29 September 2022)
OCTOBER	**FLOATING OFFSHORE WIND** Aberdeen, UK (12–13 October 2022) **MTS/IEEE OCEANS 2022** Hampton Roads, VA, USA (17–21 October 2022) **EURONAVAL** Paris, France (18–21 October 2022)
NOVEMBER	**MARINE AUTONOMY TECHNOLOGY SHOWCASE (MATS)** Southampton, UK (8–10 November 2022) **OFFSHORE SOUTH EAST ASIA (OSEA)** Singapore (15–17 November 2022) **OFFSHORE ENERGY** Amsterdam, The Netherlands (29–30 November 2022)
FEBRUARY	**SUBSEA EXPO** Aberdeen, UK (21–23 February 2023)
APRIL	**SEA AIR SPACE** National Harbor, MD, USA (3–5 April 2023) **OCEAN BUSINESS** Southampton, UK (18–20 April 2023) **WINDEUROPE 2023** Copenhagen, Denmark (25–27 April 2023)

My name is Richie Enzmann, and allow me to welcome you all to the latest issue of Ocean Robotics Planet!

WELCOME TO OCEAN ROBOTICS PLANET!

Dear Reader,

The geopolitical climate of the world has changed considerably in the past couple of months with the Russian invasion of Ukraine. It has taken our world by surprise, with potential effects on our everyday lives.

On May 1st TV hosts on Russian prime-time television claimed that a strike by the Poseidon nuclear underwater drone could wipe out the UK by generating a 500m high nuclear tsunami. H I Sutton, OSINT Analyst from Covert Shores, tells us what we need to know about this peculiar Nuclear Torpedo/AUV named Poseidon or Status-6. Continuing the defence theme George Galdorisi reports on the trials of MANTAS USVs by the U.S. Marine Corps to enhance their logistical support, and limit the exposure of personnel in dangerous situations. As we can see, all major military powers are increasing the use of drone related technologies, not only in the air, but also above and underwater.

In this issue we're also reporting on a variety of new ROV and AUV platforms coming onto the market, including the QYSEEA's FIFISH, the Hydrus AUV from Advanced Navigation, the HUGIN Edge from Kongsberg Maritime, and the SleekShip from Subsea Tech. On top of these new systems, Marc Deglinnocenti looks at his Top 10 ROVs currently on the market.

We also look at the Limiting Factor, the manned submersible piloted by Victor Vescovo, that has completed a string of historical dives over the years. It's reached the bottom of the ocean in the Mariana Trench, and dived down to the bottom of all 5 oceans of our planet: an extraordinary achievement! Another historical article covers the discovery of the Endurance - Sir Ernest Shackleton's long-lost ship - that was finally found under the ice in Antarctica by a dedicated team of scientists. I'm pleased to say that we have some truly spectacular photos of this expedition!

Finally, our poster this quarter features the T-REX, the new combined massflow/dredging tool from Subsea Tooling Services that's expected to be used across the wind, UXO, defence, and energy sectors.

We hope that you enjoy reading this issue and look forward to meeting many of you at UDT in Rotterdam, and the Global Offshore Wind exhibition in Manchester.

Best regards,
Richie Enzmann

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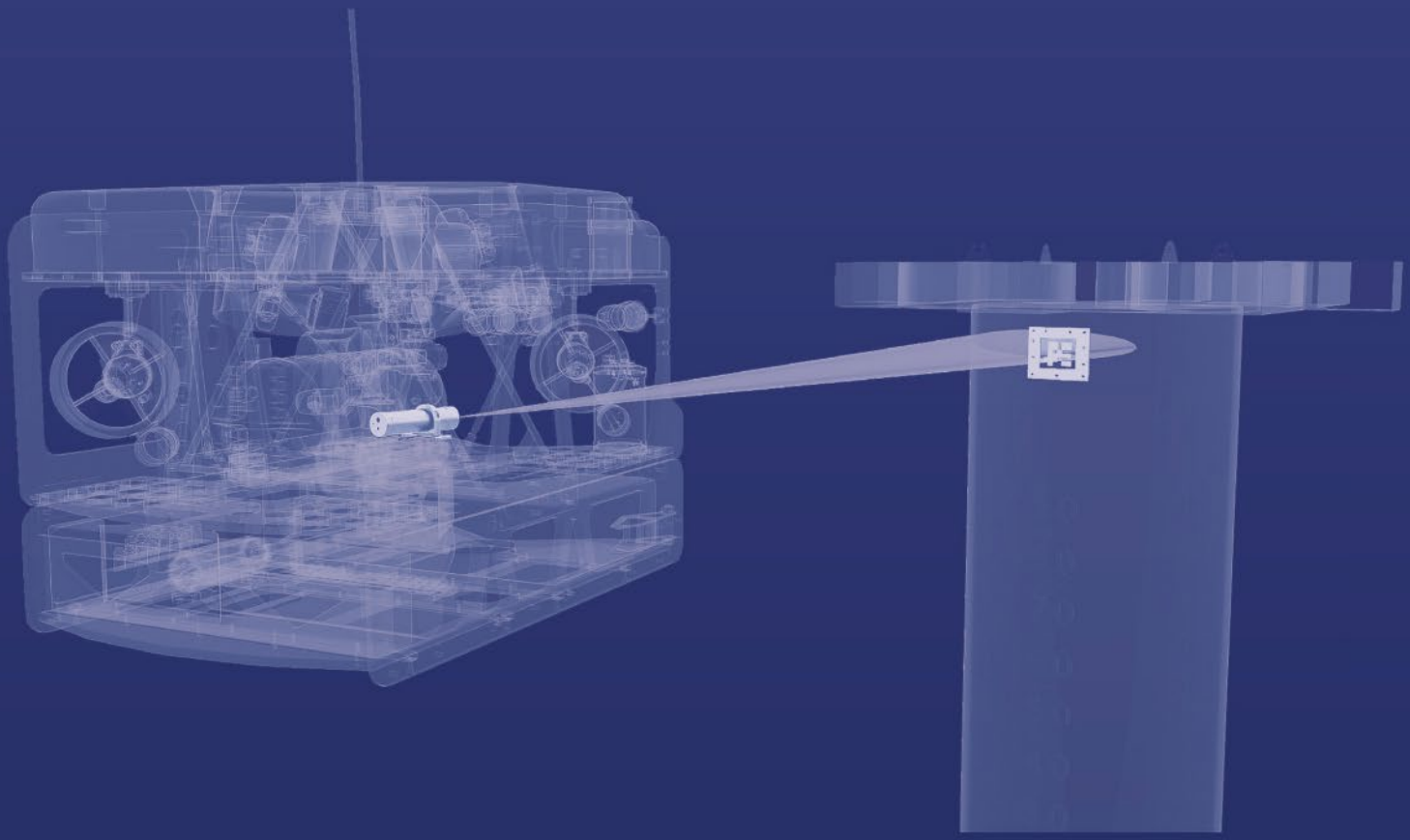

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FORSSEA ROBOTICS

QYSEA TECHNOLOGY

REDEFINING OCEAN ROBOTICS

Advancements in underwater robotics and technologies -through increasingly compact, capable, and autonomous systems- have led to a rapid boost in operating efficiencies, data-collecting methods, and working safety across the marine sectors. Since its founding in 2016, QYSEA Technology has become an industry leader in developing advanced compact inspection ROVs. Led by a core of talented and experienced engineers, AI developers, and field specialists, QYSEA leads to drive innovative and sustainable subsea solutions for professionals worldwide.

The FIFISH Underwater Robots -developed by QYSEA- is a series of compact professional ROV solutions designed for advanced small-scale operations and inspections. The FIFISH's self-developed vector thruster system achieves 360-degree freedom in underwater mobility for the operator, redefining industry standards of small robotics implemented for professional marine inspections, operations, and explorations. QYSEA's latest industry-grade models, the heavy-duty FIFISH PRO W6 (350m depth rated) and smaller-sized FIFISH PRO V6 PLUS (150m depth rated), combine a powerful motor system, tool integration platform, and intelligent adaptive functions that enhance the users' operating experience and capabilities.

FIFISH PRO W6 equipped with the 2D Imaging Sonar & Robotic Arm (Courtesy of QYSEA)

FIFISH PRO V6 PLUS equipped with the 3-Finger Robotic Arm (Courtesy of QYSEA)

Onshore Power Supply System (OPSS) compatible with all FIFISH Underwater Robots (Courtesy of QYSEA)

FIELD-LEADING TECHNOLOGIES & ADVANTAGES

QYSEA's key technological advantages are a result of its fluid and durable build, compact and powerful motor, multi-tool expansive platform, range of smart software algorithms, and advanced imaging system.

The FIFISH ROV's patented hydrodynamic and droplet-shaped design delivers minimal resistance to ocean currents, resulting in reduced power consumption and increased average dive times of up to 5 hours. In addition to its fluid design, the compact yet robust build provides a fully sealed and all-around protection against corrosion and sand particles.

The Q-Motor is a self-developed and double closed-loop induction motor system that achieves autonomous control, strong depth resistance with high stabilization, as well as improved energy efficiency. Rigorously tested to provide over 800 hours of reliable usage and operation, the six-motor system arrangement utilizes intelligent algorithms to actively adapt to its surroundings, delivering highly stable and smooth mobility for its ROV users. Combined with the ROV's light-weight aluminium propellers, the Q-Motor reaches speeds of up to 4 knots along with essential safety mechanisms to prevent overheating, short-circuits, and overcurrent.

QYSEA's patented Q-IF interface enables integration with a wide range of attachments that are specially developed to meet professional requirements across offshore operations, fish farming tasks, conservation missions, and deep-sea explorations. The integration system is achieved through the FIFISH ROV's accessory port, which unlocks access to over 60 add-on tools for inspections, measurements, object recoveries, quality samplings, navigation, and adaptive positioning. Further patented add-on systems have been developed to benefit FIFISH operators, including a portable power supply that achieves unlimited dive lengths, a live-streaming device for large-screen and multi-team collaborations, remote long-distance control using 5G networks, and much more.

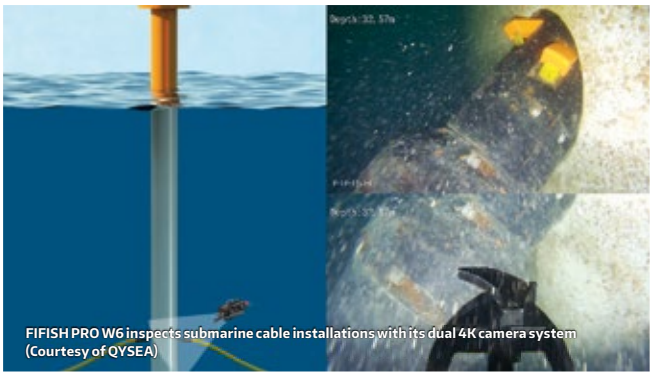
QYSEA applies a comprehensive and adaptive underwater communications system through artificial intelligence and big data analytics. From object collision avoidance to positioning locks, QYSEA's miniaturized and adaptive system aims to modernize underwater operations and intuitively understand the operator's requirements. QYSEA also aims to bring out the best of both worlds with traditional and modern solutions, by combining laser scaling and augmented reality, delivering optimal accuracy for underwater measurements of objects.

Optimized imaging is delivered through QYSEA's robust camera system and smart visual algorithms. Equipped with a single or dual 4K UHD camera at 30 FPS, along with a 166° field-of-view lens and ultra-bright LED lights of up to 12,000 lumens, the details, and colors of surrounding underwater environments are fully captured and realized. QYSEA's low-latency camera system and self-developed AI algorithms deliver vibrant imagery among turbid environments while removing all unwanted distortions, resulting in the most capable camera solution yet among small-sized ROVs.

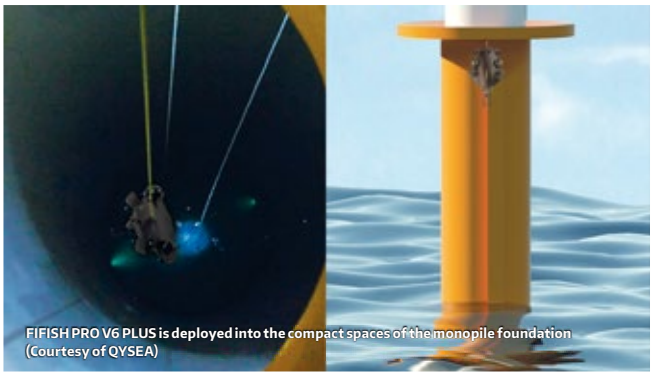
AN ESSENTIAL PARTNER IN SMALL-SCALE MARINE OPERATIONS

The combination of the FIFISH's compact size, rugged build, smart systems, expandable capabilities, and flexible movement provides an optimal solution for professionals operating in the offshore field. With complex and unpredictable hydrological conditions surrounding offshore working platforms, QYSEA's autonomous solution aims to minimize the human risks of traditional scuba diving methods and boost performance in the working field through a seamless operating experience with real-time feedback.

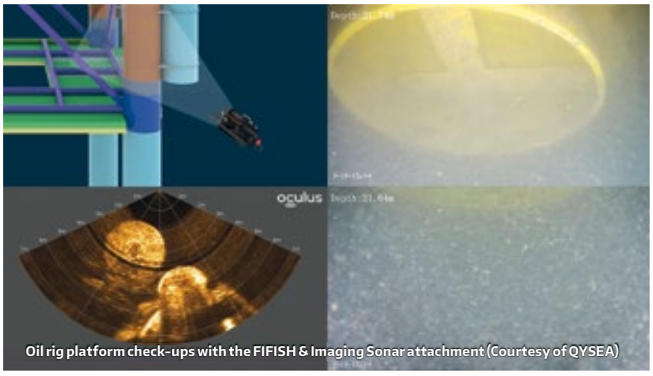
Pile foundations of offshore rigs can be frequently monitored and maintained through a simple and quick deployment of the FIFISH Underwater Robot. Examine the conditions of



FIFISH PRO W6 inspects submarine cable installations with its dual 4K camera system (Courtesy of QYSEA)



FIFISH PRO V6 PLUS is deployed into the compact spaces of the monopile foundation (Courtesy of QYSEA)



Oil rig platform check-ups with the FIFISH & Imaging Sonar attachment (Courtesy of QYSEA)

essential beams, buoys, and boards in dual 4K UHD clarity and at up to 12,000 lumen LED brightness. The FIFISH's all-directional mobility and powerful motor enable movement across strong currents and the ability to reach a depth of 30 meters in under 5 minutes. Users can achieve greater functionalities -essential to their offshore operations- by adding on a myriad of inspection, navigational, and measurement tools. The advanced imaging sonar attachment helps the operator effectively identify short-range and long-range objects in turbid conditions with dual-frequency capability. Utilizing the Station Lock Module attachment, operators gain an adaptive system allowing the FIFISH to remain in its locked position against currents and other underwater interferences with unparalleled accuracy and precision. The rugged and powerful capabilities of QYSEA's small-sized ROVs allow users to take on tasks typically performed with considerably larger vehicles.

As wind energy leads the way for renewable energy resources, offshore wind farms across the world's coastal regions are seeing increased importance, requiring high operating efficiency and frequent maintenance. The installation of essential submarine cable systems -responsible for transmitting power between the turbines and power stations- are as efficient as ever through the operational tandem of the FIFISH PRO W6 and FIFISH PRO V6 PLUS. Installing bend restrictors for the submarine cables requires the larger-sized W6 ROV to operate from the outside, using its powerful motors, adaptive stability system against currents, and a rugged robotic arm to work through currents and bring the tow rope through the entrance slot of the wind turbine's pile foundations. Within the working platform of the wind turbine, operators can release the V6 PLUS ROV down to the compact spaces of the monopile foundation, using its high-precision robotic claw to retrieve the tow rope from the and pull it back up to the platform. The restrictors and cables can then be inserted and installed through the tow rope, while the FIFISH ROVs continue to monitor the operation -from the inside and outside of the wind turbine- ensuring a smooth, seamless and successful installation.

A GREAT RANGE OF PROFESSIONAL APPLICATIONS

The FIFISH's small-size, robust operating system, and specialized tools provide operators with numerous working advantages across the marine industry, including aquaculture, shipping, underwater security, search and rescue, marine conservation, and much more.

FIFISH delivers a stable solution for fish farmers to monitor and assess their livestock. In addition to reducing operational costs and human risks, operators can utilize specialized tools -such as the Mort Remover tool to remove elements at risk of spreading diseases, or the Net Patch Kit to quickly repair damaged operating areas- to elevate the efficiency of their operations.

QYSEA's patented Underwater Quick Positioning System (U-QPS) provides operators with comprehensive real-time location tracking, three-dimensional dive path recordings, labeling of multiple points of interest (POI), and much more. Paired with the imaging sonar system, QYSEA delivers users an optimal solution for advanced underwater missions, ranging from defense and security to search and rescue.

AN ONGOING MISSION TOWARDS SUSTAINABILITY

Since its 2016 inception, QYSEA Technology's products and solutions have resonated strongly with professionals, industry specialists, and enthusiasts across the marine sector. QYSEA's core mission continues to be driving innovation within the marine industry -built on the foundations of vital research and operational feedback- in ways that best serve its new and long-standing users.

In a technological and fast-changing world, QYSEA aims to redefine the capabilities of compact ocean robotics, bringing the world into a new and exciting era of marine operations and nautical explorations.

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Nemo is designed for a depth rating of 4000 meters and a bottom track range of up to 75 meter. Near shore surface vessels, such as ASV's, uses the Nemo together with the input from a GPS to gain high end data and navigation accuracy.
The Nemo is also offered with integrated sensors for depth and sound velocity to further enhance the accuracy and ease setup and use.

"The RTS Nemo offers a high-performance INS solution for both survey work and ROV positioning" says Tor Arne Paulsen, Survey Technical Manager at DeepOcean.

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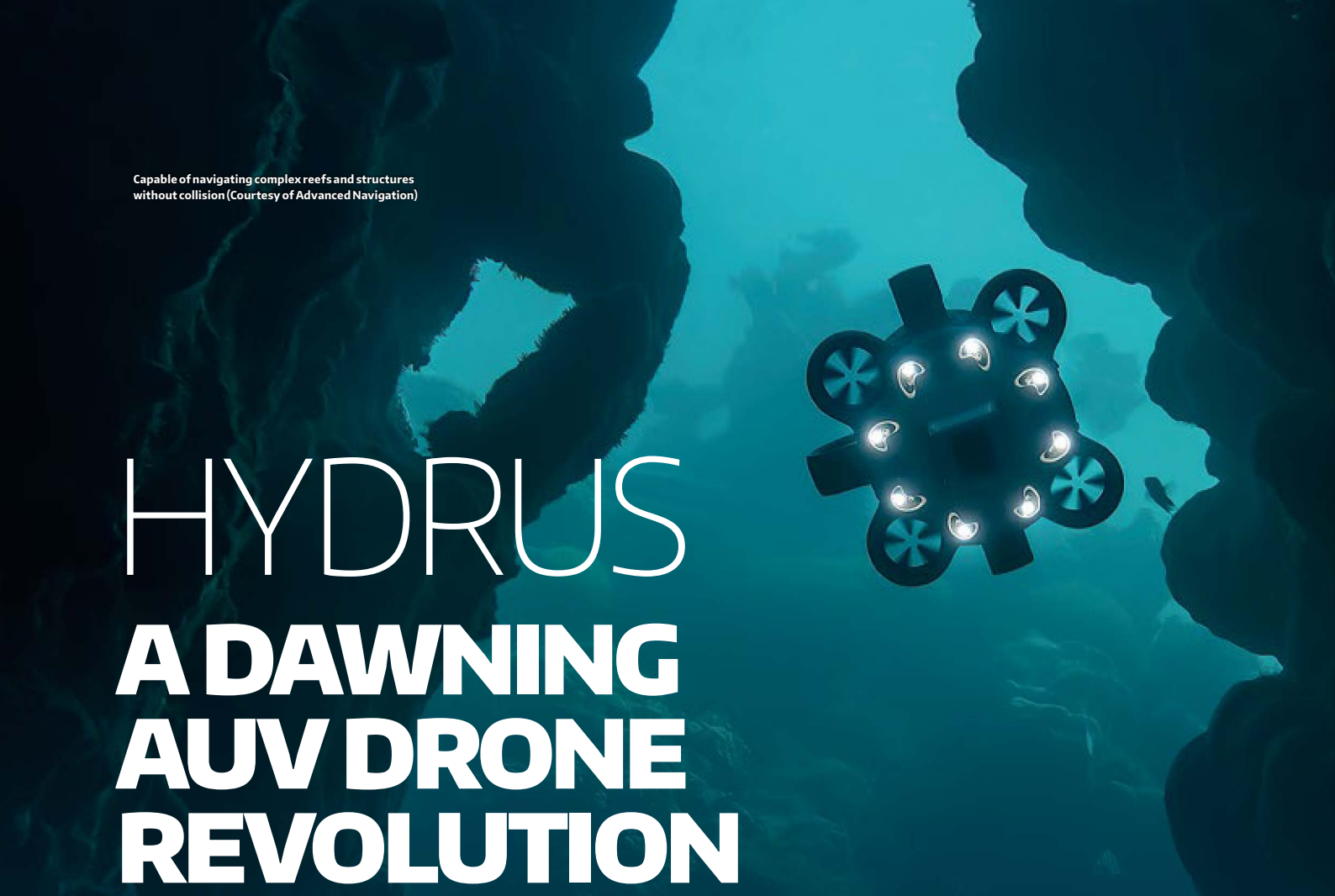


Capable of navigating complex reefs and structures without collision (Courtesy of Advanced Navigation)

HYDRUS

A DAWNING AUV DRONE REVOLUTION

Our current challenges regarding human activity, climate, and oceans are well known. The links between each are reinforced through continued research and investigation. It is understood that to instigate real change requires not only evidence, but a global, democratic drive to pursue sustainable environmental practices and to de-corporatize Earth's resources. It is evident that the mothership will not be able to miraculously right itself without drastic change in human interaction with the world.

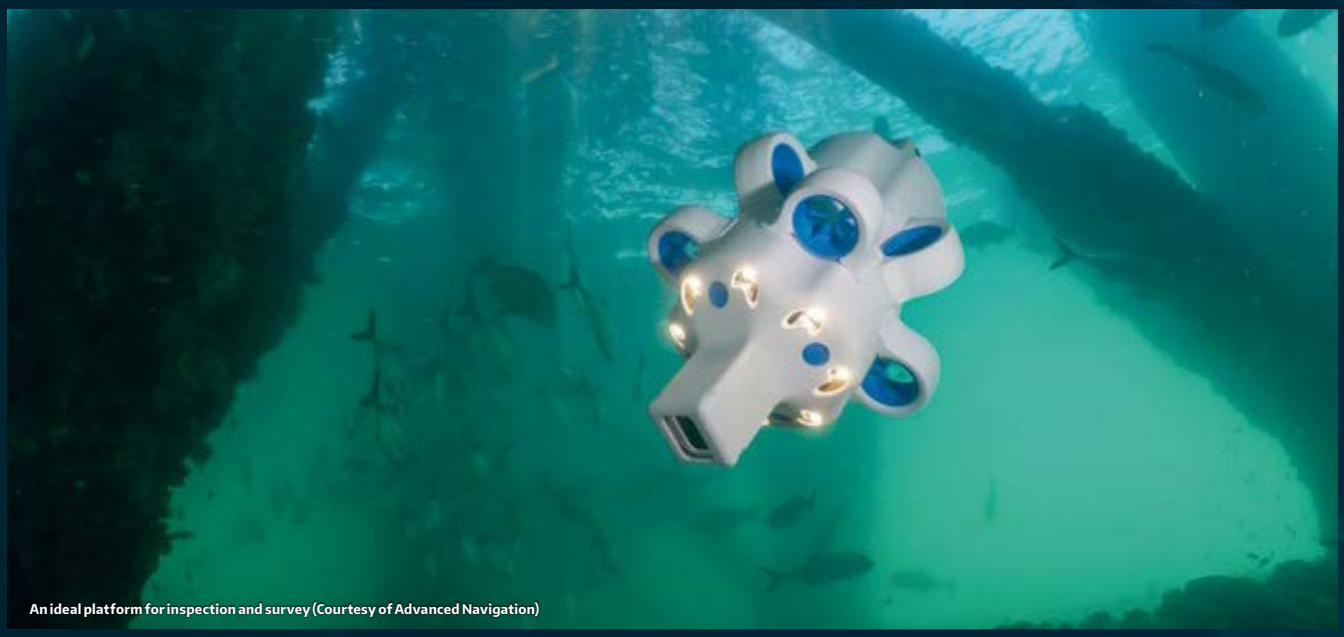
Oceans are key to the survival of planet Earth, and we require a far greater understanding of the interaction between oceans, climate, and humans to succeed in solving our problems. There are needs to reduce the cost, risks and complexity associated with subsea research, in order to open up access to the underwater world. Due to the hostility of marine environments, autonomous robotics will become increasingly influential.

In response to the need for easier, safer, and more affordable subsea robotics, Advanced Navigation leveraged its extensive experience in acoustic and inertial navigation systems and artificial intelligence to deliver a solution. With an understanding that to accelerate change, heighten ocean advocacy and engender the concept of blue economics, what is required are more eyes underwater to highlight issues and to demonstrate solutions and positive change. Advanced Navigation recognized a similar trend occurring in the aerial drone (UAV) market, where improvements in technology made this once specialized occupation a new business opportunity for many.

Hydrus is designed to make subsea data capture vastly more accessible through synthesizing complex navigation, motion control and image capture technologies, with mature artificial intelligence. The culmination of which is a solution that provides an unprecedented level of performance that is also portable, affordable, and does not require any user training. Xavier Orr, CEO and co-founder of Advanced Navigation puts the vision for Hydrus into context:

"We've seen a revolution take place in the aerial drone industry, 10-15 years ago, only qualified experts could fly drones. Today, drones are simple and reliable enough that anyone can use them – which is why we're seeing them in countless industries.

"Looking at underwater technology, we want the same thing to happen. At the moment, underwater vehicles require specialist knowledge and training to be used effectively. We've developed Hydrus to ensure professional grade underwater imagery and data is accessible to everyone, enabling greater opportunities across the ocean, whether it's inspecting offshore wind farms, capturing undersea cinematography or monitoring coral reefs."



An ideal platform for inspection and survey (Courtesy of Advanced Navigation)

WHAT HYDRUS DELIVERS

Hydrus provides data capture, surveying, and inspection to underwater tasks that benefit from high accuracy geo-referenced imagery. To maximize accessibility of the system to the broadest range of users, it is designed to be usable immediately, without requiring initial training or experience.

The system uses "missions" to set out way points for the surveying area or task. Missions are created via a point-and-click 3D map interface, where you can also simulate, refine, and replay them. Mission repeatability is as simple as reloading, then deploying the unit. Mission loading can be performed in and out of water.

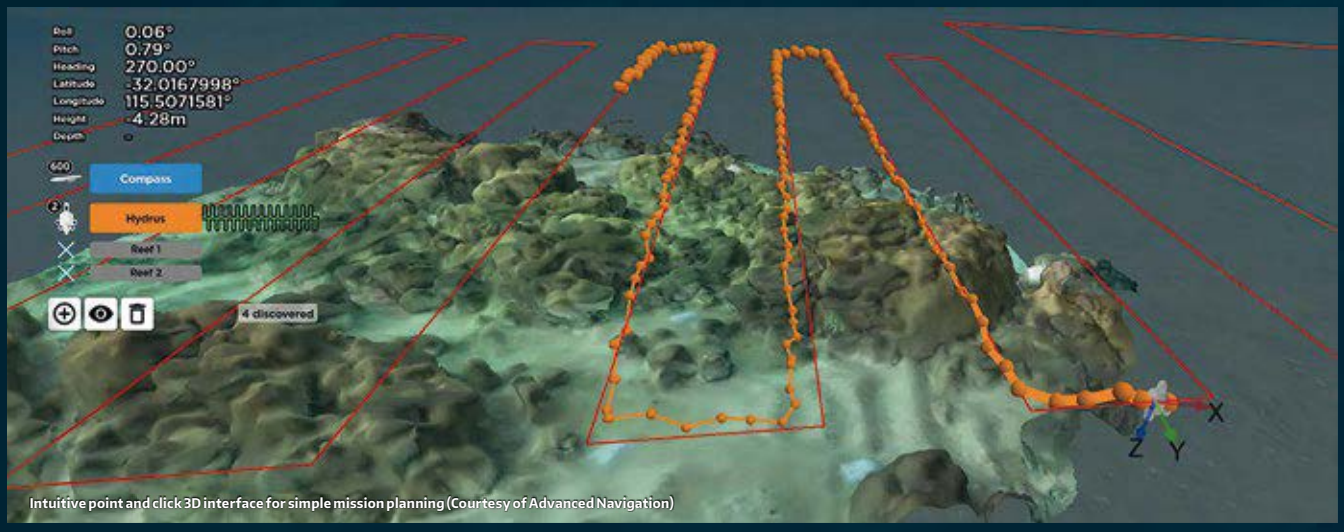
Hydrus is extremely compact and lightweight (6.7kg / 14.7lb), making it able to be launched and retrieved without special equipment or crew. Portability can be critical to getting the AUV to where it needs to be deployed, fast, so Hydrus is certified flight safe to standard UN38.3 and can be shipped by air or carried in baggage.

The onboard autonomous systems fuse the mission plan, inertial navigation system (INS) and obstacle avoidance systems. Once launched, Hydrus responds seamlessly to obstacles, turbidity, and currents to ensure consistent, high quality data capture. Upon mission completion, the unit docks automatically for wireless data upload and wireless, inductive battery charging.

Hydrus supports custom payload software by providing an open platform and substantial internal memory. Users can create, simulate, and test software modules before putting them into service. The platform provides access to various sub-systems, including camera, sensors, and navigational data. For example, machine vision software for classifying objects by shape, size and location via image and position data.

HYDRUS ANATOMY

To create Hydrus in alignment with its initial concept of drone-like performance and accessibility, Advanced Navigation employed in-house design and vertical integration manufacturing techniques. This has resulted in a



Intuitive point and click 3D interface for simple mission planning (Courtesy of Advanced Navigation)

compact, reliable, and cost-effective design that includes pressure tolerant, fully encapsulated electronics within a hull (3000m depth rating) that has no external bulkhead connectors and features smooth surfaces to minimize biofouling.

Most contemporary AUV technologies are trapped as straight-line travel devices, or are virtually tethered to pipes or cables etc. Hydrus breaks this mold through a synthesis of technologies that enable it to move like no other underwater vehicle. The motion systems are centered around an INS, DVL, USBL, and fine motion control impellers.

The INS is a MEMS-based system, operating at 1000Hz refresh rate, that uses Advanced Navigation's acclaimed artificial intelligence sensor processing and filtering. The AI/neural network approach has been refined since its conception in 2012 and represents a significant change in technology for not only filtering sensor input data for errors, but also being more capable than Kalman Filter technologies for error correction, estimation, and learning. The intelligent INS blends GNSS data when Hydrus is at the surface, with inertial measurement and data from the 2000Hz DVL to provide high accuracy position, bottom-tracking, and water-mass tracking data.

A camera still requires a diver or ROV pilot to compose the picture and take the shot. Hydrus is different... In the front vision module of the unit is a 4k 60fps camera with ground sapphire optics. Image capture is optimized using AI in real-time and is capable of rapid movement capture and enhanced machine vision capability. Images are immediately evaluated for quality – any image that does not meet requirements is re-taken before the vehicle moves ahead. The INS provides geo-referencing data for precise photogrammetry and image location information. Still image resolution is 12MP, with 4k video – both can be captured simultaneously. The vision module also houses an optical modem for high-speed data transfer whilst in water. WiFi communications can be used out of water.

There are four acoustic transducers in a Janus configuration on the front face that provide a 130° field of view for determining the physical surroundings and the distance between objects and the camera. These operate with short minimum range to allow very close tracking to objects that also improves acoustic mapping resolution. Using acoustic data, Hydrus positions itself to the ideal subject range and adjusts its variable luminescence LED lighting system to compensate for turbidity and ambient light, then captures image/video. The acoustic data is used for collision avoidance and the three-dimensional acoustic point cloud data of the seabed, terrain or objects can be used for creating 3D terrain mesh and imported into other popular mapping software. The forward DVL functionality maintains bottom-locked navigational and velocity accuracy.

Around the central hull are two orthogonally mounted impeller arrays that provide six degrees of freedom. The impeller control is coupled with the INS for navigation but also to detect and respond to current induced drift

Acoustic ranging is used to optimize focal length (Courtesy of Advanced Navigation)

The Hydrus hull is specifically designed to house multiple subsystems in the most space and performance efficient manner (Courtesy of Advanced Navigation)

Launch and retrieval are easily accomplished by one person (Courtesy of Advanced Navigation)

and movement. The hull is pre-set for buoyancy and inclination, so reducing the burden on impellers when correcting orientation. The impellers feature a in-house designed contactless circumferential drive that negates the need for axles and hubs to provide maximum resistance to interference and obstruction. The impellers are used in various combinations, speeds, and directions to maintain neutral stability even in several knot currents. For efficient high-speed travel to mission start point and dock post-mission, the unit travels horizontally.

The rear acoustic module has a USBL that can be used for navigational aid, with modem capability for status data correspondence up to 1000m distance between the Hydrus and a surface vessel. Both vision and acoustic modules have Qi inductive coils for wireless battery charging in or out of water. Hydrus can also provide power wirelessly to a payload carrier attached to the acoustic module. Water sampling data includes salinity, dissolved O_2, CO_2, temperature, and pressure.

Hardware is minimized to two PCBs – a motherboard at the front and a secondary PCB at the rear for acoustic communications and USBL. The motherboard features a single FPGA that allows multiple systems that have individual clocks to coexist and be separately synchronized to ensure that every item of data from each subsystem (INS, video, acoustic point clouds, etc.) is precise. The FPGA handles much of the signal processing to help reduce CPU burden and minimize power consumption. The main CPU is a 4-core 1.8GHz 8GB RAM unit with two cores running custom acceleration. A 1TB SSD provides data storage.

The in-house design and sophisticated subsystem fusion in Hydrus has led to reduced overall parts and full control over placement and material selection. This enables creating material boundaries and component separation to minimize internal noise and de-conflict the system electrically and digitally, all of which increase overall reliability.

MYRIAD USES

The versatility of the Hydrus system is immediately beneficial for shallow-mid depth survey and inspection, for example wrecks, bridge footings, pipe, and infrastructure. For large scale survey operations, such as offshore wind farms, Hydrus deployments will vastly improve the speed and efficiency of inspection campaigns.

More poignantly, researchers and environmental conservationists will be able to use Hydrus to assist in critical oceanographic and ecological research. Examples include inspection of coral reef canopies, regeneration, and biomass monitoring. Providing seagrass and kelp forest ground truthing as well as monitoring and studying the effects of wave and tidal movement on habitats and coastal regions are just some of the enormous range of practical applications. To quote a strategic partner in the Hydrus development program:

"Having technology like Hydrus is one way of supporting our marine researchers and scientists to access cutting-edge technology, which puts them at the forefront of tackling the greatest threats to our global ocean." said Dr Tony Worby, Director of Flourishing Oceans and the Planet Portfolio at Minderoo Foundation.

Hydrus is the drone revolution, underwater.

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A SUBSEA MARKET OPPORTUNITY

Will Rowley & Steven Barras, Offshore Solutions Group

Floating wind turbine installed 4 km offshore Agucadoura, Povoa de Varzim, Portugal in October 2011. This was the first floating offshore wind turbine installed in the Atlantic waters and was deployed without the use of any offshore heavy lift vessels. (Courtesy of iStock)

Floating offshore wind has seen a dramatic increase in pre-commercial activity over recent months. This has been characterized in large part by the successful award of up to 15GW of acreage capacity in the ScotWind lease sale, as well as recent, large-scale leasing activity in Korea and in the Celtic Sea, amongst other regions.

Most of the newly-leased acreage is slated for development within a common timeline, with initial power production projected for the 2030 – 2035 period. In addition, and as shown in Figure 1, many regions are planning additional lease sales which will further add to the volume of platforms required to be designed, built, and installed during this period and beyond; currently estimated to amount to over 6,000 units by 2035.

However, to emphasize the embryonic nature of the floating market: less than 0.1% of the identified global market of 125GW is operational today and only 20 scaled (half scale or larger) floating platforms are on location from the 6,500 currently in planning, globally.

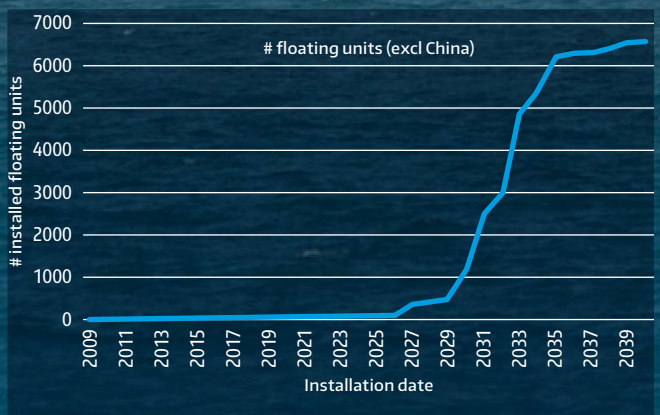

Figure 1: Number of current identified floating offshore wind units, operational and in all stages of planning. Data from Renewables Consulting Group (RCG); coverage is global as of 24th April 2022 (excluding China).

While the aggregated scale of projected platform supply, logistics, and installation is undoubtedly daunting, it is also important to recognize that the largest floating wind field developed to date has comprised only five commercial-scale floating platforms. Most commercial-scale developments under consideration today are expected to deploy between 50 and 250 platforms in a single field, with each platform requiring at least three mooring lines and three anchors or foundations.

The field-level planning, system-level design, and project execution planning required for this scale of field development has not yet been tested in the floating wind arena. While it is expected that the challenges associated with meeting the demand expectations will result in the actual number of deployed floating platforms following a significantly reduced trajectory than current estimates suggest, a number of large-scale projects will progress through to development over the next decade.

The successful development of these utility-scale projects will need to draw on experiences gained through similar scale projects in the fixed wind space, which offer important and directly relevant reference points for floating wind projects. One of the most significant experiences – and the focus of the remainder of this article – is in the area of geotechnical assessment and foundation selection and design (for the purpose of this article, "foundation" shall be taken to refer to the structural element embedded in the seabed, forming the anchor point for each mooring leg of the floating system).

Fixed wind experience has highlighted significant risk-benefit tradeoffs to be considered in the selection of the foundation type and the associated characterization of the seabed geotechnical parameters. There have been many instances of foundation failure, both during installation and operation, leading to costly and time-consuming re-evaluation, redesign, and re-installation, and resulting in significant consequences for both the contractors and developers. These failures can be broadly attributed to a combination of both a failure to adequately characterize the geotechnical conditions at each foundation location and a mismatch of foundation type to the geotechnical conditions.

Part of this issue arises from the desire to seek a "uniform" or "industrialized" platform solution to be applied over the full extent of a given lease area. While this is understandable from an economic and project execution perspective – and potentially achievable from the perspective of the floating platform itself – the nature of the offshore seabed topology and geology in many regions is such that this is often not achievable from the perspective of the foundations.

Unfortunately, full seabed characterization for a GW-scale development presents a significant challenge today in terms of cost, time, and – factoring in the concurrent developments – availability of assets (vessels and equipment). Coupled with the fact that this information is generally required to be gathered well before financial commitments are established, this means that a full characterization at each foundation location is considered prohibitive, and seabed characterization efforts are commonly subject to significant de-scoping to reduce cost.

In order to mitigate the consequences of non-homogeneous seabed conditions and limited seabed data, the current philosophy for self-stable floating platforms (non-TLPs) is to assume the use of drag-embedment anchors (DEAs). While this approach may go some way to offsetting the requirement for geotechnical characterization, DEAs introduce challenges of their own including but not limited to:

- DEAs require proof-loading, which is normally achieved using a high-capacity anchor handling tug (AHT).
- Installation method and proof loading requirements lead to the potential for under- or over-estimation of anchor displacement during installation, and/or failure to achieve the required proof load.
- Available AHT bollard pull may limit single mooring line capacity, potentially requiring additional mooring lines to be incorporated into the floating platform system design.
- Load reversal can lead to "failure" of the anchor foundation. This is particularly significant when considering "non-redundant" mooring systems, where failure of one line may result in the foundations of the remaining lines being subject to reversed loading, potentially leading to consequential failure of all foundations.
- DEAs cannot be used in areas with rocky seabed and may be limited in certain soil types.

These challenges can be addressed though the application of alternative, "conventional" foundation solutions, used in most permanent offshore facilities. However, these foundation types present additional requirements in terms of geotechnical characterization in terms of:

- A requirement for accurate geotechnical characterization at each foundation location to ensure installation and in-place capacity (cost-risk trade-off).
- Depth of required geotechnical data is dependent on type of foundation and geotechnical conditions encountered.

As such, the challenge is in finding the optimum balance of cost, schedule and risk in both the selection of foundation types and the characterization of the seabed geotechnics.

While efforts are underway to develop novel, lower cost foundation designs and site characterization technologies, the timeline of the current round of planned developments limits the opportunity for the de-risked deployment of these solutions, requiring a priority focus on innovation in the application of existing designs, technologies, and techniques.

An opportunity exists to develop an integrated, process-level approach to site characterization and foundation selection/design to optimize the cost-risk equation for the developer. At its core is the requirement to define a flexible, multi-phase, fit-for-purpose site characterization program to enable early-phase selection and design of foundations prior to embarking on a survey-informed, risk-weighted geotechnical testing and sampling program, aimed at establishing

Wind turbines assembled at Stord, Norway, under preparation to be sailed to the floating windmill farm, Hywind Scotland Pilot Park, near Peterhead, Scotland. (Courtesy of iStock)

soil profiles with a suitable degree of accuracy to enable final design of each foundation in line with the risk tolerance of the developer. Core to this approach is the requirement to optimize the application of high-cost, high-value data acquisition techniques based on initial survey results, initial foundation designs, and corresponding to the developers' investment profile.

This process can be designed so that it can be further enhanced by the implementation of lower cost foundation technologies and faster, lower-cost soil characterization techniques as they become available. It may also require different approaches to risk mitigation that balance data-led preparation with operational flexibility and optionality, such as a risk assessment of whether every location needs a borehole compared with carrying drills alongside hammers for installation.

In summary, while headline predictions appear to be over-optimistic, the floating offshore wind industry is nevertheless in the early phases of a dramatic increase in scale. Large-scale developments will progress over the next decade and will face significant technical, commercial, and risk-management challenges, requiring novel approaches to the development process, and drawing on the experiences of both the fixed wind and offshore oil and gas industries.

Each floating wind development will need to determine a field-specific approach to CAPEX and risk, starting with site characterization and foundation selection, which experience has shown represent a real and significant downside risk. Contractors and technology providers will need to work with the developers in determining a risk-optimized approach to balance the up-front cost, time and asset requirements associated with site characterization against the potential consequences of foundation failure and reinstatement. This will be best achieved using a process-driven approach which can be configured to first employ available technology, while enabling the implementation of new technologies as they become available and proven.

This is a "once in a generation" opportunity for a new approach to be applied, at scale, into an emerging market. Foundation risk may be hidden to many, but it's real to those contractors currently in expensive litigation over foundation failures. For solutions providers, the market currently has willing buyers and a clear opportunity.

ABOUT OFFSHORE SOLUTIONS GROUP

Formed in 2020, OSG is dedicated to enabling the practical delivery of commercial scale floating wind developments through the application of specialist technical expertise and extensive floating development experience.

We support Developers by delivering proven solutions alongside new technologies to de-risk projects, schedules, and costs. Starting at strategic planning and working through to operational delivery, OSG is a key partner to ensure the successful delivery of floating wind technologies.

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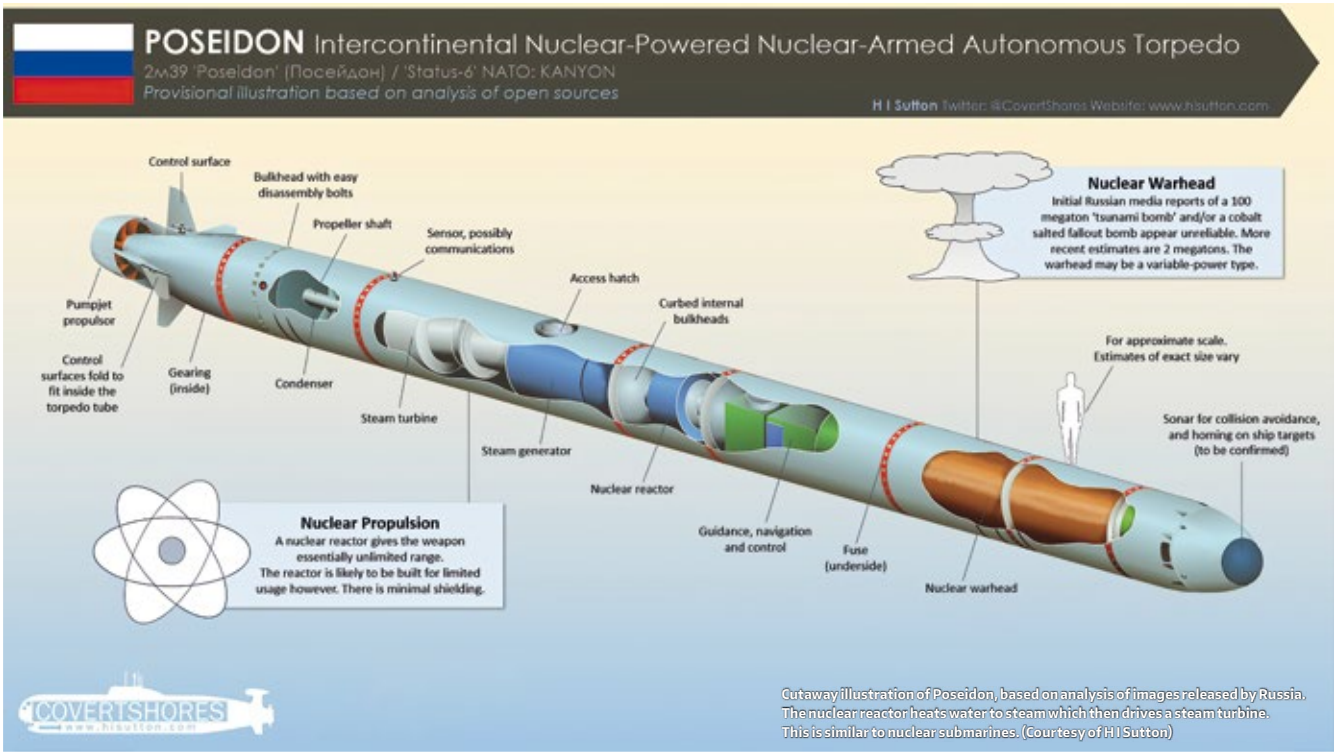

RUSSIA'S NEW 'POSEIDON' SUPER-WEAPON

WHAT YOU NEED TO KNOW

H I Sutton, OSINT Analyst, Covert Shores

Russia has raised tensions further by placing its nuclear forces on higher alert, termed "special regime of combat duty". We take a closer look at one of its most controversial weapons. Among a myriad of new and impressive 'super weapons', Poseidon stands out.

As Russia ratchets up the nuclear threat over the past few days, following their invasion of Ukraine, one of the weapons on people's minds is Poseidon. This nuclear 'mega torpedo' is unique in the history of the world.

Despite speculation, we do not believe that Poseidon has been deployed. The system is not yet ready. But it does raise concerns for nuclear stability in the near future. It changes the shape of nuclear deterrence and will become one of Russia's most feared weapons.

Poseidon is an 'Intercontinental Nuclear-Powered Nuclear-Armed Autonomous Torpedo'. It is a giant torpedo which can hit coastal cities with devastating results. Compared to an intercontinental ballistic missile it is very slow, but possibly unstoppable.

Russia maintains that it can also be used as a tactical nuclear weapon against warships. High-value targets would include aircraft carriers. This is harder to rationalize than the second-strike nuclear deterrence role, but it is a constant theme. Ever since it was first revealed in November 2015, then known as Status-6. it has been described as a multirole system.

The weapon's expected speed, around 70 knots, is fast enough to make it realistically uncatchable to existing torpedoes. And its operating depths, perhaps as deep as 1,000 meters (3,300 feet) puts it beyond reach. Western planners will have to develop new weapons to intercept it. And that will take considerable time and investment.

A nuclear reactor gives the weapon essentially unlimited range. This gives it new levels of operational flexibility in terms of launch and target locations. Although it is restricted to at-sea or coastal targets, such as New York, Los Angeles. It can be launched from under the protection of the ice cap, or from coastal waters.

In reality the reactor is likely to be built for limited usage, however. It does not appear that it is intended for sustained use, which will shape the way it can be used. This fits with it being a weapon, shot in anger. rather than a prototypical underwater drone.

Although the weapon is large, we estimate in the region of 100 tons, it is still small by nuclear submarine standards. It uses direct drive from the steam turbine, via gearing, to the pumpjet. The small diameter does not appear to allow for any significant quietening so the craft will not be particularly stealthy. Additionally, there is minimal shielding so it may leave a trail of radiopacity. This could be a factor in tracking it, especially during trails.

The shielding also raises the that the reactor would not be run while the weapon is aboard the submarine. This would require additional shielding to protect the crew.

MYTHS AND MISCONCEPTIONS ABOUT POSEIDON

Perhaps because so little is known about the weapon there has been a lot of speculation. And because it is a completely new category of weapon there is no previous system to borrow interpretations from. This contributes to popular misconceptions. However, we have been following development since before 2015 and have narrowed down many aspects.

The system is not a direct development of the unbuilt T-15 megatorpedo from the 1950s. That was a weapon some Russian planners expected to be carried by submarines to attack ports. It had a nuclear warhead but regular propulsion, meaning that it was quite short ranged. Which similar in scale and armament, the two are separated by both years and doctrine.

Poseidon is a weapon. Although its incredible range requires autonomy, it is not a drone in the same sense as other uncrewed underwater vehicles. There are no signs of buoyancy control or surveillance systems, so it is not an intelligence asset.

Another myth is that it is supercavitating, like the famous VA-111 Shkval torpedo. This would allow it to travel extremely fast, at over 100 knots. Supercavitation works by creating bubbles at the nose and then riding inside the bubble created to reduce friction. These weapons require rocket propulsion and extra-large control surfaces which must be outside the bubble. Poseidon has none of this.

And it is designed to be carried by a submarine in a sealed tube. These submarines are incredibly expensive and are a massive investment for the Russian Navy. This suggests that it is not designed to be forward deployed as a mine, waiting to detonate in an enemy port.

Initial Russian media reports of a 100 megaton 'tsunami bomb' and/or a cobalt salted fallout bomb appear unreliable. More recent estimates are 2 megatons. The warhead may be a variable-power type.

POSEIDON'S DAY WILL COME

Poseidon is a completely new category of weapon. It will reshape naval planning in both Russia and the West, leading to new requirements and new counter-weapons. A weapon which cannot be nullified with anti-missile defenses. In future nuclear tensions, if we live through this one, it will be a strong factor.

But we are not there yet. As of today, none of the submarines to carry it are operational. One test submarine, Sarov which can carry a single round, is in service. Another boat, Belgorod, is not yet commissioned. It could be speculated that Russia could attempt a launch if desperate enough. But it is currently nowhere near the threat level of traditional submarine launched missiles.

Poseidon's day will come.

ABOUT H I SUTTON

Courtesy of H I Sutton

H I Sutton writes about the secretive and under-reported submarines, seeking out unusual and interesting vessels and technologies involved in fighting beneath the waves. Submarines, capabilities, naval special forces underwater vehicles and the changing world of underwater warfare and seabed warfare. To do this he combines the latest Open-Source Intelligence (OSINT) with the traditional art and science of defense analysis. He occasionally writes non-fiction books on these topics and draws analysis-based illustrations to bring the subject to life. In addition, H I Sutton is a naval history buff and data geek. His personal website about these topics is Covert Shores (www.hisutton.com)

U.S. MARINE CORPS EXPLORES USING UNMANNED SURFACE VEHICLES TO ENHANCE LOGISTICS SUPPORT FOR EXPEDITIONARY FORCES

George Galdorisi, Director of Strategic Assessments and Technical Futures at the U.S. Navy's Command and Control Center of Excellence

PERSPECTIVE

If my three tours in the U.S. Navy's amphibious forces – where I worked closely with embarked U.S. Marines in a large number of amphibious exercises – taught me anything, it is that while many functions are important in an amphibious assault, once the assault is underway and troops are on the beach, logistics is the critical factor in ensuring their success. U.S. Marines in the fight use enormous quantities of ammunition, fuel, food, and other material as they attempt to move off the beachhead and inland.

The importance of logistics goes back as far as recorded warfare. Over 2,500 years ago, Sun Tzu noted: "The line between disorder and order lies in logistics." Two hundred years later, Alexander the Great put it this way: "My logisticians are a humorless lot…they know if my campaign fails, they are the first ones I will slay." In the maritime domain, Captain Alfred Thayer Mahan said: "Logistics are as vital to military success as daily food is to daily work."

In the two decades after the September 11, 2001 attacks, the U.S. Marine Corps has been heavily engaged in Iraq and Afghanistan and not often embarked in the Navy's amphibious ships. Today, the Marines are back to sea and working with their Navy partners to ensure that the nation's amphibious assault forces are, in the words of the Commandant of the Marine Corps, General David Berger: "Prepared for large-scale amphibious operations."

A NEW EMPHASIS OF SHIP-TO-SHORE LOGISTICS

As the Marine Corps pivots from land wars to assaults from the sea, their logistics needs are changing dramatically. Now, the emphasis is on how to assault a heavily defended beach – and just as importantly – how to sustain Marines on the beachhead as they attempt to push inland. The mission will ultimately fail if the Marines are not able to have reliable and continuous sustainment in order to press the fight off the beaches and toward the objective area.

Here is how two researchers at a major think tank described the challenge of conducting any amphibious assault in the third decade of the 21st Century:

Amphibious assaults in the face of sophisticated anti-access/area denial (A2AD) capabilities threaten strategic reach and operational freedom of maneuver. The prospect of assaulting a hostile shore today is more daunting than ever. The capacity of Marines to push inland must depend on the security of their logistical support.

Devil Ray T38 (Courtesy of Jack Rowley)

Devil Ray T38 at sixty knots (Courtesy of Jack Rowley)

Devil Ray T38 (Courtesy of Jack Rowley)

While many naval professionals do acknowledge the importance of logistics, this vital function often gets shunted aside as a priority. Here is how one U.S. naval officer put it in the pages of the U.S. Naval Institute Proceedings in an article entitled "Improve Combat Logistics":

Warfare is often viewed through the lens of iconic objects, such as a field of men wearing blue and gray uniforms, the M-4 Sherman tank, and the nuclear-powered aircraft carrier. What those images ignore are the forces that provide combat logistics—the sinews that link the resources to the warfighter.

Senior Marine Corps officers are emphasizing the importance of logistics to sustain effective expeditionary operations. The Commanding General of the First Marine Expeditionary Force, Lieutenant General George W. Smith, Jr., put it this way: "We are not putting enough emphasis on logistics...We can't win without sustainment...The challenge for the Marine Corps is the last logistical mile."

Other Marine Corps officers have emphasized the importance of seeking technology solutions for the Services' needs, especially in the logistics arena, with the Commanding General, Marine Corps Combat Development Command, Lieutenant General Karsten Heckl, stating: "We need to get unmanned platforms into operators' hands."

AN EMERGING LOGISTICS SOLUTION USING UNMANNED SURFACE VEHICLES

Recognizing their need to find an innovative solution to substantial logistics challenges encountered during an amphibious assault, the Navy and Marine Corps have been proactive in leveraging emerging technology – often commercial-off-the-shelf (COTS) technologies – in exercises, experiments, and demonstrations in order to explore potential logistics alternatives.

One U.S Navy-Marine Corps exercise, Joint Exercise Valiant Shield, overseen by Commander Marine Forces Pacific (MARFORPAC), and conducted on the Marianas Island Range Complex as well as on the island of Guam, focused specifically on the logistics function, something of critical importance to Marine Corps warfighters. Valiant Shield demonstrated the ability of COTS technologies – in this case, unmanned surface vehicles – to perform the vital logistics function.

The expeditionary force commander used a catamaran-style hull 12-foot MANTAS USV to provide rapid ship-to-shore logistics resupply. While this small, autonomously operated, USV carried only one hundred and twenty pounds of cargo, the proof-of-concept worked and successfully demonstrated that unmanned surface vehicles could safely and effectively resupply troops ashore.

Side View of the Devil Ray T38 (Courtesy of Jack Rowley)

Using unmanned vehicles could be a game-changer for expeditionary assault forces. Beyond taking operators out of harm's way, using USVs for this task frees manned craft for other missions. Having a continuous, preprogrammed, logistics resupply process to perform one of the "dull, dirty and dangerous" functions important in an amphibious assault gives the commander one less thing to worry about in the chaotic environment of an amphibious operation.

FROM EXPERIMENT TO ACTUALIZATION

While Joint Exercise Valiant Shield validated the concept of using COTS USVs to resupply Marines on the beach, delivering supplies in 120-pound increments is not a game changer. For this reason, the Navy and Marine Corps are now exploring the viability of using larger COTS USVs to provide logistics support to Marines on the beach.

For this reason, the maker of the MANTAS family of USVs (Maritime Tactical Systems, Inc.) has been challenged by the Navy and Marine Corps to "scale-up" the 12-foot MANTAS USV and develop larger proof-of-concept unmanned surface vehicles for this mission. Larger MARTAC unmanned surface vehicles, ranging from 24-foot to 50-foot long, have been designed and are now being fielded in a number of Navy and Marine Corps exercises, experiments and demonstrations.

Every amphibious ship I served on was stuffed to the gills with necessary gear for the Marines. But those mountains of equipment are no use to Marines if they are not delivered to the beach quickly, continuously, and reliably. That is difficult to do if every supply mission from ship-to-shore causes the amphibious assault commander to worry about putting humans in harm's way.

The basic specifications of the "Expeditionary Class" USV provide an indication of the ability of these craft to deliver a steady, continuous stream of logistics support to Marines on the beach. The T38 Devil Ray travels at cruise speed of 25 knots and has the ability to carry a payload up to 4,500 pounds. The larger T50 Devil Ray travels at cruise speed of 25 knots and can carry a payload of 10,000 pounds.

THE FUTURE OF EXPEDITIONARY LOGISTICS SUPPORT

As a former operator who is intrigued with new technology, I did some back-of-the-envelope math to understand what an expeditionary strike group equipped with a number of T38s and T50s could do to resupply troops on the beach. Having observed any number of amphibious exercises during my time in uniform, I am mindful that an amphibious formation typically stands no more than 15-25 nautical miles off the beach being assaulted.

Using a notional stand-off distance of 20 nautical miles, an amphibious formation equipped with four T38s traveling at their cruise speed of 25 knots could deliver 18,000 pounds of material from the ships to the beach per hour. Multiply that by twenty-four hours and you get a buildup of well-over 400,000 pounds of vital material per day, enough to support a substantial force of troops ashore. Using four T50s in a similar manner, the amount of material delivered approaches one million pounds a day.

The Navy and Marine Corps are planning an ambitious schedule of exercises, experiments, and demonstrations in the years ahead. Based on the promising performance of small, unmanned surface vehicles in exercises designed to demonstrate how USVs can support expeditionary assault forces, the Navy and Marine Corps would be well-served to experiment further with larger USVs to perform this vital logistics sustainment mission.

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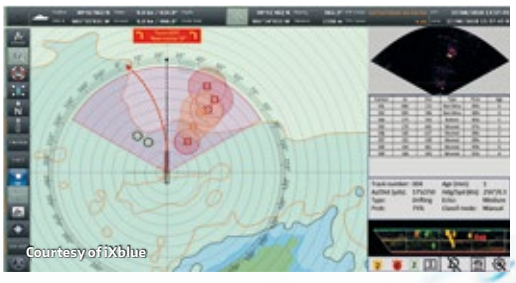
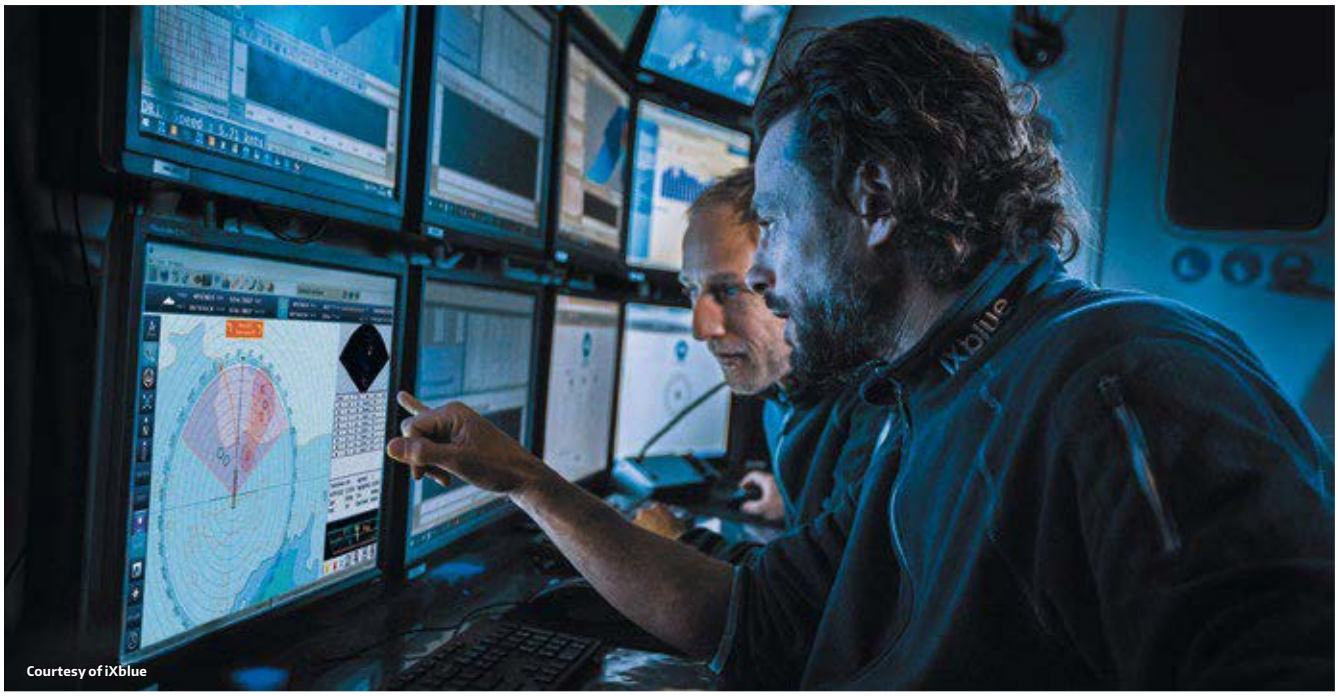
"Leveraging iXblue's expertise in navigation and subsea imaging, this new FLS technology offers highly reliable long-range detection (up to 600 meters for a -15 dB target), ensuring safety of navigation for surface vessels and submarines." explains Julien Guichard, Defense Program Manager at the Sonar division. "Thanks to its innovative electronically steerable Mils Cross antennas, SeapiX-FLS Series provides unrivaled coverage of the entire water column, from surface to sea bottom. Each detection is then mapped in real-time within the surrounding environment, and autonomously provided to external systems, or displayed in 2D/3D within iXblue's operator oriented MMI. This system can also centralize and simultaneously display information gathered by multiple SeapiX-FLS. This is a particularly interesting feature for REA missions for instance, as naval forces will be able to send in a fleet of unmanned vessels to conduct the mission with more flexibility and safety. Another key feature of the SeapiX-FLS Series is the ability to generate a real-time obstacle detection probability map. This information is

SeapiX-FLS 7 Forward Looking Sonar for mine and obstacle avoidance (Courtesy of iXblue)

SeapiX-FLS 5 Forward Looking Sonar for obstacle avoidance, water column and seabed awareness (Courtesy of iXblue)





Courtesy of iXblue

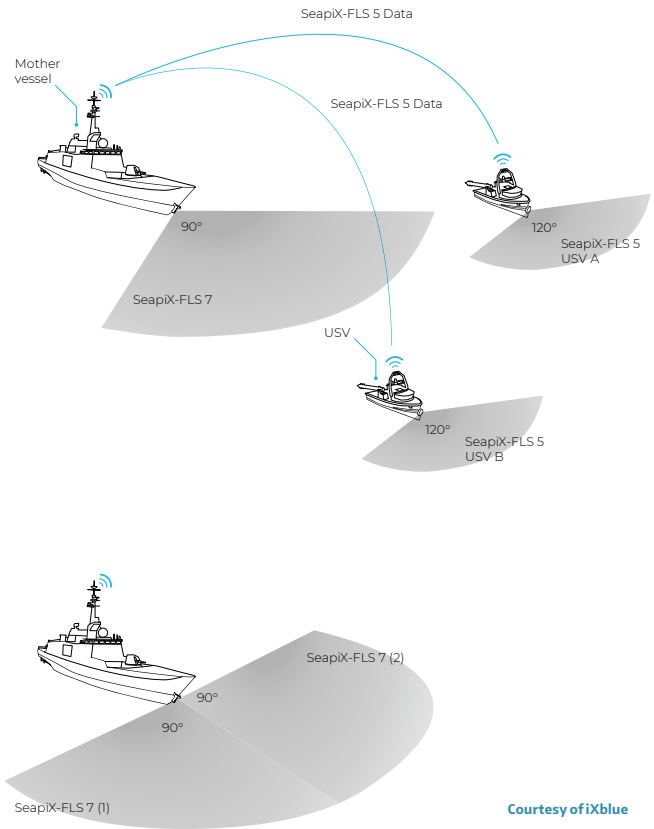
OBJECT TYPE	SEAPIX-FLS 5 DETECTION PERFORMANCE	SEAPIX-FLS 7 DETECTION PERFORMANCE
Water Column Object (-15dB)	>300m	>600m
Drifting Object (-15dB)	>300m	>450m
Bottom Object (-15dB)	>200m	>350m
Water Column Low TS Object (-25dB)	>250m	>520m

crucial for crew decision making, allowing them to adapt their speed according to their underwater environment, and thus navigate with more safety both for the crew and the platform."

Available in two versions, the SeapiX-FLS Series is perfectly suited for all types of carriers and covers a wide range of tasks. SeapiX-FLS 5, offering a range of 300m, is perfectly suited for USVs (Unmanned Surface Vessels) and other small auxiliary carriers. SeapiX-FLS 7, with a range of up to 600m, will be dedicated to surface vessels and submarines. SeapiX-FLS can also be installed on fixed platforms (buoys, tripods on the seabed, etc.) for port and subsea infrastructure surveillance missions.

SeapiX-FLS 7 will equip future Belgian and Dutch Mine Countermeasures Vessels. Indeed, on top of iXblue inertial navigation systems, Belgium Naval & Robotics (consortium between Naval Group and ECA Group) selected iXblue's forward looking sonar to provide a precise and real-time detection of mines.

"All in all, our SeapiX-FLS Series truly brings superiority to naval forces as it provides crews with an intelligible representation of their full surrounding environment, which in turns helps them make informed decisions in a reduced timeframe." Continues Julien Guichard. "This is a real asset to conduct more efficient and safer operations, keeping both humans and strategic vessels out of harm's way."



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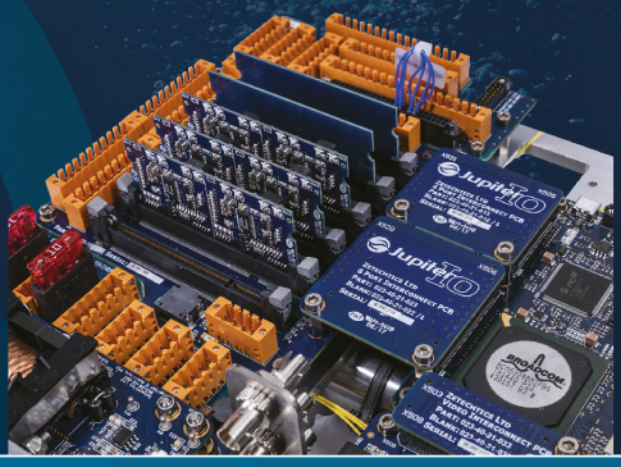

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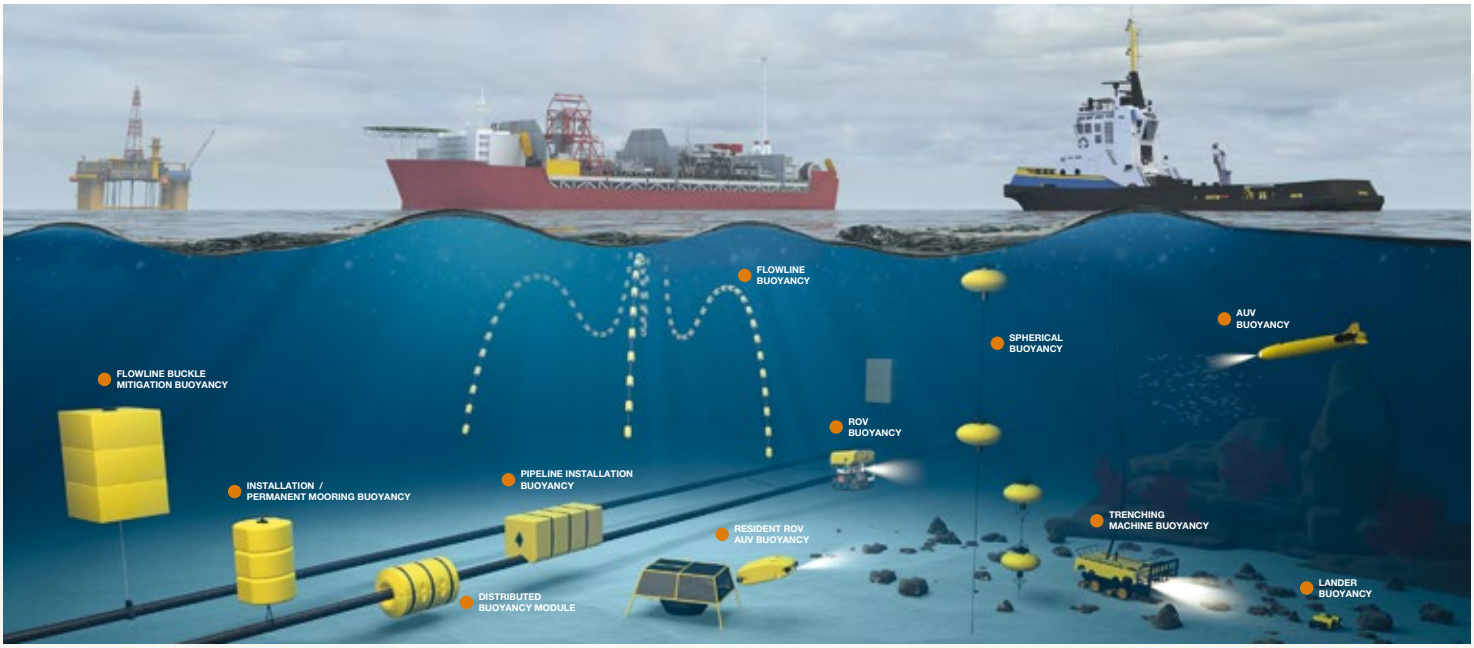

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Courtesy of Victor Vescovo / Caladan Oceanic

THE LIMITING FACTOR

JOURNEY TO THE BOTTOM OF THE OCEAN

Richie Enzmann, Ocean Robotics Planet

In the early hours of the evening on a regular weekday there was an unusual gathering of like-minded people at the Royal Institution in central London. They all had an interest in ocean exploration and were eagerly listening to a talk presented by three extraordinary gentlemen. These gentlemen, who are pioneers of our industry, were Victor Vescovo, Patrick Lahey, and Don Walsh. The Royal Institution, a place of historical discoveries and scientific announcements, provided the ideal setting to talk about their accomplishments.

The achievements of Lt. Don Walsh and Jacques Piccard have been well documented over the years. In 1960, the pair were the first men in history to descend to the very bottom of the ocean, to the Mariana Trench, and then safely come back to the surface.

Sixty years later Texan entrepreneur and retired naval officer Victor Vescovo came up with an even more daring idea to dive down to the bottom of all five oceans in our planet, after climbing the highest mountains on all continents. In this challenging task he was aided by Patrick Lahey, President and CEO of Triton Submarines. He provided Victor with all the necessary tools and technology to succeed in his world-first mission, and thus the Triton 36000/2 "Limiting Factor" was born.

The Limiting Factor is a two-man vessel that is capable of diving to full ocean depth. It is the world's first and only manned submersible that is commercially certified (DNV-GL) for dives to 11,000 m / 36,000 ft.

(Courtesy of Five Deeps Mariana Trench© / Reeve Jolliffe©)

THE TECHNOLOGICAL CHALLENGE

The challenge posed to the deep-diving experts at Triton Submarines was to develop a vehicle that would enable repeatable journeys to the ocean's deepest point. Neither of the two previous submersibles to reach full ocean depth made the journey more than once.

Unlike a typical Triton submersible where the predominant trajectory is forward, the Limiting Factor's movements are primarily descent and ascent. As such, its configuration has been optimised to travel vertically through the water-column.

Despite the departure from their iconic horizontally efficient sphere-and-pontoon arrangement, Triton's design team were keen to adhere to the design values that have made Triton the most popular choice between scientists, researchers, explorers, and filmmakers.

KEY FEATURES

Weld-Free Titanium Pressure Hull

The defining feature of the Limiting Factor is the 90mm thick pressure hull. Having been machined to within 99.933% of true spherical form, it is testament to the precision engineering that made this DNV-GL certified, reusable, full ocean depth submersible possible.

All-Day Dives

The Limiting Factor has been designed for practical and professional applications. Dives of more than 16 hours are made possible by the large 65kWh battery, hydrodynamically-efficient design, comfortable interior, and life support provisions. For scientists, filmmakers, and explorers, it maximises the time available to carry out multiple tasks per dive, and at full ocean depth.

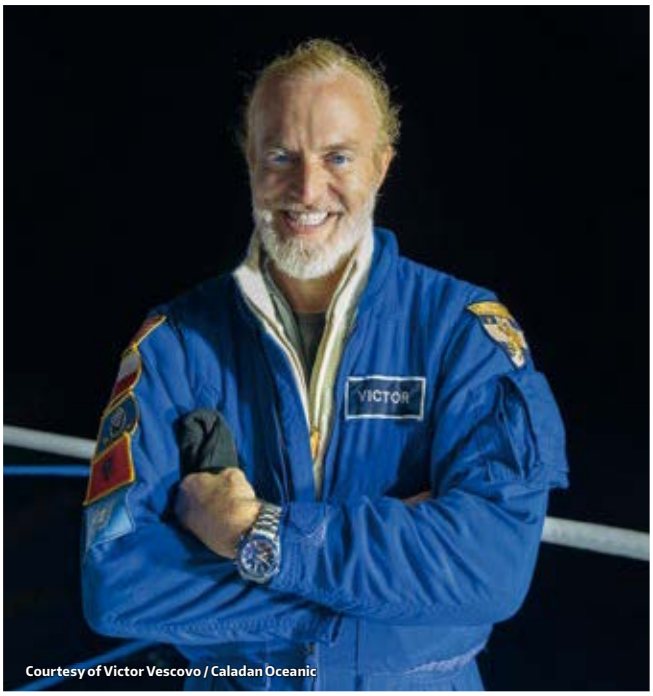
Courtesy of Victor Vescovo / Caladan Oceanic

Complete Situational Awareness

A hallmark of every Triton is the unparalleled view afforded to the pilot and passengers. Three optically perfect viewports provide occupants an uncompromised downward and forward view through the titanium pressure hull. Low-light cameras surround the Limiting Factor, augmenting the eyes-on view for complete situational awareness in the darkness of the Hadal Zone. A high-definition (4K) digital camera was tested and used on expeditions beginning in early 2019 to support the expedition's film partners.

A Platform for Professionals

As a platform for filmmakers, scientists, and explorers, the Limiting Factor offers virtually limitless possibilities. The LF was designed to perform a variety of mission types. It is equipped with multiple high-definition cameras and one 4K camera, a high-performance lighting rig, an array of scientific sampling equipment, and a highly dextrous multi-axis manipulator arm. And with no part of the ocean off-limits, its capabilities are simply unmatched.



Courtesy of Victor Vescovo / Caladan Oceanic

Simplicity Of Operation

The Limiting Factor has been designed for simplicity. The design of the onboard systems, the layout of the pilot controls, the handling arrangements on the surface and, of course, piloting the vehicle, have all been refined to minimise complexity.

THE DESIGN

Pilot situational awareness, which is fundamental to Triton's design philosophy, has been maximised. All systems external to the pressure hull are mounted to the sides and top of the hull, affording the pilot only minimally obstructed downward and completely unobstructed forward sightlines through three acrylic viewports. External fixtures are mounted outside of the pilot's eye-line, while high-output LEDs offer great illumination at depth. The view is augmented by an array of FOD-capable, low-light cameras.

The interior of the Limiting Factor is a study in comfort, utility, and ergonomics. Pilot controls are quickly identifiable and easy to operate. Leather padded seats and multiple seating ensure comfortable 12-14-hour dives in a temperature-controlled interior.

Designed specifically for lengthy expeditions in remote areas, the Limiting Factor's essential systems are designed with simplicity and reliability foremost of mind. Maintenance can be carried out at sea using standard tooling, while some more elaborate repairs can be carried out by a skilled ships' crew, if required.

SAFETY

Uniform across the entirety of Triton's fleet is third-party confirmation to the integrity of the design and build by a recognised international Classification Society. For Triton, the Limiting Factor could be no exception; although the process

(Courtesy of Five Deeps Mariana Trench© / Reeve Jolliffe©)

is expensive, arduous, and time-consuming, it is the best guarantee that a submersible has been developed thoughtfully, carefully, and with engineering rigour.

Commercial certification also represents the gold standard for vessel safety. It allows the sub to be insured by standard maritime agents and should give peace of mind to any sub passengers that they will be as safe in their dives as on any other commercially rated vessel.

On completion of the fifth and final deep dive, DNV-GL will certify the Limiting Factor for repeatable dives to full ocean depth.

The Limiting Factor features multiple, fully redundant methods of returning to the surface. While the primary methods do not require any electrical power, some others do. This accounts for emergency ascent conditions in every possible submarine power state. It should be noted that the sub has twelve separate batteries, and in the event that no electrical power is available, the main ballast weights are designed to release automatically for immediate emergency ascent.

INTRODUCING THE PRESSURE DROP

DSSV Pressure Drop was built in 1985 in Tacoma, Washington. At 68.3 m / 224 ft in length, with accommodation for up to 47 persons, and with a 12-ton A-Frame fitted astern, she is the ideal platform from which to conduct scientific and research projects using a manned submersible.

Courtesy of Victor Vescovo / Caladan Oceanic

(Courtesy of Five Deeps Mariana Trench© / Reeve Jolliffe©)

(Courtesy of Five Deeps Mariana Trench© / Reeve Jolliffe©)

(Courtesy of Five Deeps Mariana Trench© / Reeve Jolliffe©)

The ship has a strong research pedigree. In 2002, NOAA (the National Oceanic and Atmospheric Organization) acquired the vessel and converted it to a multiple-disciplinary platform capable of performing a broad range of missions. The ship conducted oceanographic research and assessments throughout the eastern Pacific, including the U.S. West Coast, and Central and South America.

In 2017, the Pressure Drop was acquired by Caladan Oceanic, and a comprehensive refit program began. Focussed largely on the accommodation and science areas, the refit has transformed the vessel into a much more comfortable and capable scientific research ship. With her state-of-the-art Kongsberg EM124 multibeam sonar array, she can map even the very deepest areas of the seafloor in relatively high resolution. The sonar plays an important role in determining with great accuracy the true depths of the Five Deeps. In some cases, the sonar is used to clarify inaccuracies in documented depths and may ultimately lead to the reclassification of some of them.

2021 CAPTAIN DON WALSH AWARD FOR OCEAN EXPLORATION

The Marine Technology Society (MTS) and the Society for Underwater Technology (SUT) announced that the 2021 Captain Don Walsh Award for Ocean Exploration was won jointly by Victor Vescovo and Patrick Lahey for the 2019 Five Deeps Expedition, and further dives of scientific or historical interest in subsequent years. The Five Deeps Expedition was the first to reach the deepest point in each of the Earth's five oceans: the Puerto Rico Trench in the Atlantic, South Sandwich Trench in the Southern Ocean, Java Trench in the Indian Ocean, Challenger Deep in the Pacific, and Molloy Deep in the Arctic.

In 2020, Victor Vescovo partnered with the French Navy to dive on the wreck of the submarine Minerve, and also worked with the International Hydrographic Bureau and the Monaco Blue Initiative to explore the deepest spot in the Mediterranean. He then partnered with the King Abdullah University of Science and Technology (KAUST) in Saudi Arabia to conduct scientific dives to the unique brine lakes at the bottom of the Red Sea.

After a second year of dives into the Challenger Deep - which included former astronaut Kathy Sullivan, the first women to dive to the deepest depths - the Pressure Drop surveyed the entire northern "Ring of Fire" from Guam to Alaska, discovering, mapping, and naming over 70 new underwater features. During the 2021 dives, Victor Vescovo performed his 12th dive into the Challenger Deep, and discovered the deepest wreck in history, the U.S. World War II destroyer Johnston off the Philippine Island of Samar.

Victor Vescovo has mapped over 1 million square kilometres of ocean floor and donated all of his data to the Nippon Foundation General Bathymetric Chart of the Oceans (GEBCO) Seabed 2030 project.

Kathy Sullivan and Victor Vescovo following the dive to the Challenger Deep
(Courtesy of Victor Vescovo / Caladan Oceanic)

Courtesy of Kongsberg Maritime

HUGIN EDGE MAKING A SPLASH

Richard Mills, Vice President - Marine Robotics Sales, Kongsberg Maritime

At Oceanology International in March this year, Kongsberg Maritime introduced a new member of the HUGIN® family of Autonomous Underwater Vehicles (AUVs): HUGIN Edge. It made quite a splash!

Visibly different from the previous versions of HUGIN, the new vehicle represents how we see the future of autonomous systems, adding more capability focused on mission efficiency. How we got to this point is an interesting story that began more than 30 years ago.

The first HUGIN AUV took to the water on 7th May 1993. This was part of a joint project between Simrad (now Kongsberg Maritime), Forsvarets forskningsinstitutt (FFI, the Norwegian Defence Research Establishment) and Statoil, now known as Equinor. The original idea for an AUV came from Per Thoresen, a research director at FFI, who came up with a plan for sea water battery powered uncrewed submarines in the 1970s.

The first HUGIN used a streamlined, low-drag hull form for long endurance and efficiency. It didn't take long for this to be replaced with a traditional cylindrical shape that allows for modularity, ease of maintenance and provides a built-in upgrade path. When sensors and hardware were changing so rapidly this was key to the early success of the HUGIN® AUV System with multiple configurations delivered to commercial, scientific and defence customers. HUGINs have covered more survey kilometres of seabed than any other AUV available as a commercial product.

The story of HUGIN is not just one of technology, it is also one of people. Several key people have been involved since day one and continue to be involved in the development of future capabilities. Nils Størkersen, Bjørn Jalving, Jon Kristensen,

Richard Mills (Vice President of Marine Robotics Sales) conducting the launch of HUGIN Edge in front of a crowd of interested onlookers at Oceanology International in London, March 2022 (Courtesy of Kongsberg Maritime)

Per Espen Hagen and Odd Arild Pedersen boast a combined 150 years of HUGIN experience between them, often swapping between FFI, Kongsberg and sometimes back to FFI.

In recent times, younger developers including Sigurd Fjerdingen and Craig Wallace have joined the growing Marine Robotics team at Kongsberg Maritime. Sigurd has refreshed our approach to autonomy and software development, and now oversees the entire product portfolio. Craig brings valuable operational experience along with technical prowess in his role as product manager for HUGIN Edge.

Everyone who has ever worked on HUGIN has one thing in common though: a desire to keep developing the best AUV in the world.

The HUGIN AUV System has evolved from a single product into the HUGIN® family of AUVs available today, with capabilities designed to meet mission requirements across market segments. The HUGIN family of AUVs today comprises four distinct models. The existing models are the classic HUGIN AUV, the HUGIN Superior and the HUGIN Endurance. These are all at the very pinnacle of each of their operational and market segments. Now joining that family is the newest and smallest member: HUGIN Edge.

HUGIN Edge returns to a low-drag ethos. It combines efficient packaging with stability and hydrodynamic performance to optimise not just the propulsion load, but also data quality. It is also visibly a step forward, a leap into the future.

It also fills an obvious gap in our portfolio being a mid-sized AUV. HUGIN Edge measures 4 metres in length and weighs 300 kilograms. It carries an array of payload sensors to meet the vast majority of commercial and defence application. These comprise a sidescan sonar, upgradeable to synthetic aperture sonar; an ultrahigh frequency multibeam echosounder and a magnetometer. In the aft section there is a sub-bottom profiler or high-resolution camera, swappable by the customer.

The new shape has been optimised using advanced hydrodynamic design for low drag and low noise – maximising performance from the onboard acoustic sensors. The 'flattened' body cross-section enhances stability, maximising side-scan and synthetic aperture sonar performance.

The design concept follows the free-flooding style of the other members of the HUGIN family, predominantly comprising composite wrapped syntactic foam. This provides strength and rigidity, plus a degree of resilience from impact damage.

The nose features a new 3 sector forward looking sonar (FLS) that provides collision avoidance, contour smoothing and trajectory planning. With a wider field of view, the FLS scans 20 degrees either side, as well as retaining the 120-degree vertical view. The ability to see a long way ahead of the vehicle, even when crabbing, provides enhanced safety along with the ability to pick the flight path to maintain a smooth attitude. That ensures good data quality, which is imperative with high resolution sensors.

One of the important things for us is not just packaging sensors into a new shape, but to also add capabilities. Sometimes those capabilities are mechanical, like the low drag shape; and sometimes they are operational. Making the system easier to use and smarter at the same time.

The HUGIN Family of AUVs (Courtesy of Kongsberg Maritime)

One example of this is how we launch and retrieve the system. A new automated launch and recovery systems (A-LARS) is under development to combine elements of the proven Stinger ramp-based LARS with the automated docking capability introduced with the subsurface LARS for HUGIN and HUGIN Superior.

Designed from the outset for truly autonomous missions and operations from reduced crewed, or uncrewed platforms, a great deal of operational automation and autonomy is built into HUGIN Edge. This includes elements such as inductive charging and wireless data offload. These are key enabling technologies to make over the horizon operations from an Uncrewed Surface Vehicle (USV) or Maritime Autonomous Surface Ship (MASS) possible.

With HUGIN Edge we introduce some smart mission planning tools and in-mission autonomy to help operators get the best out of their AUVs. Our goal is to transition from event or waypoint-based to performance-based autonomy.

Mission planning has always been a challenge that requires a level of specialist knowledge and experience that takes time for operators to acquire. HUGIN Edge features Goal Based Mission Planning (GBMP) to help alleviate that and ensure that all missions are both effective and efficient. The new planning tool is embedded within the HUGIN OS topside; it is a simple to use system that provides sophisticated mission plans for many different mission profiles and activities.

The GBMP interface replaces the traditional technique of drawing a survey pattern on chart based graphical interface. With this new way of planning missions, the operator selects an area of operations drawing a polygon around the outer limits of the survey or search area. Then an activity is chosen, and the relevant parameters defined.

For survey applications this may include sonar density, overlap or area coverage. For search and detection missions the operator can specify known targets or potentially just object size and strength of sonar return. The software then calculates the most efficient way to conduct the mission, meeting the performance criteria and within the maximum mission duration. That includes generating waypoints and events or actions such as controlling sensor settings, depth, speed, and heading.

The mission plan is then loaded onto HUGIN Edge, and this is where the smart in-mission autonomy takes over. During the dive, the mission controller measures what is being achieved against the plan. If the live performance deviates from the plan the in-mission performance-based autonomy can implement a change. For example, if a sensor does not achieve the expected range for a set area coverage rate, the performance-based autonomy may decide to shorten the track spacing. It could also work the other way and then communicate with the operator that the mission will be completed ahead of time.

HUGIN Edge represents the culmination of more than 30 years of experience and development in AUVs, introducing class-leading platform performance; a combination of high-quality sensors never packaged into a mid-sized vehicle before; and smart planning capabilities matched by performance-based autonomy to optimize system performance.

The future is bright; the future is orange!

The HUGIN 1 in the mid-1990s with Odd Arild and Atle Gran. Odd Arild became our operations manager responsible for all HUGIN deliveries for many years, before returning to FFI. Atle was a field technician in the 1990s before starting his own company, coming back to Kongsberg Maritime 7 years ago where he joined the Marine Robotics sales team. (Courtesy of Kongsberg Maritime)

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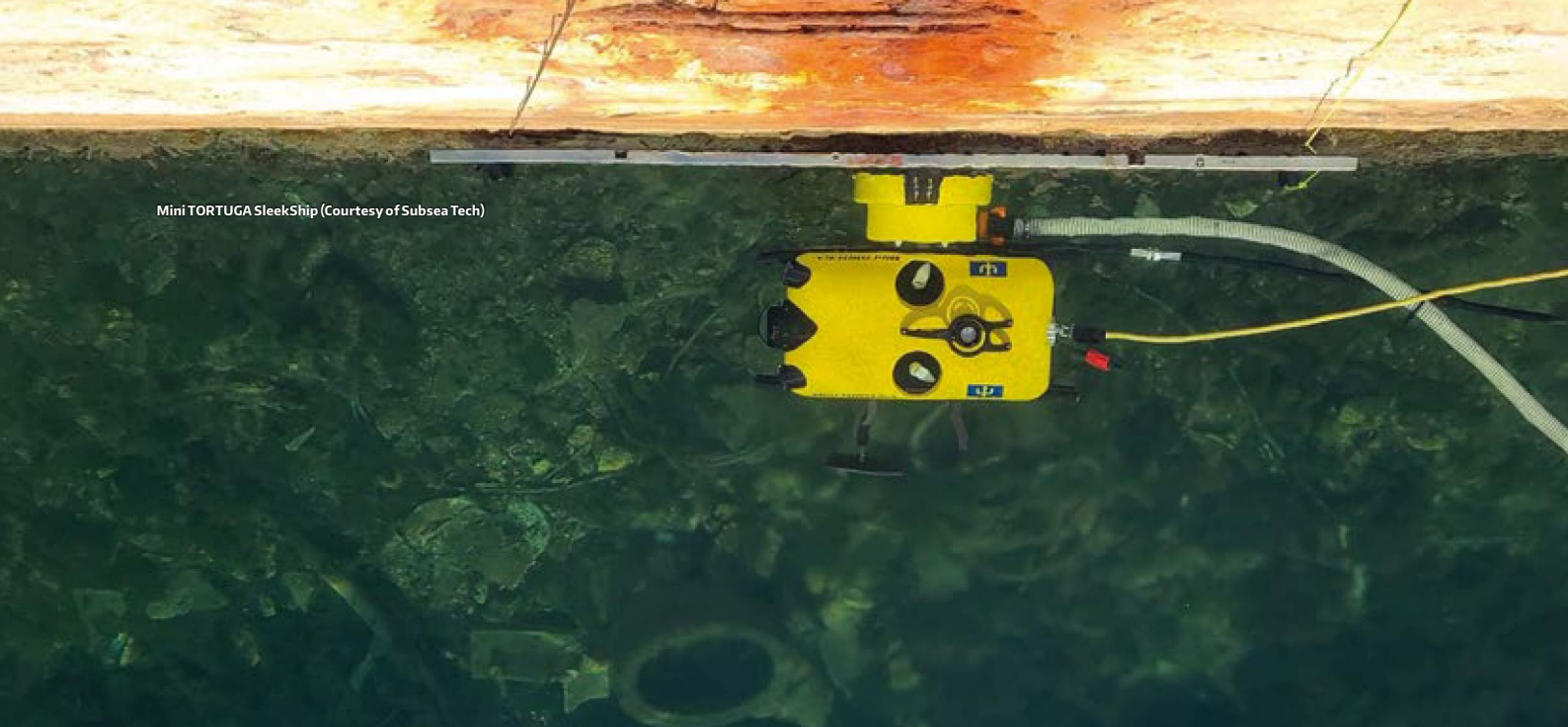


Mini TORTUGA SleekShip (Courtesy of Subsea Tech)

SLEEKSHIP

AN INNOVATIVE SOLUTION FOR THE INSPECTION AND CLEANING OF BIOFOULING ON SHIP HULLS

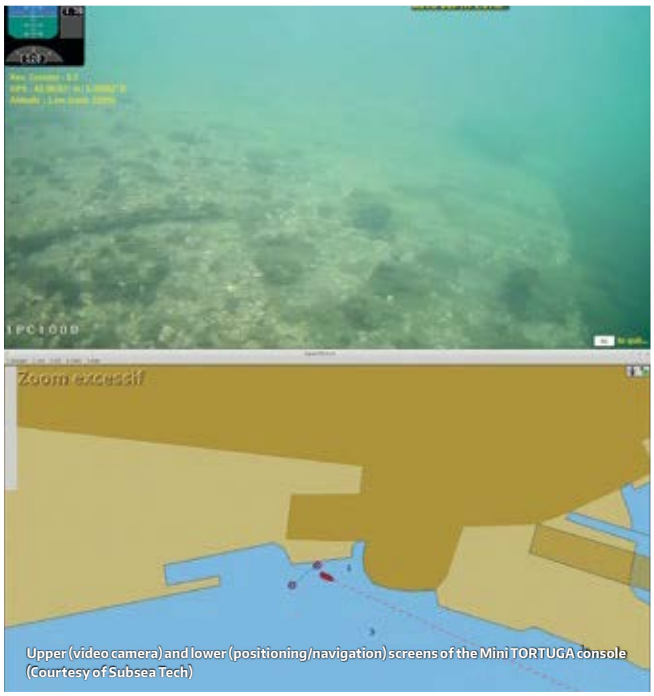
SleekShip redefines the management of biofouling on ships' hulls by allowing inspection and cleaning at early stages.

The accumulation of biofouling on hulls can pose a major problem at every level of a ship's operation. It significantly alters the hydrodynamics of ships, while increasing drag, fuel consumption, and CO2 emissions, not to mention enabling transportation of invasive species. There is currently no effective way of accurately assessing fouling levels while a ship is in the water, and dry-docking creates costly downtime for operators. Furthermore, if a vessel is not regularly taken out of the water for inspection, the likelihood of biofouling development increases, requiring more aggressive cleaning methods that can damage the hull coating.

The solution developed under the SleekShip project allows the status of biofouling development to be assessed and quantified, while prioritising and targeting areas to be cleaned. It combines a semi-autonomous underwater robot,

Mini TORTUGA SleekShip (Courtesy of Subsea Tech)

Mini TORTUGA (Courtesy of Subsea Tech)



Upper (video camera) and lower (positioning/navigation) screens of the Mini TORTUGA console (Courtesy of Subsea Tech)

a new cavitation-based cleaning tool, and a hyperspectral imaging system. The latter takes over from video inspection, which is inefficient for non-visible early-stage biofouling. Also, the hyperspectral imaging is able to mitigate low visibility due to the backscattering of light caused by suspended particles.

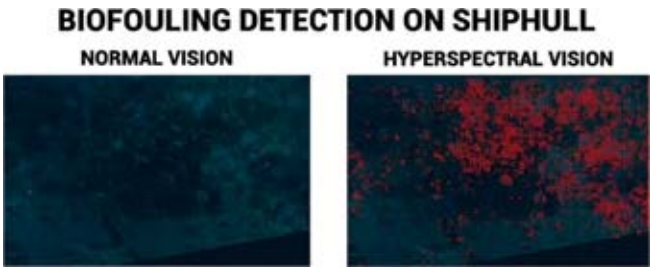
By enabling service providers to reliably detect the early stages of biofouling development in harbours and open sea environments, SleekShip is expected to generate savings of more than €3 billion over five years following its launch into the global shipping industry.

SOLUTION OVERVIEW

THE MINI TORTUGA: HIGHLY VERSATILE AND PORTABLE ROV

Fully developed by Subsea Tech, this lightweight and compact semi-autonomous underwater vehicle has four horizontal and two vertical thrusters for optimal manoeuvrability. Weighing in at only 17kg, the Mini TORTUGA may be handled

QCell's SpectralSea camera integrated on Mini TORTUGA ROV (Courtesy of Subsea Tech)



The SpectralSea camera acquires live color and spectral images simultaneously. The left side image is what conventional cameras "sees" on the ship hull. The right-hand image is what the SpectralSea camera "sees" in the exact same conditions. All target's details became visible with great clarity (biofouling in red) (Courtesy of Subsea Tech)

by a single operator, thus easing launch and recovery operations from any kind of platform (pier, vessel, etc.). It's equipped with an underwater acoustic positioning system and intelligent navigation software, combining positioning data with that of the ROV's other sensors – INS, DVL and depth meter – so the ROV's trajectory can be automatically controlled. The surface console offers a user-friendly double screen interface that allows the operator controlling the ROV to have real-time feedback from both video and hyperspectral cameras, as well as from ROV positioning.

HYPERSPECTRAL CAMERA: SEEING THE INVISIBLE

Underwater conditions cause a loss of contrast and colour, as well as light absorption, that is not managed by conventional cameras. Hyperspectral imaging addresses these three challenges by using spectral colour bands to identify objects and materials in an image. The SpectralSea camera, developed and manufactured by Crete-based QCell, is a video rate spectral imager that offers a physics-based primary enhancement of the underwater visibility. This is complemented with advanced, real-time algorithms that recognise and deconvolve the scattering components. Mounted at the stern of the Mini TORTUGA, the SpectralSea camera faces the ship hull while the ROV is flying along it and generates real-time imaging on the surface console screen.

BIOFOULING KILLER ROTOR

Traditional underwater cleaning systems make use of abrasive brushes or high-pressure jetting which remove significant layers of anti-fouling paint, with the same dispersion in the environment, and makes the surface more vulnerable to the establishment of organisms.

Mini TORTUGA SleekShip (Courtesy of Subsea Tech)

Cavitation is the rapid formation and collapse of bubbles (vapour cavities) in a liquid. These vapour cavities implode on impact with the cleanable surface, and create high energetic shock-waves that remove corrosion, dirt, debris, fouling, instable coatings and other deposits from ship hulls, propellers, and other underwater structures. Cavitation cleaning requires much less pressure than conventional jetting systems (160 versus more than 250 bars) and therefore does not damage the hull coating.

Subsea Tech has designed and manufactured a cavitation cleaning tool consisting of a bell jar fitted with a double nozzle rotor, supplied with high pressure water by a 160psi surface motor pump. Integrated on the Mini TORTUGA, this tool allows for cleaning large areas while confining debris, which is removed to the surface via a suction system (hose and pump). Thus, it is possible to carry out cleaning in harbour areas even under strict regulatory conditions.

For this project, Subsea Tech has partnered with four other companies and institutions on this H2020 project (Danaos from Cyprus, TWI and Qcell form Greece, and M.Danchor from Israel) and provides – in addition to its technological developments – its quay side facilities in Marseille for real conditions trials.

(Courtesy of Subsea Tech)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 950854.

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TOP TEN PLUS ONE EDUCATIONAL ROVS FOR 2022

By Capt. Marc Deglinnocenti

The beginning of 2022 has seen another technological leap in Remotely Operated Vehicle (ROV) designs. As we go up in technology in marine educational ROVs, we can all go down to deeper depths with better results. Now more than ever before both youth and adults alike can study the underwater realm of our world. Since 71% of the earth is covered in water, these new underwater robots that are powered by batteries and sometimes powered through their control tethers, offer students and scientists a new look into that realm. There are many types of ROVs on the market today that can be great learning tools. They vary in complexity, diving depth, cost, controls, and ability. With so many ROVs to choose from, only a countdown of ten can be listed here. This short list won't show you all the educational ROVs, but it will show you how varied these remotely operated underwater robots can be. Let's get started with some very inexpensive yet very capable ROVs and then work our way up to the more expensive ones.

HONORABLE MENTION: A Chinese company called Chasing has made this list with their M2 Pro ROV. With a depth rating of 150 metres (492 feet), this little eight thruster ROV has a base price of only $4999 (£3601, €4215). The grabber arm is an extra $399 (£287, €336). It comes standard with a 200 metre tether, but 300 and 400 metre tethers are available. The custom hand crank reel is $699 (£504, €589) extra. Other options include a laser scale, a sophisticated control console at $2999 (£2160, €2529), AC or DC external power supplies for unlimited dive times instead of the standard five-hour battery, extra cameras and lights, multibeam sonar, a multi-interface docking station, and even Ultra-Sonic Baseline (USBL) compatibility for underwater tracking. This slimly designed ROV has a top speed of four knots. Shipping is free, and they have a fine warranty and a responsive customer service department.

Chinese Chasing brand ROV M2 Pro. (Courtesy of Chasing)

BlueROV2 assembled kit with the Heavy eight thruster configuration. (Courtesy of Blue Robotics)

10.

Blue Robotics offers their BlueROV2 which gets more versatile every year. This year is no exception, because this ROV's options now includes new control software. This open-source firmware is part of the ArduSub free software. It brings a vast new number of control features to this basic 100 metre rated ROV. It comes with a video screen game controller that you can use with your own laptop computer too. This ROV is a self-build kit. It can be bought with all the extras right away, or you can upgrade it as additional funds become available to you. This versatility can let you go from a basic 100 metre dive rating to a 400 metre one when you're ready. You can go from six thrusters to eight, two lights to four lights, and so forth. Options include sonars, gabbers, shore power supply, and GPS. New options are always on the horizon too. They do have a large online store with numerous hardware and software add-ons for you to choose from what you need now and from what you want later. You can hire a company to build it for you at a premium cost, or you can assemble it yourself. If you do decide to take it on as a project, it comes with detailed instructions. There are also some online assembly videos and even an online forum. If you do assemble it yourself, you'll probably be able to trouble shoot it in the field with the proper tools and spare parts on hand. It's rumored that Blue Robotics has some even newer tech coming out later this year.

Shark Marine upgrades to their Sea Wolf V ROV. (Courtesy of Shark Marine)

9.

For years Shark Marine Technologies has made a great 300 metre rated ROV called the Barracuda. Now they've upped their game by double with their new Sea Wolf V which can dive down to 600 metres. They also went from the four thrusters of the Barracuda to six with the Sea Wolf V. Just as some other ROV companies, Shark Marine of Canada has adopted a modular equipment design. This makes modifying the ROV in the field easier to adapt to newly discovered job tasks and other situations as they arise. Their ROV piloting software is called DiveLog, and it makes piloting the Sea Wolf V easier and more versatile. With DiveLog you can pilot it manually or semi-autonomously. Another software option is their Total Navigation System. There are also some nice hardware options for you to consider. It comes standard with some valuable sensors that measure depth, leaks, heading, pitch, roll, and internal and external temperatures. Some other options for this ROV are high-definition video and still cameras, a laser scale, recovery reels, various manipulator arms- both electric and hydraulic, launch and recover systems, Doppler Navigation System, USBL and Long Baseline (LBL) positioning systems, multibeam sonars as well as other sonars, sediment sampler, metal thickness gauge, and even a radiation detector! The external power supply for this 600 metre ROV is 220 to 240 VAC at 50 to 60 hertz. It weighs 95 kg (209 lbs).

Aegir 50 ROV is the workhorse of Ocean Robotics. (Courtesy of Ocean Robotics)

8.

The Aegir 50 ROV is the workhorse of Ocean Robotics of Sweden. This ROV is more than a simple observation ROV, because it can be equipped with many sensors and tools for work and research. These sensors and tools are easy to change out in the field too. The Aegir 50 comes standard with a multitude of power connectors- 1 x 300 VDC (up to 1 kW), 2 x 24 VDC (up to 250 W), and 2 x ±24 VDC (3 Amps). An optional 230 VAC external power connector can also be fitted. That's a lot of power options for an ROV. A total of seven individually switched 24 DCV power channels are available on the ROV for additional equipment usage. The communication connectors are equally numerous and diverse. There are two camera connections that can support both PAL and NTSC formats. You get a bargain four LED lights coming standard while many other ROVs only come with two. It also comes with a depth sensor with a depth warning alarm, leak alarms, a 3D magnetometer, accelerometer, and a gyroscope. Many different types and brands of optional sonars, manipulation arms, and sensors can be added on. It even has an Ocean Robotics station keeping option. So, you might already have a suitable power supply, sonar, hardware, communication link, or an XCS control system in your possession that can work just fine on the Aegir 50 ROV. By the way, this is a 750 to 1000 metre (2461 to 3281 feet) deep diving ROV.

Seamor Marine, Mako, JPG from their website, shown with dual function gripper. (Courtesy of Seamor)

7.

Seamor Marine is a Canadian based ROV company that has made some new inroads into its ROV technology as well as its ROV availability. Early in 2021 Seamor Marine and RS Aqua Ltd. of Portsmouth, UK, signed a partnership agreement to distribute Seamor's ROVs in the United Kingdom and Ireland. Their newest ROV is the Mako. It sports eight thrusters with auto depth and auto heading standard along with pitch and roll sensors making this an easy to control ROV for new users. Some optional features like an impressive 2000 meter depth rating makes Mako a great ROV for the ROV professionals too. Other options include a 22.5 kg (50 lbs) payload, extra zoom cameras and lights, a dual function gripper or seven function manipulator arm, five different company sonars, USBL compatibility, Cathode T and Ultrasound Testing probe integration, and an altimeter with auto altitude control among other options such as a laser scale. Mako gets high marks for ease of control along with these multiple options.

SeaDrone Pro Enforcer comes with a gripper and sonar as standard equipment. (Courtesy of SeaDrone)

6.

The SeaDrone brand of ROVs look like underwater UFOs. Based in California's Silicon Valley and produced in Mexico, their line of ROVs are priced from $11211 (£8183, €9478) for their 125 metre depth rated one to $29899 (£21825, €25278) for their 150 metre depth rated Pro Enforcer. That's relatively inexpensive for ROVs, and it's the Pro Enforcer model that shines as the best. It was primarily designed for law enforcement within inland waters like bays, rivers, lakes, and ponds. It's very portable with a three hour battery run time. It can

SeaDrone's new XROV. (Courtesy of SeaDrone)

be handheld (10 kg, 22 lbs) and easily launched from docks and small boats. That might be just right for the type of educational or research work that you do in those same waters. What is truly remarkable is the amount of hardware included in the Pro Enforcer package. The ROV comes with batteries, charger and cords, tether and reel, camera with tilt, O-rings set, vacuum pump, and a gripper which is almost always an additional purchase option with other ROV brands. For the very first time as standard equipment for this low priced ROV, it also comes with a multibeam sonar! A laser scale and a Doppler Velocity Log (DVL) for current speed readings are just a couple of options for this ROV. Their new Mission Planning software can turn this little ROV into a semi-autonomous hull inspection tool for your research vessel maintenance needs as well. The unbelievable value of this ROV package as well as its ease of operation for tricky waters along with its versatility makes it a great purchase. They also just introduced their new 400 metre XROV which can run at 4 knots.

Deep Trekker's Revolution NAV comes with a gripper and laser scale standard. (Courtesy of Deep Trekker)

5. The next company on the list is Canada's Deep Trekker line of ROVs. They have also upped their game from their previous Revolution ROV to their new Revolution NAV. The Revolution NAV has automatic stabilization, station keeping, and altitude holding built right in for ease of operation and better underwater studies. You can also map its underwater movements via its USBL positioning sensor down to 305 metres (1000 feet). You can even mark several waypoints on that map that you might want to return to for further studies. The camera has pan and tilt capabilities with a wide 260° panning ability for even more ease of operation. The Revolution NAV comes as a package and is $65549 USD (£47409, €55429). The six thrusters are magnetically coupled to the propellers to prevent high pressure leaks at deep depths. This ROV is one of the very few that comes with a gripper arm and a laser scale included as standard equipment within a package deal at this price level. Some options include a multibeam sonar, DVL, and a six-piece gripper attachment kit for that included gripper arm. They also came out with new water and sediment sampler options.

Deep Trekker unveiled their new Pivot Nav with a 97° tilting equipment platform. (Courtesy of Deep Trekker)

4. Number four on this list goes to a Deep Trekker ROV called the Pivot Nav. Once again this new ROV is all about the advances made in the ROV technology field. The Pivot has six variable thrusters that keep the ROV stable, level, and able to move sideways. The "pivot" term refers to the equipment that's mounted on this 300 metre ROV's equipment platform. Instead of the operator having to tilt the whole ROV to get some more detailed sonar scans or better tool positions, the sonar is mounted on a tilting platform along with the gripper arm tool. The camera also pivots along with its lights. This makes controlling the ROV during operations much easier. New software makes this ROV semi-autonomous with station keeping capabilities and therefore an overall breeze to operate. This two to three hour endurance ROV comes with two batteries for a six hour dive day and will soon have an optional power supply for continuous operations. Other options include a thickness gauge, USBL positioning, DVL, depth and altitude sensors, heading, pitch, roll, and temperature sensors, Cathodic Protection (CP) probe, Sonde Water Analysis sensor, Dissolved Oxygen gauge, and even a turn count readout so that you don't get your tether too twisted up. This single ROV base price is $45999 USD (£33269, €38897).

VideoRay's ROV Defender has new software options and many hardware choices. (Courtesy of VideoRay)

3. The United States based company known as VideoRay has made it on this top ten list with their ROV Defender. VideoRay has also introduced some new technology with their innovative new control software. This third-party control and navigation software is from Greensea Systems or Seebyte. This allows for more precise control of the vehicle's position and orientation. The ROV Defender is now a popular choice for dangerous or heavy-duty missions such as mine clearance or for cleaning nets at offshore fish farms. It's no wonder why VideoRay placed the Defender in its "Mission Specialist" category. With seven thrusters, the Defender can move in any direction, and maintain active pitch to orientate the vehicle in a vertical upward or downward position. That unique

function is beyond the ability of many other brands of ROVs. This ROV comes with an impressive depth rating of 1,000 metres (3,280ft) with a four-knot underwater speed. NEWS FLASH: Late in 2021 VideoRay released some new product options which includes a much more portable, topside, splash proof, video controller. The external power requirements for the Defender are some fairly common voltages of 110 VAC or 220 VAC. The options are too numerous to list here. I will say that you'll be hard pressed to find an option that won't work with the Defender for your particular mission. Dual robotic arms and a fiber optic tether are just two of those options. The system toolkit along with a comprehensive two-year warranty comes with it standard. Comprehensive training courses are also available.

SAAB Seaeye Leopard can dive down to 3000 metres and perform multiple tasks. (Courtesy of SAAB Seaeye)

2. The runner-up at second place on this list comes from the Swedish SAAB Seaeye line of ROVs. Their deepest diving (3000 metres) ROV is the Leopard. This ROV is not for your average children's school use though. It needs a hefty three phase 380-480 VAC power supply to operate it. The Leopard comes equipped with 11 brushless thrusters and their iCON™ intelligent control system to help you manage them all. That means that it has autopilots for heading, depth, pitch and roll, transiting, station keeping, standoff, and altitude controls with autonomous navigation mission capabilities. This ROV can be found all over the world including the Spanish Navy, Ocean Infinity of the USA and the UK, Rovco of the UK, Belov Engenharia of Brazil, and so many more. This ROV was made for deep diving work and discoveries, and its capabilities and options are numerous.

Oceaneering's 4000 metre NEXXUS ROV (Courtesy of Oceaneering)

1. The first place spot goes to the Oceaneering ROV Nexxus. The Nexxus has a dive depth of 3000 metres (10000 feet) with an option to go to 4000 metres (13000 feet). It comes standard with an integrated API compliant system and two manipulator arms of seven functions each. It has two hydraulic power units each with a 125 horsepower rating for some serious tooling capabilities. To help the operator with those activities, it also has automatic station keeping. The ROV's autonomous feature can also navigate you to that work site. Obstacle avoidance software gets you there in one piece too. This is all done with a simple and safe 24 volt DC or 110 volt AC power supplies. Data link options include multiple RS232 and RS485 connectors, Ethernet, and Fiber Optics. Of course it also comes with a myriad of scientific instrumentation such as sonar, Doppler Velocity Log, compass, depth sensor, SD to UHD cameras, and even a gyroscopic stabilizer to name just a few. This is truly a deep diving smart ROV that represents a continued fast pace of technological advances in the ROV marketplace.

This list just scratches the surface of the many ROVs that can dive down to explore below our surface waters. There are now hundreds of ROV brands to choose from. You can follow up by better researching one of these listed here, or you can find a different make and model on your own. Either way, you can now see how easy it can be to increase the knowledge of your educational courses and classes with an ROV or while performing your own personal research. The excitement levels and student retention levels are worth the ROV investment alone. That investment can be achieved with even a small school budget, because many of the above ROV videos displays can be shared with students, teachers, parents, and scientists live via the internet. You can start teaching marine biology, ecology, geology, and marine archeology much better with an ROV. With just a look at some of these ROVs, you can plainly see that there's an ROV out there that's just right for you.

CAPT. MARC DEGLINNOCENTI

Capt. Marc Deglinnocenti has sea time on various types of vessels dating back to 1974. Those vessels included conventional and tractor tugs, sailboats, ferryboats, water taxis, training ships, warships, cargo barges, containerships, near coastal passenger vessels, paddlewheels, and research vessels to name a few. He was in the U.S. Merchant Marine for 33 years, 25 of which as a master mariner. He was also a designated qualified engineer and held many individual certifications and positions on ships such as QMED, able bodied seaman (lifeboatman along with the AB), unlimited radar observer, shipboard firefighting, and assistance towing endorsement. He served as an engineering officer, deck officer, commissary officer, and he even was a California State credentialed maritime teacher. He now writes technical maritime and marine science articles.

oldarmada@gmail.com

Berthed alongside one another, Falkor and Falkor (too) (left and right respectively) in Freire Shipyard, where the latter (too) is undergoing an ambitious refit. Equipment from R/V Falkor is being lifted across to Falkor (too) while the new ship undergoes a rapid transformation. The huge hangar door on the side of Falkor (too) is open during A-Frame tests. Eventually this will be where Remotely Operated Vehicle (ROV) SuBastian is launched and recovered from. (Photo by Alex Ingle/SOI)

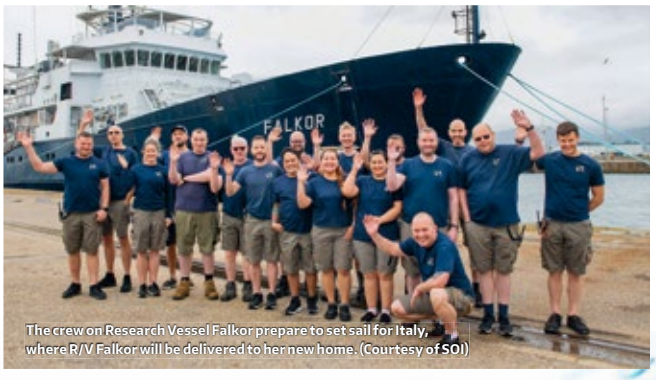
SCHMIDT OCEAN INSTITUTE DONATES RESEARCH VESSEL

TO THE NATIONAL RESEARCH COUNCIL (CNR)

Founders Eric and Wendy Schmidt donate research vessel Falkor to Italy's science agency to conduct ocean science in the Mediterranean and beyond.

Schmidt Ocean Institute announced today the donation of its 82.9-meter research vessel, Falkor, to the Italian Consiglio Nazionale delle Ricerche (CNR), expanding the science agency's fleet of research vessels and continuing Falkor's legacy of conducting ocean science. The ship will be renamed to Gaia Blu.

Originally built in 1981 as a fishery protection vessel, the ship was acquired by Eric and Wendy Schmidt in 2009 when they founded Schmidt Ocean Institute. Following an extensive three-year refit, the ship was converted to the world's first year-round philanthropic research vessel made available



The crew on Research Vessel Falkor prepare to set sail for Italy, where R/V Falkor will be delivered to her new home. (Courtesy of SOI)

Research Vessel Falkor (too) and R/V Falkor docked next to each other in Vigo, Spain for cross-decking and refit upgrading. (Photo by Rolan Gutier/SOI)

(L-R) Dr. Jyotika Virmani (Executive Director of Schmidt Ocean Institue) and Prof. Maria Chiara Carrozza (President of CNR) shake hands over documents verifying the donation of Research Vessel Falkor. (Courtesy of SOI)

Research Vessel Falkor (too) and R/V Falkor pass by each other as Falkor (too) is towed into dry dock in Vigo, Spain for refit upgrading. (Photo by Alex Ingle/SOI)

for free to scientists. To date, research vessel Falkor has embarked on 81 expeditions hosting 1,056 international scientists. The vessel has sailed a distance more than 12 times around the world and mapped over 1.3 million square kilometers of ocean floor. Expeditions on the vessel have led to numerous discoveries including a 500 meter tall coral reef in the Great Barrier Reef, stunning "gardens" of deep-sea corals off South Western Australia, and the collection of rare footage of the elusive glass octopus.

"After a decade of remarkable discoveries and scientific research with Schmidt Ocean Institute, we can imagine no better home for Falkor than CNR," said Wendy Schmidt, co-founder of Schmidt Ocean Institute. "We are delighted they will continue Falkor's legacy of exploring the ocean, supporting marine science and bringing the wonders of the ocean to the public."

CNR has contributed greatly to marine research in the Mediterranean Sea, Atlantic Ocean, and polar regions; it is the largest research organization in Italy and includes 88 institutes distributed across the country. The marine community of CNR is composed of over 450 people working in the Earth Systems Science and the Engineering and Informatics Departments.

"CNR has a century of experience conducting science and investing in talented researchers, making it an excellent new home for Falkor," said Eric Schmidt, co-founder of Schmidt Ocean Institute. "We look forward to seeing what new discoveries come from Falkor's ongoing work at sea."

"Receiving research vessel Falkor from Schmidt Ocean Institute is extremely beneficial for CNR and the entire Italian scientific community," said Prof. Maria Chiara Carrozza, president of CNR. "This donation will foster collaboration with international research institutes and universities involved in studying the anthropogenically impacted Mediterranean basin, one of the cradles of human civilization. Falkor will also offer a unique opportunity to the Italian scientific community to work on the world's ocean on a multi-year plan, within both European and other international projects."

Schmidt Ocean Institute will continue operations with its new ship, Falkor (too), that will launch in early fall after outfitting it with the most sophisticated maritime technologies. The new vessel is significantly larger at 110 meters and will continue SOI's mission to support global ocean research.

MEET THE MANTAS

GAME-CHANGING USV PREPARES FOR SUMMER DEPLOYMENTS

Sören Themann, CEO, Subsea Europe Services

New speed and agility capabilities are set to optimise marine data acquisition and open the door to more pro-active, value-centric hydrographic survey business models.

Despite AUVs covering millions of survey lines since their commercial introduction in the mid-nineties, obtaining bathymetric data today is still mostly a manual process carried out by dedicated vessels crewed by professionals. Unfortunately, this means that data gathering is still hindered by the age-old logistical nightmare of pulling many moving parts together to make a marine project possible.

While new hydrographic and positioning technologies have helped to automate some niches within the marine survey workflow, commercial-grade geophysical seafloor maps for engineering use are usually only created when a specific need arises. Current marine survey methodology cannot accommodate a reliably viable business model that does not depend on data acquisition subsequent to being commissioned by a paying client.

Whether as it's straightforward as updating seafloor data for the regular dredging of a busy harbour channel, or as complex as positioning the pilings for a 100-turbine offshore wind farm 50km from the coast, the ability to collect accurate data is only possible because of a significant value chain. Clients, contractors, marine operators, and equipment suppliers must work together to plan and execute complex, costly, and often time-sensitive operations.

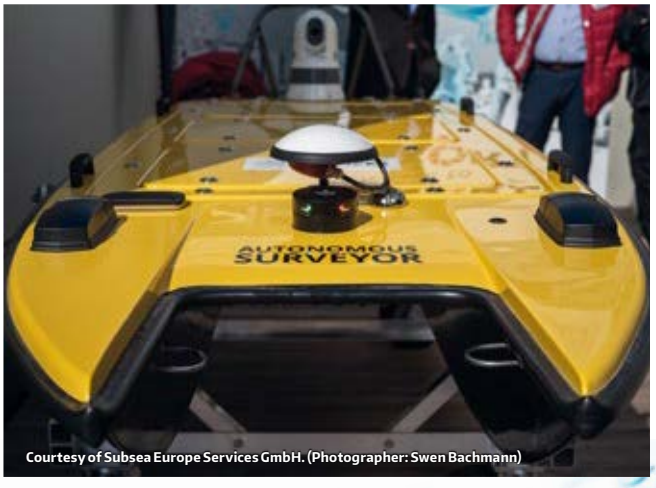
This mostly happens reactively, following the client request or RFP, which puts most stakeholders under constant pressure. And, with so many moving parts it's safe to say that some projects go smoother than others. Meeting the client's time-frame – which could be based on countless conditions that they must adhere to avoid penalties – is a particular challenge as the right vessels, equipment, or staff may not be available.

Meeting cost expectations is vital also. Unforeseen circumstances could turn a two-day job into a four-day job for the vessel and team at sea. Immediately the cost of the project doubles. In some cases, a second survey may be needed if the data from the original has problems or needs extra verification. Integrating these significant extra costs with an original estimate is challenging, especially when considering the countless parameters, and how the original scope may be forced to grow.

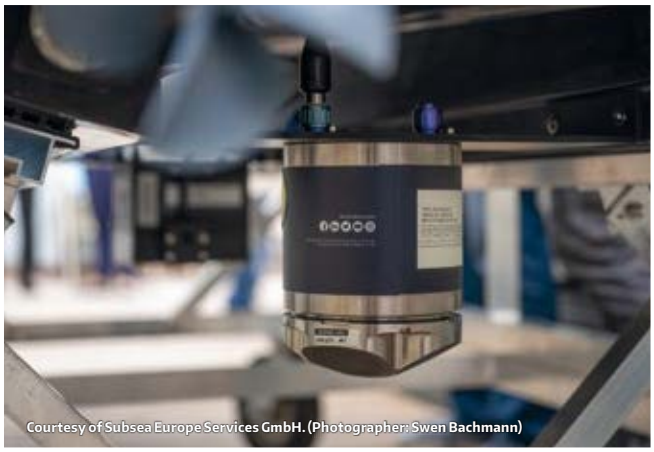
It has to be said, with the logistical complexity and the technical difficulty of providing a sub-centimetre, actionable picture of something obscured by hundreds or thousands of metres of ocean, the marine survey industry does an amazing job. But there is always room for improvement, which is why the use of Unmanned Surface Vehicles (USV) for bathymetric survey is growing, especially in the last five years as technology has started to catch up with ambition.

Among the developments, there are new USV platforms that can disrupt the entire marine survey workflow. One such promising innovation is a new USV from Hamburg headquartered Subsea Europe Services, which can not only optimise marine data acquisition, but offer a new pro-active route to obtaining marine data on spec: essentially a Data-as-a-Service business model.

Courtesy of MARTAC



Courtesy of Subsea Europe Services GmbH. (Photographer: Swen Bachmann)


Courtesy of Subsea Europe Services GmbH. (Photographer: Swen Bachmann)

Courtesy of Subsea Europe Services GmbH. (Photographer: Swen Bachmann)

Christened as the 'Autonomous Surveyor' at a ceremony in May, this MANTAS T12 USV is a brand-new turnkey hydrographic survey solution that could become the next-gen platform to unlock pro-active marine surveys without a client engaged in advance. In doing so it wipes out the inefficiencies and often unpredictable costs of a reactive workflow, so end-customers can simply purchase the data they need when they need it.

MEET MANTAS

The proving point behind such a claim boils down to the speed, agility, and (relatively) low weight of the MANTAS T12 platform; a USV derived from the unmanned patrol and anti-submarine vessels built for defence and government clients by Florida-based Maritime Tactical Systems Inc. (MARTAC). Together with MARTAC, Subsea Europe Services has now created a unique entry into the global fleet of USVs designed for subsea geophysical surveying.

The Autonomous Surveyor differs significantly from other USVs being used by survey companies today, which in the most part still reflect the design tropes of manned survey vessels, especially in terms of their size, speed, weight, and maneuverability. Doubtless, these USVs are doing a fantastic job at collecting bathymetric data, but the Autonomous Surveyor is designed to collect data to the same industry standard quality, but faster and with more flexibility during operations.

At 12ft long with a draft of just seven inches and a top speed of 30 knots (delivered by a clean all-electric motor and propulsion system) the MANTAS T12 performance specs are way beyond any current platform with the ability to conduct hydrographic survey to s-44 exclusive order standards. And when you have this kind of speed, you can save time in transit and reduce non-productive time that could amount to days or weeks for many offshore projects.

But as hydroacoustic technology development continues apace, the potential savings go further still. When combining the performance attributes of the Autonomous Surveyor with the promised capabilities of new multibeam, sensor, and positioning systems, it will likely be able to survey at speeds in the region of 15-20 knots: close to triple the speed of a standard survey line today.

If all was black and white, the cost of data acquisition could immediately be slashed by two thirds. It's important to note that this is due as much to the multibeam system as to the survey platform. However, the MANTAS platform is unique in that it's already designed for high-speed and tight maneuvers, so will be able to take advantage of next generation hydroacoustic technology as soon as it becomes available.

ARTIFICIAL INTELLIGENCE

In addition to speed, the Autonomous Surveyor is also designed for stability and tight maneuvering in even the roughest conditions, which is a key performance parameter for surveying, but will prove even more essential when next generation hydroacoustic systems start to use A.I. for real-time, on-board data processing.

It is expected that new systems will have the ability to deliver a constant stream of real-time, high-quality data during a survey, providing a huge boost in efficiency for decision support on manned survey vessels as well as USVs. But by integrating this data stream with more advanced USVs – with their own A.I. or autonomy controller – the survey payload and platform will work together to make decisions in milliseconds. This means that anomalies, points of interest, or corrupted data can all be checked without the need for a human in the loop.

Going forward, such fully autonomous operation – which is still a few years away as a widespread practice and will depend on regulations for unmanned vessels catching up with reality – could see MANTAS USVs operating on their own for an entire day, returning to base to transfer data, and then going back out again on replaced or recharged batteries. This is all while collecting commercial quality bathymetric data on spec. An entire fleet could operate 24 hours a day to build an extensive data library ready for immediate application to any engineering projects on demand.

Another scenario, which is enabled by the lightness and easy out-of-water handling of the MANTAS T12, is the use of Vessels of Opportunity or "Mother Ships" as "homes" or storage. Take for instance a service vessel moving engineers on a wind farm day in and day out. The vessel would only need a very small deck

Courtesy of Subsea Europe Services GmbH. (Photographer: Swen Bachmann)

Courtesy of Subsea Europe Services GmbH. (Photographer: Swen Bachmann)

crane as a launch and recovery system and no survey expertise on board past training for safe deployment and retrieval.

Through this, energy companies, prime contractors, or survey companies can offer novel approaches that reduce the cost and improve the readiness of marine surveying; essentially developing their own business models based on the speed and flexibility of the MANTAS T12.

The ability to reduce the cost per data point collected is why it will be possible to conduct marine data acquisition without prior commission. The savings reduce the financial commitment that a survey company has if deciding to survey proactively and build their own data sets to sell when a company or organisation makes an enquiry.

Of course, multi-client survey projects can lower investment risk, but arranging such a service only adds to the logistical challenges we have already discussed. The USV-enabled Data-as-a-Service model, however, negates the chokepoints and machinations that hold-up the current planning and operational processes.

NEXT STEPS

As you can see ship captains and navigators, as well as superyacht and sailboat skippers, have it easy, relatively speaking. They can go online and get the navigational charts they need on demand. With modern ECDIS and chart plotters, they do not even need to a visit a website as updates and recent maps of new areas can be downloaded directly.

Now imagine that this is possible for bathymetric data acquired and processed to s-44 exclusive order standards. Energy company's prime contractors, service providers, or anyone involved in the entire value chain can immediately access the data they need. In turn, the providers lower investment in collecting the data enabled by the MANTAS USV can be realised.

The decisive step could be just like the skipper's chart-plotter: bathymetric data fed directly to operational technology on a wind turbine installation vessel, direct from a marine survey supplier's own cloud environment. No need to instigate a complex and costly marine survey; just subscribe to the service!

This is all an incredibly positive future for USVs and their application to marine survey, and the end-customers that need subsea data. But it gets better! The cost per data point can be reduced further still when using a multiple USV "swarm" approach. 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.

Subsea Europe Services and its partners continue to drive their innovative survey USV program forward, with the ambition to make Data-as-a-Service a truly viable business model. At first though, the team is looking to share the new efficiencies of the Autonomous Surveyor with forward looking clients; it will be available for rental as a turnkey system with the support of trained technicians this summer.

Once the time and cost saving potential has been fully locked in, MANTAS T12 solutions are expected to become a common sight around Europe, perhaps on their own, or possibly even as part of a swarm. So, if you see one, you can be sure it's making everything easier for everyone depending on it to collect high quality marine data.

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The stern of the Endurance. (Image © Falklands Maritime Heritage Trust / National Geographic)

ENDURANCE IS FOUND

Mark Antelme

The Falklands Maritime Heritage Trust is pleased to confirm that the Endurance22 Expedition has located the wreck of Endurance, Sir Ernest Shackleton's ship which has not been seen since it was crushed by the ice and sank in the Weddell Sea in 1915.

One hundred years after Shackleton's death, Endurance was found at a depth of 3008 metres in the Weddell Sea, within the search area defined by the expedition team before its departure from Cape Town, and approximately four miles south of the position originally recorded by Captain Worsley.

The team worked from the South African polar research and logistics vessel, S.A. Agulhas II, owned by the Department of Forestry, Fisheries and Environment and under Master, Capt. Knowledge Bengu, using Saab's Sabertooth hybrid underwater search vehicles. The wreck is protected as a Historic Site and Monument under the Antarctic Treaty, ensuring that whilst the wreck is being surveyed and filmed it will not be touched or disturbed in any way. The Endurance22 Expedition's activities involved no intrusion into the wreck and the Sabertooth AUVs are not fitted with any devices capable of actions such as digging, boring, scooping etc.

Image © James Blake and Falklands Maritime Heritage Trust / National Geographic

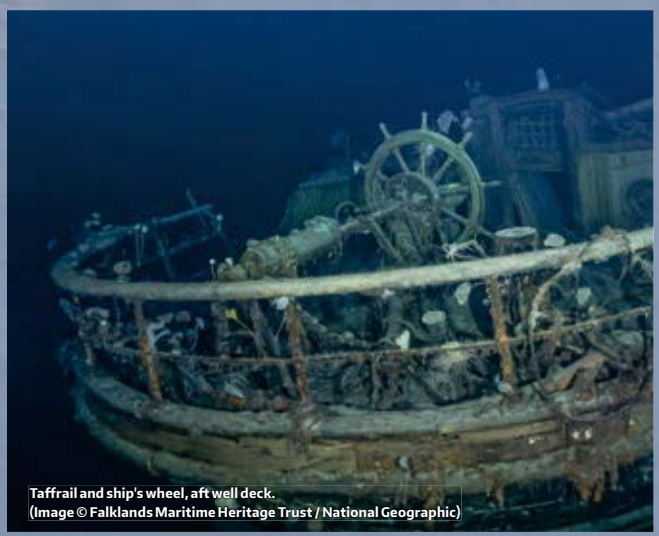
The Falklands Maritime Heritage Trust, under the chairmanship of Donald Lamont, and the Expedition Leader, Dr John Shears, have assembled an interdisciplinary and international team of marine archaeologists, engineers, scientists, and technicians who, working with the highly experienced officers and crew of S.A. Agulhas II, have the skills and knowledge to locate, survey and film the wreck of Endurance and conduct related scientific research in the Weddell Sea.

The Endurance22 Expedition was the first to deploy SAAB Sabertooth underwater vehicles to search for the wreck of Sir Ernest Shackleton's lost ship, Endurance. These hybrid vehicles combine the attributes of a Remote Operating Vehicle (ROV) – always linked to the surface – and an Autonomous Underwater Vehicle (AUV) – capable of operating without such a link.

When the vessel was crushed in the ice and sank in 1915, Captain Frank Worsley took detailed measurements of the location using a sextant and recorded it in his diary, which is now in the Scott Polar Research Institute (SPRI) archives. Consequently, the expedition team knew where to focus its search efforts and where to deploy the Sabertooths under the ice, in order to locate the wreck.

The Sabertooths have the ability to reach sites up to one hundred miles away from the ship from which they are launched and to return with photos, video and survey data. This meant that even if the sea ice conditions were difficult, it could be possible for the expedition to survey the site of the wreck, even if the expedition ship S.A. Agulhas II couldn't reach the location itself.

If the Agulhas II ship couldn't get close to the wreck site, the Expedition planned to create one or possibly two ice camps,



Taffrail and ship's wheel, aft well deck.
(Image © Falklands Maritime Heritage Trust / National Geographic)

Starboard bow. (Image © Falklands Maritime Heritage Trust / National Geographic)

Image © Esther Horvath & Falklands Maritime Heritage Trust / National Geographic

where holes would be drilled through the sea ice using a giant auger ice drill over three feet (about one meter) in diameter. This would be wide enough for the Sabertooth AUV to be lowered through to try and locate, survey and film the wreck of Endurance. Luckily, conditions in sea ice allowed the expedition ship to get close enough to the Endurance wreck site, where the AUVs were launched directly from the vessel.

The Sabertooths were fitted with High-Definition cameras and side-scan imaging capability. Made in Sweden by SAAB and operated by the underwater search specialists, the Sabertooths can search and map huge patches of the ocean floor to depths of up to 4,000 meters (13,123 feet) sending the data to the surface in real-time.

The live feed from the AUV showing the found wreck of Endurance on the ship's monitors. (Image © Esther Horvath & Falklands Maritime Heritage Trust / National Geographic)

Image © Esther Horvath & Falklands Maritime Heritage Trust / National Geographic

Image © Falklands Maritime Heritage Trust / National Geographic

When the Endurance was successfully found, she was surveyed by the AUV's laser scanner to produce a 3D model and full photogrammetric coverage of the wreck and its debris field. The resulting graphical data will be precisely scaled allowing the wreck, together with its equipment, fittings, and contents, to be recorded to a level of accuracy comparable to that of an archaeological survey on land.

The historical research and survey data collected by the Expedition will be used as vital baseline information for the future monitoring and protection of the wreck of the Endurance.

Image © Esther Horvath & Falklands Maritime Heritage Trust / National Geographic

Image © Esther Horvath & Falklands Maritime Heritage Trust / National Geographic

Image © Esther Horvath & Falklands Maritime Heritage Trust / National Geographic

ROV PLANET WINS 2ND PRIZE

in the "General Excellence – Periodicals" Category Awarded by the Idaho Press Club

ROV Planet (now published as Ocean Robotics Planet) won the 2nd prize award by the Idaho Press Club. The article titled "Deep Trekker Treks into Tech" was awarded in the "General Excellence – Periodicals" category.

About the Idaho Press Club

The Idaho Press Club is a statewide association of working journalists, from all media, dedicated to improving the practice of journalism in Idaho. The Idaho Press Club's mission is to promote excellence in journalism, freedom of expression, and freedom of information.

OCEAN ROBOTICS Planet Powered by ROVplanet

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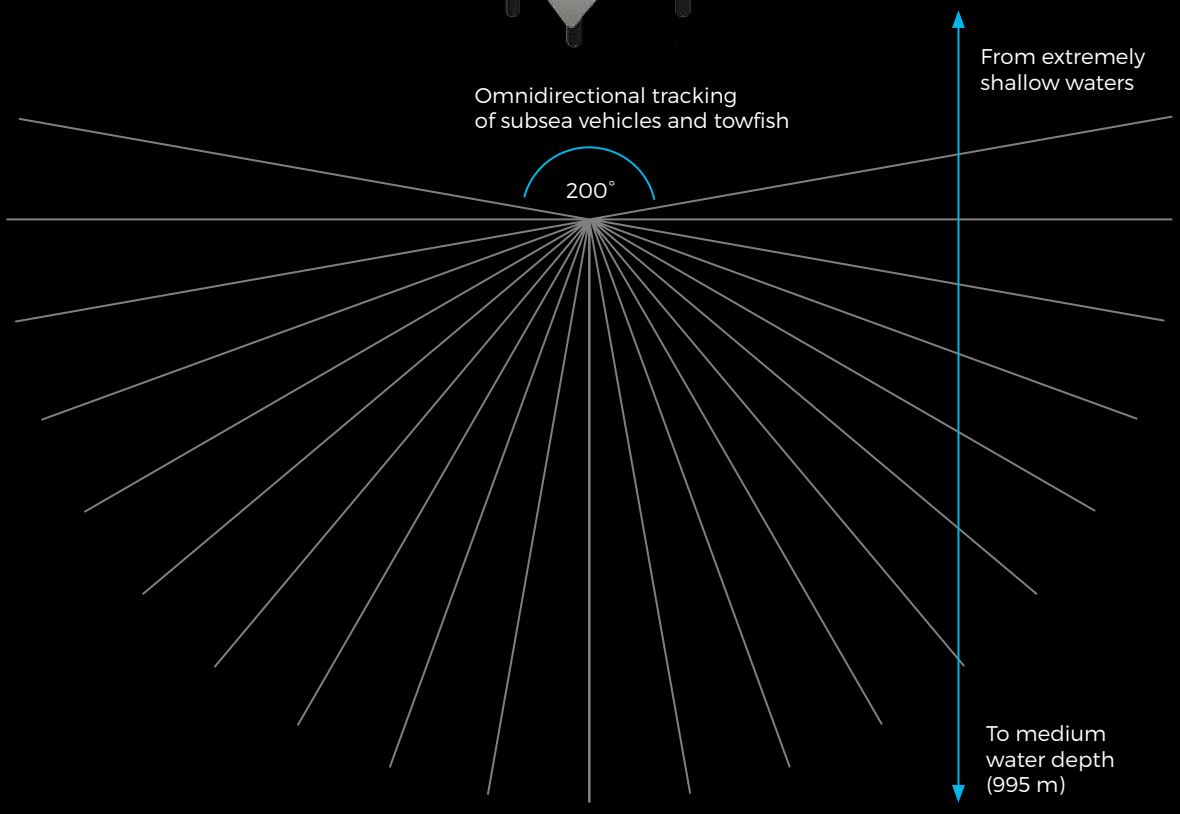
Never lose track of your AUV.

GAPS M5 USBL SYSTEM
Gaps M5 offers an export-free, pre-calibrated positioning and communication solution for the tracking of subsea vehicles and towfish. Its telemetry feature allows for AUV control & command, INS recalibration, as well as efficient data retrieval.



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