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30

ISSUE

Q1 / 2022

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EVENTS CALENDAR 2022

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

FEBRUARY

MTS/IEEE OCEANS'22
Chennai, India (21-24 February 2022)

SUBSEA EXPO
Aberdeen, Scotland, UK (22–24 February 2022)

MARCH

OCEANOLOGY INTERNATIONAL
London, UK (15–17 March 2022)

APRIL

WINDEUROPE 2022
Bilbao, Spain (5-7 April 2022)

DEEP SEA MINING SUMMIT
London, UK (26-27 April 2022)

MAY

OFFSHORE TECHNOLOGY CONFERENCE (OTC)
Houston, TX, USA (2-5 May 2022)

AQUACULTURE UK
Aviemore, UK (3-5 May 2022)

UNMANNED MARITIME SYSTEMS TECHNOLOGY (UMS)
London, UK (11-12 May 2022)

JUNE

UNDERSEA DEFENCE TECHNOLOGY (UDT)
Rotterdam, The Netherlands (7-9 June 2022)

GLOBAL OFFSHORE WIND 2022
Manchester, UK
(21-22 June 2022)

SEPTEMBER

WINDENERGY
Hamburg, Germany (27-30 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)

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,

We have decided to rename the title of the magazine to better reflect the ongoing changes in the industry. Long gone are the times of using only ROVs in subsea operations and the focus is steadily moving towards other types of new robotic solutions and platforms entering the underwater space: AUVs, UUVs, USVs, ROTVs, ROV/AUV hybrids, resident vehicles, and the list of acronyms go on. Of course, we have been covering many of these technologies over the past years, but we felt that it was important to state the obvious in the title of the magazine too.

In this issue we have a great line up of articles for you starting with a range of unique remote robotic solutions offered by TSC Subsea that are delivered via the use of ROVs to inspect welds, wall thicknesses of pipes, and other NDT solutions to monitor the integrity of underwater structures. Then we look at remote operations and piloting from operating centres. Oceaneering is the leader of this technology and has developed its own Remote Piloting and Control Technology (RPACT) to facilitate control of the ROV from beyond the horizon.

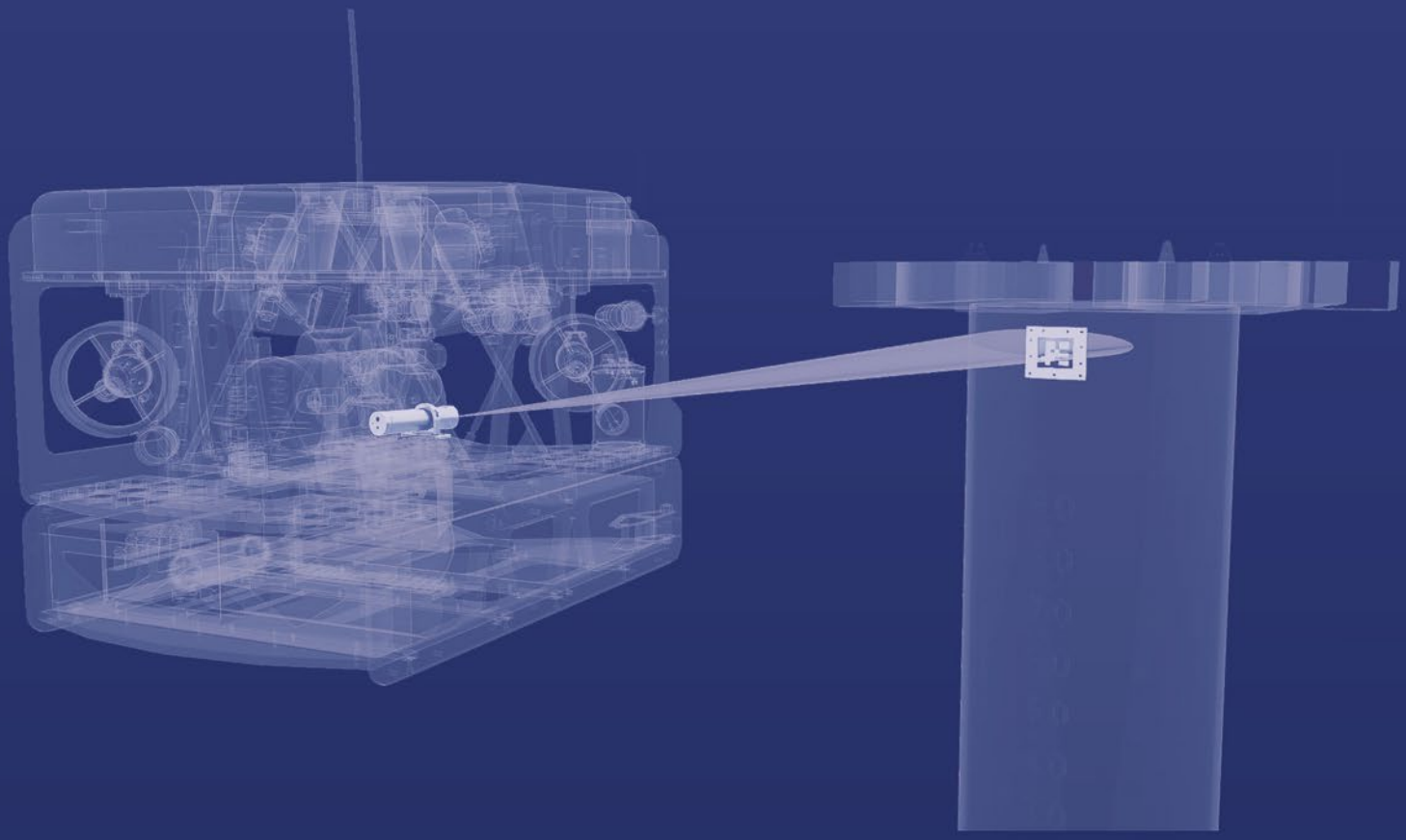
We are also featuring a range of Unmanned Surface Vessels such as the new 18m SEA-KIT, the T38 Devil Ray, and the DriX FlipiX combo. These unmanned surface vehicles have an increased role to play in unexploded ordnance (UxO) and mine countermeasure (MCM) applications.

Finally, we have a couple of interviews where we sit down with experts to find out more about the demo of a new hydrogen powered subsea HPU and about the trends in undersea warfare.

We hope that you will enjoy reading this issue and look forward to meeting many of you again at conferences and exhibitions in 2022.

Best regards,
Richie Enzmann

Inclination Monitoring Has Never Been So Easy



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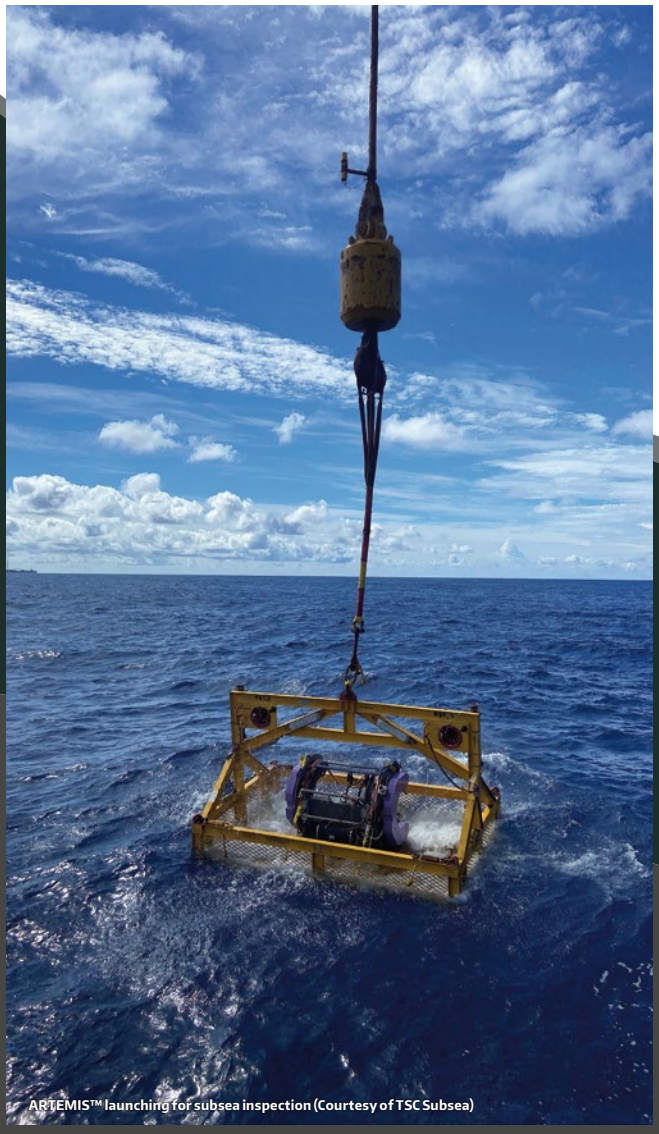
V-LOC calculates your assets real-time coordinates thanks to open-source tags which are affixed to them. Our technology is embedded inside a calibrated camera which exists in both air and subsea versions for highly accurate marine surveys.

FORSSEA ROBOTICS

IMPROVING SUBSEA INSPECTION COSTS AND SAFETY

THROUGH ROV DEPLOYED REMOTE ROBOTIC SOLUTIONS

TSC Subsea is a global leader in designing innovative, cutting-edge, remotely deployed subsea NDT systems for the energy sector.



ARTEMIS™ launching for subsea inspection (Courtesy of TSC Subsea)

Specialising in developing advanced subsea inspection methods, the technology and suite of tools it has developed is demonstrating how the rise of increasingly sophisticated robotics is creating a safer industry, carrying out crucial and essential inspections in areas where divers can't operate.

Year on year, it's refining and developing its expertise, demonstrating that innovation and the adaptability to match clients' needs are providing solutions where it was thought none existed. It's doing this through processes that are safer and more cost-effective, while producing exceptionally accurate, auditable, quality data.

In the past 12 months alone, that expertise, ingenuity, and globally leading solutions have been in such demand that the company has had to respond to increased customer requirements. It has expanded from its core bases in Norway and the UK to open new facilities in Brazil, the US, and Australia

NodeScanner™ installed on a Work Class ROV (Courtesy of TSC Subsea)

At the heart of its growth has been the introduction of a range of new tools. These have been developed in co-operation with clients to solve specific problems in some of the most challenging underwater terrains around the world, while enhancing the existing solutions in its high technology toolbox.

And in the energy transition journey and the move towards net zero, the market-leading remote inspection technology which TSC Subsea is developing is key to reducing carbon footprints. It helps reduce the need to move personnel around the world. Employing the latest communication technology to support its remotely deployed tooling, the company is continuing to push those boundaries even further, increasing the effectiveness of operations.

Born and bred in the oil and gas sector, the company is looking ahead to the future. Many of the offshore wind turbine foundations mirror the types of platforms found in the O&G sector, with the same failure mechanisms. Fatigue cracking in welds due to dynamic loading on jackets has been an issue since their first installation offshore in the North Sea in the early 70's. This has been a key application for TSC Subsea technology.

Its proprietary ACFM tech was originally developed to solve this major problem more than 30 years ago. Over the last decade, TSC Subsea has developed diverless automated scanning systems, deployed by ROV to check the nodal welds for fatigue cracks on jacket style platforms. Now, with wind turbines being built using the same style, it is the ideal opportunity to deploy TSC Subsea expertise and tech to a different sector.

This also applies to break-down of grouting connections on monopile structures; the same connections exist in oil and gas with the same expected failures over time. TSC Subsea worked with a major Norwegian O&G operator throughout 2021 to develop a robust tech-driven solution to accurately map the integrity of the connection using its ART technology.

With larger offshore wind developments coming online, more advanced, tech-driven diverless solutions are required. TSC Subsea's readily transferable portfolio of inspection technology, scanners, and crawlers is well placed to service the offshore wind sector.

INNOVATIVE TECHNOLOGIES: ART, ACFM, PECA AND PA

TSC Subsea's proprietary inspection technology is based on Acoustic Resonance Technology (ART), Alternating Current Field Measurements (ACFM), Pulsed Eddy Current Array (PECA), and Phased Array (PA) platforms. This range of technologies provide clients with cost effective diverless solutions to efficiently improve the asset integrity knowledge of their infrastructure. Utilising high quality data, packaged within field-proven scanning systems, allows our clients to manage operations based on the most reliable and repeatable inspection results. This minimizes unscheduled stoppages, incidents, and environmental impacts.

WALL THICKNESS MAPPING

ART is a patented, ultra-wideband acoustic inspection technology which offers penetration and wall thickness measurement capabilities through coatings and exceeds those of existing inspection technologies. In addition to analysing the material resonances, the technology uses time-of-flight measurements. These provide accurate external geometry measurement for ovality and dents.

ART uses a transducer which shoots a broadband sound signal toward a target such as a pipe wall. The signal duration is sufficiently long to generate oscillations in the target. As the oscillating target continues to be struck by the sound signal, the resonance greatly amplifies the oscillations. The resonating frequencies are characteristic of the thickness and material of the target. Attaining accurate data with direct measurement of wall thickness makes it possible to calculate corrosion rates more effectively and cuts down on the number of inspections that are ultimately required.

TSC Subsea's ART is deployed remotely via our ARTEMIS™ system to provide unique external inspection of subsea assets, including rigid and flexible pipelines, flowlines, and risers.

CRACK DETECTION TECHNOLOGY

ACFM® was originally developed as a way for divers to find and depth-size fatigue cracking in jacket structures, so it's no surprise that the technique has become a benchmark in subsea crack detection. We use the latest generation U41


NodeScanner™ in action (Courtesy of TSC Subsea)


MagCrawler™ inspecting a weld (Courtesy of TSC Subsea)

true ACFM® subsea inspection system. It's recognised as the industry-standard platform for diver, and ROV-deployed inspections where high PoD and low false calls are key factors in the determination of offshore asset integrity. The ability to accurately depth-size defects to produce the information required allows engineering decisions to be made that protects and extends the life of these assets.

ACFM®, remotely deployed via our NodeScanner™ and MagCrawler™ equipment, provides external inspection of subsea asset welds and other crack-like indications. ACFM® introduces an alternating current into the surface of a component to detect surface-breaking cracks. The presence of a crack disturbs the electromagnetic field, and the return signal is instantaneously converted by advanced mathematical techniques so that operators are alerted to the presence of defects.

CORROSION SCREENING

PECA is an advanced electromagnetic inspection technology used in detecting flaws and corrosion in ferrous materials typically hidden under layers of coating or marine growth. It's deployed remotely via our robotic scanning systems. TSC Subsea's Subsea Pulsed Eddy Current Technology Array (SPECTA) scans through thick insulation such as concrete and polypropylene, which are used to protect subsea pipelines and structures. SPECTA is also well suited for the inspection of subsea storage tanks, piles, and vessel hulls because there is no need to remove heavy marine growth.

A magnetic field is created by an electrical current in the coil of a probe. When the probe is placed on the pipe or structures coating, the field penetrates through all the layers (including sheeting, if present) and stabilises in the component thickness. Then the electrical current in the transmission coil is turned off, causing a sudden drop in the magnetic field.

As a result of electromagnetic induction, eddy currents appear in the component wall. The eddy currents diffuse inward and decrease in strength. The decrease in eddy currents is monitored by the SPECTA probe and used to determine the wall thickness. The thicker the wall, the longer it takes for the eddy currents to decay to zero. SPECTA is therefore utilised to assess transient eddy currents in a conductive component following a sharp electromagnetic transition.

DELIVERY AND SCANNING SYSTEMS TO DEPLOY THE TECHNOLOGIES

The type of technology to be utilised depends on the type of inspection the client wants to perform. However, the deployment method for this technology also depends on the access and geometry of the object being inspected.

In recent years TSC Subsea have developed several application-specific delivery systems and scanners. Our ARTEMIS system that is perfectly suited to pipelines and risers; the teach-and-learn node scanners which learn and repeat the complex weld geometry of a nodal weld; the magnetic crawlers capable of navigating to the inspection site from topside; and the grout integrity scanners for the pile connection that verify the grout seal condition typically found on offshore wind turbine towers.

ARTEMIS

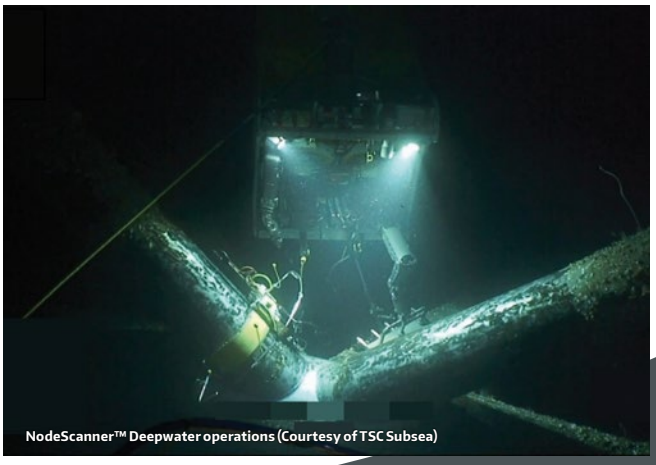
ARTEMIS® is a subsea external pipeline and riser inspection system that inspects subsea pipelines and risers with measurement capabilities which exceed existing alternative technologies. It is deployed on an ROV to inspect subsea pipelines in order to assess their internal condition. With its unique sensor design, it can perform a full circumferential scan in a fraction of the time needed by other technologies. Also, as there is no radioactive source, health and safety risks are significantly reduced.

ARTEMIS VCOMPACT

The ARTEMIS® vCompact has been designed, developed, and built by TSC Subsea's team of engineers to work in tandem with inspection and work-class ROV's for the remote inspection of subsea pipelines and structures. High-resolution wall thickness measurement through coating is made possible with the inclusion of ART as part of the ARTEMIS® vCompact design.

GROUTING INTEGRITY ASSESSMENT

The only subsea external scanning inspection for grouting integrity assessment currently in use in the North Sea, the ART GUIDE (Acoustic Resonance Technology Grout Underwater Inspection DElivery) system is remotely deployed using work or inspection class ROVs and is designed for quick interfacing.


NodeScanner™ Deepwater operations (Courtesy of TSC Subsea)


ARTEMIS™ Field joint inspection on a piggyback line (Courtesy of TSC Subsea)

MagCrawler™ in action (Courtesy of TSC Subsea)

It was custom designed and built for a major operator in the North Sea to cover a technology gap, providing a solution which could improve the level of input data for the integrity assessment on grouted structures. ART GUIDE is made for the inspection of grouted connections, anywhere that two steel interfaces are connected using grout. It has applications on offshore platforms, fixed offshore wind installations, the hulls of ship, and other subsea applications.

NODESCANNER™

Certain jacket nodes — fatigue-sensitive nodes for example — are subject to significant dynamic loading and require regular inspections to detect the initiation of fatigue cracks. The complex nature of the welds rules out inspections via 'direct scanning' even with the best work-class ROVs, and the difficult access and conditions are often outside the capabilities of divers.

TSC Subsea's field proven NodeScanner™ system addresses these issues. An ROV places the NodeScanner on the brace, then stands back and monitors the inspection progress. The NodeScanner's unique teach-and-learn system provides the dexterity and control needed to quickly and accurately scan the area in question.

The NodeScanner system, designed to work in tandem with ROVs in the deployment of TSC Subsea's ACFM® array probes, inspects difficult-to-reach areas and complex geometries, such as tubular welded node joints. The multi-element arrays ensure maximum weld coverage and POD, whilst limiting false calls.

MAGCRAWLER™

The TSC Subsea MagCrawler™ represents the latest in remote subsea inspection technology. It was developed specifically to enable the ROV deployment of TSC Subsea's exclusive ACFM® array probes to inspect subsea geometries such as circumferential welds in pipes/tubulars, fillet, and full-penetration welds in plates. The MagCrawler™ provides access to areas that are restricted, dangerous, or expensive to reach using divers, such as the splash zone and confined compartments. Once the MagCrawler™ magnetically attaches to the inspection surface, the ROV releases it. Two rubber caterpillar tracks provide crawler traction and are highly manoeuvrable to steer the crawler over the inspection surface.

TSC SUBSEA

ENHANCING TRUST UNDERWATER

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RUBHY ACOUSTIC BUOY

REAL TIME DATA ANALYSIS

PAM

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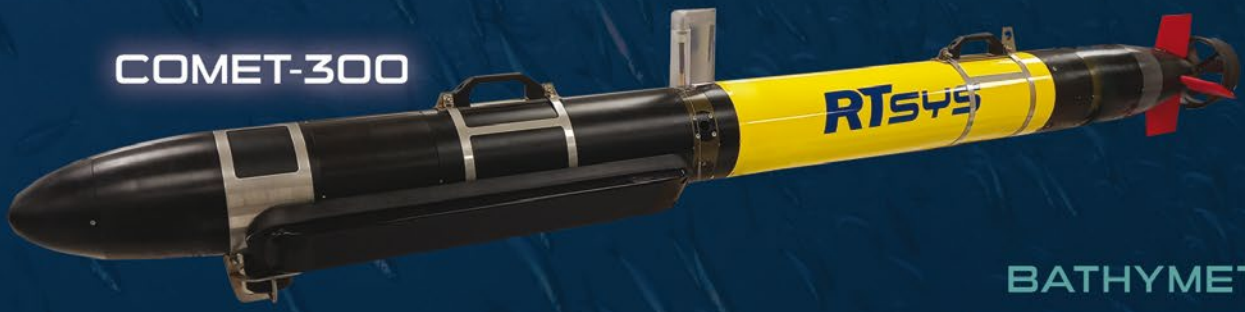
Underwater Acoustics & Drones

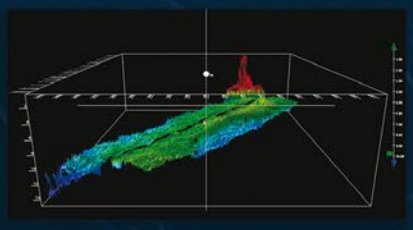
COMET-300



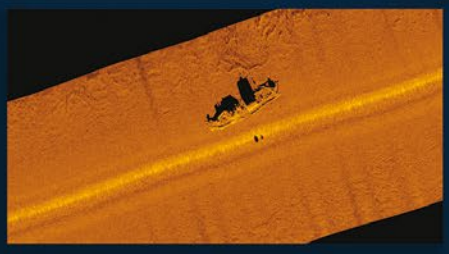
AUV

NEMOSENS by RTSYS

BATHYMETRY



SEABED SURVEY



WATER QUALITY

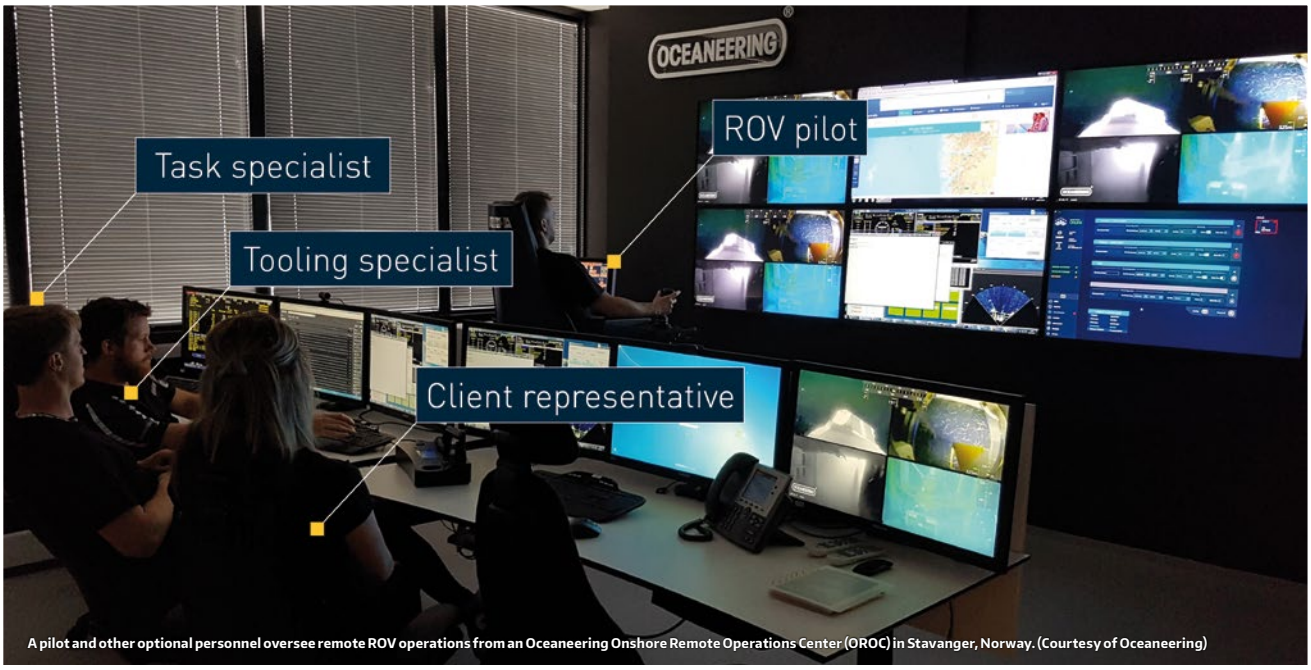
rtsys.eu

An Illustration of Remote Operations. (Courtesy of Oceaneering)

MAKING THE CASE FOR SAFE, ROBUST REMOTE OPERATIONS

By Mark Philip and Nick Rouge, Oceaneering

While the COVID-19 pandemic has highlighted the need to reduce offshore-based work crews and enable home- or office-based personnel to contribute to teams anywhere around the globe, the groundwork to enable this new way of working began almost 20 years ago.



A pilot and other optional personnel oversee remote ROV operations from an Oceaneering Onshore Remote Operations Center (OROC) in Stavanger, Norway. (Courtesy of Oceaneering)

Today, Oceaneering can operate Remotely Operated Vehicles (ROVs) from virtually anywhere, including dedicated Onshore Remote Operation Centers (OROC) in Stavanger, Norway; Morgan City, Louisiana; and a new OROC opening soon in Aberdeen.

WHAT IS REMOTE ROV PILOTING?

An ROV is by nature a device that is remotely operated by a pilot situated several kilometers away. Remote ROV operation is similar in nature; the main difference being that the separation between pilot and ROV is now many hundreds, or even thousands, of kilometers away. This "virtual extension" of the ROV's umbilical is accomplished using high-speed vessel-to-shore data communications links, such as VSAT, LTE, or subsea optical fiber. In addition to piloting activities, the ROV remote piloting enables subject matter experts, task specialists, certified inspectors, and customer and third-party witnesses to participate in offshore activity from an onshore OROC or any other worksite.

Oceaneering has developed its Remote Piloting and Control Technology (RPACT) to facilitate control of the ROV from beyond the horizon. This specialized control software includes a handshaking system that is used to transfer ROV control between local (offshore) and remote (onshore) pilots. This, combined with visual and audible indicators, ensures that each pilot is fully aware of who has control of the ROV at any given moment. The software supports both full and partial transfer of control. Partial transfer of control enables the local pilot to fly the ROV while the remote pilot operates manipulators, or vice versa. The software continuously monitors the quality of the connection and provides failsafe features that ensure control automatically defaults back to the local pilot if the communication link fails unexpectedly. These features are all crucial to ensuring that the customer's operations can be conducted safely and reliably from shore.

Onshore ROV pilots also need to be able to see the images from the ROV to control it safely. Specialized video streaming equipment is used to transmit video to shore in a manner that minimizes both bandwidth consumption and latency. These features are vitally important, as bandwidth is typically limited at offshore worksites and excessive latency can make it challenging to operate the ROV.

When remote piloting operations are performed from a manned vessel, rig, or platform, the ROV crew consists of offshore pilots and technicians in addition to onshore pilots. The offshore team also handles the launch and recovery, tooling changes, and vehicle maintenance required.

Activities carried out using remote operations from shore-based centers include general visual inspection, close visual inspection, cleaning, leak detection, and interfacing with subsea infrastructure, etc. The image above shows one of our operation rooms in action and demonstrates the range of personnel (both Oceaneering and Customer) that can be relocated onshore using this technology.

BENEFITS

Working from a remote onshore-based location eliminates offshore and transportation safety exposure for the shore-based team. On multiple occasions Oceaneering has transitioned from 12-hour operations to 24-hour operations without the need for additional personnel mobilization. This flexibility has been key in responding to unforeseen shifts in the end users' operations.

For example, subsea specialists are often required to go offshore, but typically spend several days on the asset due to logistical needs and uncertainty of the time the operation will take place. Now this is no longer necessary. Remote piloting of ROV systems from shore enables teams to manage multiple operations that require specialist oversight from a single location.

Illustration of how the handshaking system works to transfer ROV control between local and remote pilots. (Courtesy of Oceaneering)

Remote ROV Piloting also brings benefits for workers, who are now able to maintain a better work/life balance. Instead of being offshore for several weeks at a time, they can work a standard shift at an onshore-based office, or even a home office, while remaining close to family and friends.

REMOTE PILOTING TECHNOLOGY DEVELOPMENT AND OPENING OF FIRST OROC

Oceaneering's first proof-of-concept demonstration occurred in 2004, when an ROV in the North Sea was controlled from our office in Stavanger, Norway. The demonstration was highly successful, but the industry was not ready to embrace this new mode of operation and so it subsequently lay dormant for a few years.

Around 2014, Oceaneering began to see an increased demand from customers to reduce headcount at offshore job sites. Reducing headcount saves costs to the customer, as well as reducing the carbon emissions associated with transporting and housing personnel offshore. Furthermore, it provides greater flexibility in staffing levels, as personnel can be mobilized to an OROC much faster than it takes to travel to an offshore worksite, particularly if that site happens to be overseas.

In response to this increasing demand, 2015 saw Oceaneering open the first OROC in Stavanger, Norway. This state-of-the-art facility has five operation rooms, allowing simultaneous operation of up to six ROV systems offshore, as well as providing office and lounge facilities for visiting customers. There are plans to add two additional operating rooms due to increasing demand.

A key enabler for remote piloting from our OROC facility in Stavanger is the extensive LTE data network that has been established in the North Sea. This high bandwidth, low latency data network is ideal for remote operations.

REMOTE SURVEY

In 2016, Oceaneering's Survey group began offering its Remotely Operated Survey (ROS) services. ROS allows an onshore surveyor to operate a suite of survey equipment installed on a vessel or rig offshore. To support this business, our Survey OROC was established in Lafayette, Louisiana. This facility allows an onshore surveyor to remotely operate equipment at multiple offshore worksites simultaneously and completely removes the need for personnel offshore once the equipment has been installed. To date, the group has successfully supported over 100 rig moves.

In addition to rig positioning, the Survey OROC fully supports remote metrology, fully remote Acoustic Doppler Current Profiles (ADCP), and hybrid onshore/offshore vessel positioning.

ROS requires less bandwidth than remote ROV operations, which makes it ideally suited to areas where communications infrastructure is less well developed, such as the Caribbean and West Africa.

REGIONAL EXPANSION AND REDUNDANCY

In 2020, a second ROV OROC was opened in Morgan City, Louisiana, which has the capacity to support simultaneous operation of up to four ROV systems. Its primary function is to support remote ROV operations in North and South America. However, the facility offers important redundancy for remote ROV operations, as each of our OROCs can quickly assume the duties of its counterpart in the event of unexpected power or data outages.

The Morgan City OROC has since conducted the first commercial remote piloting of an ROV in the Gulf of Mexico (GoM) using the customer's existing data communications infrastructure, which included a high-speed microwave link to a tension leg platform (TLP) offshore. A proprietary remote piloting package was shipped to the asset and installed by the ROV crew onboard the asset in the GoM. This package established a secure communications link to shore, which was used to transmit video, audio, and control data.

By utilizing pilots at OROC, the customer successfully completed the work scope while reducing overall headcount offshore.

Additional work scopes in GoM are planned for 2022.

CROSS BORDER REMOTE PILOTING

In 2021, Oceaneering worked with a client in the UK to successfully conduct the first onshore remote piloting of an ROV offshore West of Shetland. It was also the first commercial cross-border implementation due to the pilots sitting in Oceaneering's Stavanger facilities.

From 20 July to 5 August, Oceaneering was tasked with observing drilling operations at 141 m water depth. The Stavanger-based remote piloting team operated the ROV for over 70 hours during the campaign program with 100% uptime.

Oceaneering and the client worked together to ensure secure offshore connectivity for the remote ROV piloting operations. This involved close collaboration between Oceaneering and the client to establish a bridge between the data networks of both companies, without compromising their respective cyber security policies. The result of the collaboration established a secure data link via subsea optical fiber to the worksite offshore.

RESIDENT ROVS

Oceaneering's remote piloting technology is a key enabler for its fully remote Liberty™ E-ROV system, which once deployed, is operated exclusively from shore without the need for a surface support vessel. This work class ROV system is entirely self-sufficient with onboard battery and LTE communications systems.

Mission duration is dictated by work scope, which places varying demands on the battery system. Liberty has been specifically designed to maximize battery life using a combination of power-efficient hardware plus software features that include the ability to hibernate when not in use. Deployments of up to 60 days have easily been accomplished since the vehicle was introduced.

Removing ROV crew, customer representatives, and the support vessel from the offshore worksite significantly reduces the cost and carbon footprint of the campaign.

TRAINING FOR THE NEW WAY OF WORKING

Oceaneering recognized very quickly that remote operation of an ROV introduces new challenges for pilots, in particular the added latency inherent in long-distance data links. As a result, we have developed a competency program that teaches pilots how to:

- Mitigate the effects of latency
- Safely pass control between local and remote consoles
- Collaborate on control e.g., one pilot flies and the other operates manipulator
- Effectively communicate when not co-located
- Safely manage unexpected loss of communication.

CONCLUSION

Collaboration between service companies and operators has led to the successful implementation of remote ROV operations in Europe and the US Gulf of Mexico. This approach has brought benefits such as reducing HSE exposure to personnel (particularly critical during the pandemic), providing leadership in operations that one day will become the norm.

The biggest challenge in moving ROV control to an onshore facility has historically been the data communications path. Communications infrastructure offshore has greatly improved over the past 10 years, with optical fiber cables and LTE networks becoming more widely available, especially in the North Sea and Gulf of Mexico. On projects where existing communications infrastructure is insufficient, Oceaneering can install a fully redundant satellite agnostic intelligent link (SAIL) to ensure 99.9% uptime for data communications.

As a result of this connectivity, remote operations have grown exponentially over the past three years and Oceaneering recently surpassed the significant milestone of 70,000 hours of remote ROV operations, with half of this total occurring in 2021 alone.

Oceaneering remains focused on advancing ROV and automated vehicle systems to realize a reduced carbon future. Remote operations play an important part in lowering carbon footprints associated with offshore energy generation. Our Liberty E-ROV and Freedom™ AUV systems further the goals of reducing mobilization, reducing HSE risks to personnel, reducing environment footprint, and making subsea work more efficient. Furthermore, we continue to advance a new generation of ROVs designed specifically with remote operations in mind.

With our investment in technology and facilities, Oceaneering is fully committed to maintaining its position as the leading provider of remote ROV and Survey services.

ABOUT THE AUTHORS

Mark Philip is a Senior Manager for Oceaneering's remote services and control software business. He has been with Oceaneering for 36 years. He holds an Electrical and Electronic Engineering degree from Robert Gordon's Institute of Technology in Aberdeen.

Nick Rouge is a Subsea Robotics Product Manager for Oceaneering, Nick is responsible for commercializing remote piloting in the Gulf of Mexico. Nick earned his Bachelor of Science in mechanical engineering from Texas A&M University and is pursuing a Master of Science in subsea engineering from the University of Houston.

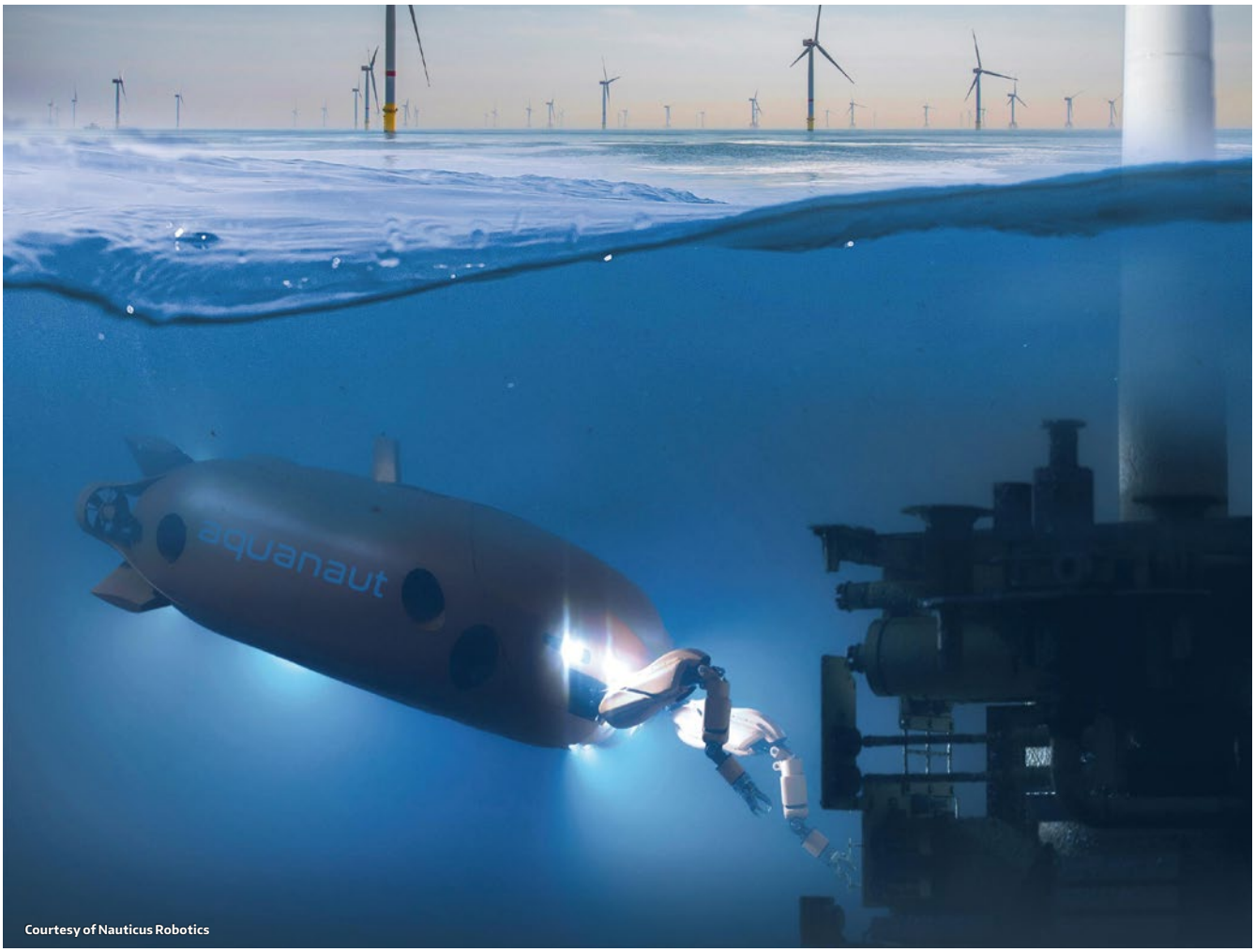
Author Mark Philip
(Courtesy of Oceaneering)

Author Nick Rouge
(Courtesy of Oceaneering)

NAUTICUS ROBOTICS TO GO PUBLIC VIA SPAC MERGER

Nauticus Robotics, Inc. is combining with CleanTech Acquisition Corp. (CLAQ) in a deal that will result in Nauticus becoming a public company. Upon closing of the transaction, CleanTech Acquisition Corp. will be renamed Nauticus Robotics, Inc. listing on Nasdaq under the new ticker symbol "KITT". Nauticus is expected to have a pro forma equity valuation of $561 million, assuming no redemptions, as reported in the company's December 2021 definitive agreement announcement.

Courtesy of Nauticus Robotics



Courtesy of Nauticus Robotics

Led by former National Aeronautics and Space Administration (NASA) engineers including Founder, Chairman and Chief Executive Officer Nicolaus Radford, the Houston-area autonomy software and robotics firm has identified significant parallels between space and sea, adapting spaceflight technology to accelerate the blue economy. Using artificial-intelligence software that enables their robots to make robust decisions underwater to enable complex actions, Nauticus is pioneering revolutionary improvements to the existing infrastructure required for underwater operations. The status quo spread currently deployed has arguably not changed its basic form for over 50 years, when ROVs were first introduced as an, at the time, innovative means to push deeper into the ocean in place of divers. In today's environmentally sensitive and cost-conscious mindset, emerging markets are challenging the existing methodology.

"With applicability in sectors across renewable and conventional energy, port management, defense and even aquaculture, the autonomous software and robotic fleets we're building have the opportunity to disrupt the multibillion-dollar ocean services market," Radford commented. "By setting out to penetrate this market with our fleet of ocean robots from the surface to the seabed, Nauticus is providing more cost-effective, safer and sustainable alternatives across the marine technology and services industry."

Nauticus seeks to replace the large, heavy topside infrastructure commonly powering legacy systems with its own fleet of green, autonomous marine robots. The company's proprietary cloud-based AI software platform, aptly named ToolKITT, allows for the autonomous nature of these machines, ultimately providing safer and more cost-effective operating conditions with limited need for on-site personnel. Nauticus' robots can perform a host of complex oceanic duties, from data collection and surveillance to subsea asset maintenance.

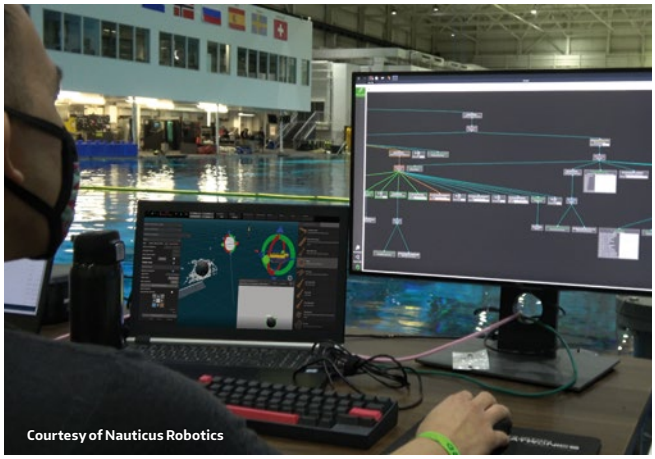
THE MERGER AGREEMENT

Engineers at Nauticus have been developing the software platform responsible for the functionality of its robots since 2014, which they believe will not only supplement but also vastly disrupt the current market. Capitalizing on investor enthusiasm from industry heavyweights such as Schlumberger and Transocean, Nauticus has sought financing through its merger to help make that objective a reality. According to Radford and CleanTech Acquisition Corp. CEO Eli Spiro, the proposed transaction is an important step toward Nauticus becoming a major player in the space, supplying the capital and resources needed to accelerate growth and further develop its suite of autonomous software and robots to achieve the intended future state of the Blue Economy.


Courtesy of Nauticus Robotics


Courtesy of Nauticus Robotics


Courtesy of Nauticus Robotics


Courtesy of Nauticus Robotics

"This merger with CleanTech to bring Nauticus public represents an important milestone in the evolution of the Nauticus story and, even more importantly, a tangible step closer to our company's goal of solving ongoing problems in the Blue Economy with meaningful, innovative and environmentally conscious solutions," said Radford. "I'm looking forward to this partnership and everything it will yield for our combined company." Radford and Spiro expect a strong growth trajectory in the coming years.

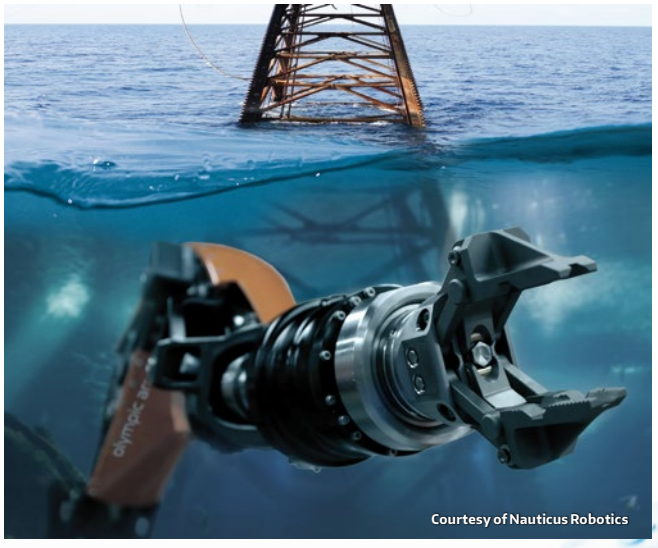
ABOUT NAUTICUS

Nauticus Robotics is a Houston-area developer of ocean robots, autonomy cloud software, and services that provide 21st century ocean robotic solutions to combat the global impacts on the world's marine environment. The interconnected, purpose-built product ecosystem of both surface and subsea robots is powered by Nauticus' autonomous software platform ToolKITT that affords ocean robots real machine intelligence, not just automation. This approach will transform the industry to an economically efficient and environmentally sustainable model. This modernized approach to ocean robotics as a service has resulted in the development of a range of products for retrofit/upgrading legacy systems and other vehicle platforms. Nauticus' services provide customers the necessary data collection, analytics, and subsea manipulation capabilities to support and maintain assets while significantly reducing their operational footprint, operating cost, and greenhouse gas emissions, to improve offshore health, safety, and environmental exposure.

ABOUT CLAQ

CleanTech Acquisition Corp. is a special purpose acquisition company formed in June 2020 with the purpose of entering into a business combination with one or more businesses. CleanTech Sponsor I LLC and CleanTech Investments LLC, an affiliate of Chardan, are the founders and co-sponsors of CLAQ.

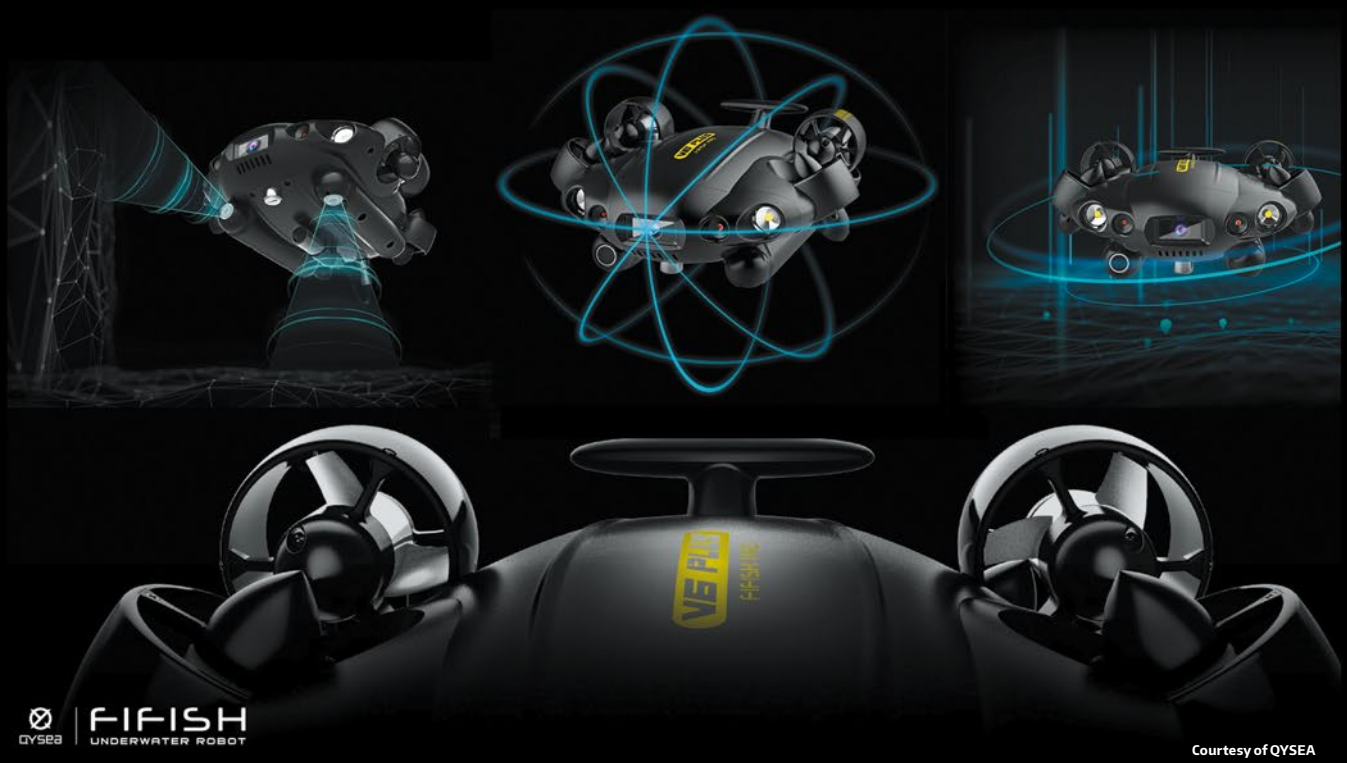
For more information about Nauticus, its vision, and its product line, visit nauticusrobotics.com


Courtesy of Nauticus Robotics

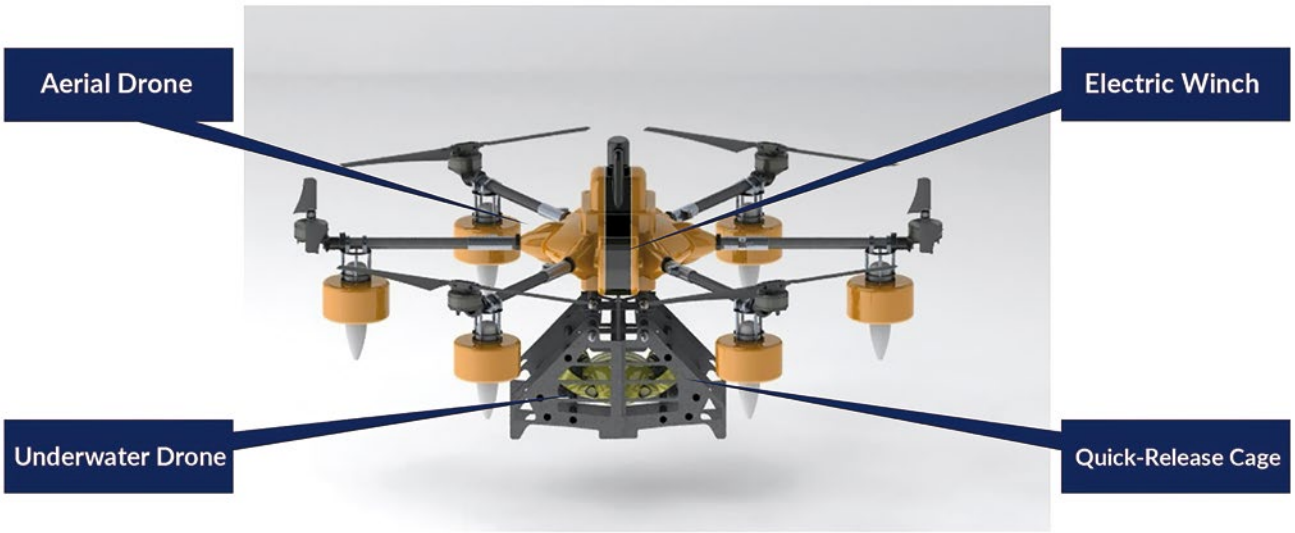
ROV PLANET BUYER'S GUIDE

WORLD'S FIRST SEA-TO-AIR DRONE REDEFINES OFFSHORE OPERATIONS

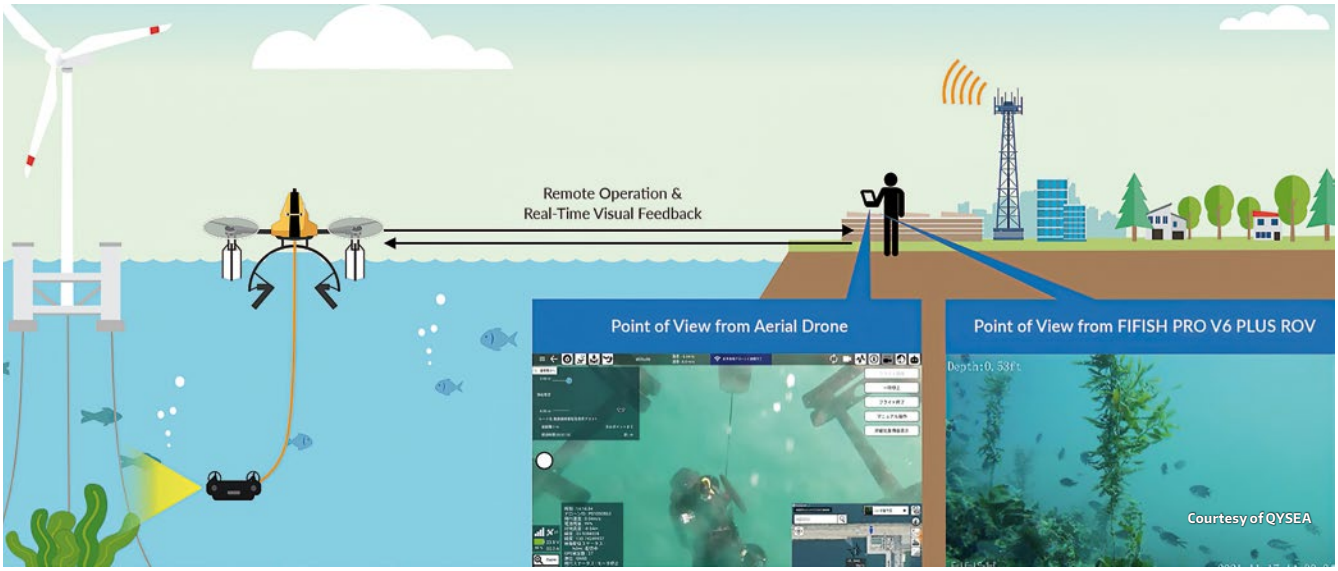
Although ROVs are highly capable of performing a variety of underwater operational tasks on their own, getting them to actual dive sites can still prove challenging at times. An all-new integrated system is designed to help, by using an aerial drone to transport and deploy a compact-sized professional ROV.



Courtesy of QYSEA



Courtesy of QYSEA



Known as the Sea-Air Integrated Drone, the hybrid setup was recently demonstrated in December of 2021 at the Hakkeijima Sea Paradise amusement park in Yokohama. The project was brought to life and into the oceans through a partnership between Japanese telecommunications operator KDDI, commercial drone manufacturer PRODRONE, and underwater robotics firm QYSEA Technology. The revolutionary drone aims to modernize offshore and marine operations through its intelligent capabilities, seamless operational efficiency, and minimized human risks.

SEAMLESS OPERATION FROM LAND, AIR, AND SEA

The world's first sea-to-air drone essentially features the combination of a heavy-duty aerial drone and QYSEA's industrial-class FIFISH PRO V6 PLUS ROV. This ambitious project had been set out by KDDI six years earlier, who had sought to combine advanced mobile communication networks with high-performance UAV technologies that would deliver extended flying distances and operating times.

The drone is operated remotely to fly to its pre-set route at sea. After landing at its designated location, the FIFISH ROV is released and deployed to work. Using a 5G system and network, the pilot is then able to remotely operate the ROV from a safe working location, and perform a variety of underwater inspection, maintenance, and repair tasks.

A shore-based human operator utilizes long-range mobile communications to initially fly the system out to its offshore destination, where they are guided by both GPS and a real-time feed from the multicopter's onboard cameras. The user then lands the copter on the water, where it rests on attached floats, with one on each of its six arms. The FIFISH is subsequently released from its cage but remains attached to the multicopter by its communications cable. It then proceeds to perform its dive, controlled remotely by the operator, who is now watching the real-time video feed through the ROV's 4K camera. Once the diving task is complete, an electric winch on the multicopter is used to pull the FIFISH back into its cage, so that the vehicle as a whole can fly back to its onshore destination.

Courtesy of QYSEA

The technological achievement between KDDI and QYSEA has resulted in the first commercial drone capable of operating seamlessly through land, sea, and air.

ELEVATING UPON TRADITIONAL METHODS

Traditional and widely used methods for underwater inspections often involve challenges with time, energy, monetary costs, and human risks, where human workers needed to drive boats out to offshore platforms and make multiple dives through unpredictable, and at times dangerous, underwater environments to complete their inspections.

The KDDI and QYSEA jointly developed 'Sea-Air Integrated Drone' provides a breakthrough within remote marine-based operational work. Without needing to leave their onshore working locations, operates can safely and efficiently conduct inspections with real-time visual feedback. In addition, operators can carry out tasks using a variety of sampling, measurement, and manipulation tools, as well as live-stream missions for multi-person collaborations.

ESSENTIAL MARINE-BASED APPLICATIONS

The 'Sea-Air Integrated Drone' shows to have far-reaching applications across various marine-based industries. Some of the drone system's possible applications include the inspection, maintenance, and repair work in aquaculture operations, offshore wind turbines, or other subsea infrastructures. The system will also be beneficial across scientific studies, hull inspections, or search and recovery missions.

Within offshore applications, the drone system can safely fly out to areas, deploying the ROV in unpredictable ocean environments and compact spaces to perform complex inspections and maintenance work of frames and foundations. For marine farms far away from shores, the drone system takes off and accurately lands at its destination, where the ROV is released to monitor livestock and crops, as well as perform net repairs, sick fish removal, and samplings of water quality through the ROV's multitude of add-ons.


Courtesy of QYSEA

With further details of its release coming in 2022, the 'Sea-Air Integrated Drone' will undoubtedly lead an essential path towards the development of a sustainable ocean economy and the global goal of carbon neutrality.

ADDITIONAL VEHICLE INTEGRATIONS WITH THE FIFISH

In China's Shandong province, QYSEA has recently teamed up with local technology scientists to debut the nation's first unmanned drone and ship for mariculture operations. Utilizing remote communication technologies, aquaculture farmers and scientists can sail out to farms to monitor livestock and crops from a safe onshore location.

Through the technological collaboration of ocean robotics and artificial intelligence, the unmanned sea vehicle delivers seamless surface-to-underwater control, ultra-clear and real-time imaging feedback, as well as remote autonomous operational capability. With fewer required costs, manpower, and energy, the emergence of compact unmanned ROVs is a great breakthrough in efficiency and sustainability, compared to the traditional methods used in mariculture operations. Established in 2016 within the heart of China's technology and manufacturing hub, QYSEA is committed to delivering exceptional expertise in the R&D, manufacturing, and sales of underwater robots. As a company, they have broken numerous industrial barriers to establishing a leading market position with their ROV technologies, proudly garnering recognition for their innovations (CES, Future Maker, GIC) and functionalities (iF Design, Good Design).

FIFISH PRO V6 PLUS ROV

FIFISH PRO V6 PLUS is a compact-sized expert in advanced underwater solutions. With a diving depth of 150 meters, an intelligent interface to add on a variety of add-on tools, and the all-new integration of a Q-motor stabilization system, small-scale underwater operations can be fully optimized.

The FIFISH PRO V6 PLUS delivers 6 degrees of freedom, allowing the operator to achieve any posture and angle of movement. With the intelligent distance and altitude lock systems, the ROV adapts to unpredictable environments to move with boosted stability.


Courtesy of QYSEA


Courtesy of QYSEA


Courtesy of QYSEA


Courtesy of QYSEA

Courtesy of Oceanology International

OCEANOLOGY INTERNATIONAL PREPARES TO REOPEN ITS DOORS

THE OCEANOLOGY INTERNATIONAL EXHIBITION AND CONFERENCE RETURNS TO EXCEL LONDON IN MARCH 2022

Heartening news for the global ocean technology and science community is that the Oceanology International (Oi) exhibition and conference is back on the calendar. The three-day Oceanology International 2022 is scheduled to take place in ExCel London on March 15-17, 2022 – and exhibitor numbers are reported to be already on a par with previous shows.

With the welfare of attendees a paramount concern, organiser RX Global has designed an exhibition and conference space which leaves no stone unturned in creating a covid-safe environment. This means that visitors will be able to take in the full range of diverse content provided by an Oi event for the first time in four long years.

In addition to the welcome return of long-term Oi exhibitors such as iXblue, Kongsberg Maritime, Fugro and Teledyne Marine, the Oi22 show floor will be accommodating 83 new stands hosting companies which are exhibiting at an Oi event for the first time. These include GeoAcoustics Ltd, which supplies sonar equipment for bathymetry, side scan and sub-bottom profiling; and Blueprint Lab, which manufactures robotic arms for use in challenging subsea environments.

At the centre of ocean innovation and technology, Oi will showcase world-first product introductions including the culmination of a four-year, EU-supported project called AIRCOAT, a revolutionary hull coating which reduces friction, fouling and emissions while increasing vessel performance. From Sweden, Amo Kabel will launch the first DNV-approved

Courtesy of Oceanology International

aluminium power cables, replacing traditional copper. A record-breaking underwater AUV thruster will be launched by Tianjin Haoye Technology of China, while Canada's Seamor Marine will introduce the new Mako ROV, built to carry a variety of accessories and with the power capacity to run them all simultaneously. These innovative products and many more unique advances in maritime technology will be seen for the first-time during Oceanology International 2022.

A growing attraction on the exhibition floor is the Ocean ICT area, showcasing more than 20 companies dedicated to the latest developments in ocean IT, communications, satellite, and data solutions. These include BeamworX, which specializes in the acquisition, processing and integration of single/multi-beam echosounder and laser data; Hydromea, an emerging supplier in high-speed wireless underwater communication and portable robotics; and WSENSE, which manufactures monitoring and comms systems that harness a unique patented solution in the Internet of Underwater Things (IoUT).

Another networking feature for Oi22 will be Oi Connect, bringing together ocean professionals to participate in free, brokered one-to-one meetings. Visitors can arrange meetings with their selected exhibitor representatives who are looking to grow their business networks. This service is organised by Oi in collaboration with both Sector Global, a renowned meetings broker, and EEN (the Enterprise Europe Network). Meetings can be arranged to take place on the exhibitor's stand or in the quiet of a dedicated Oi Connect meetings lounge.

Always popular at Oi events are the multiple on-water product demonstrations, this year on an even bigger scale and scope, unique to Oi and staged in the adjacent Royal Victoria Dock. At Oi22, Fugro will be demonstrating its Blue Essence 12m uncrewed surface vessel (USV), the first in the industry with an electric remote-operated vehicle (eROV) controlled from an onshore remote operations centre. USVs will play an important role in the maritime sector, offering a safer, more sustainable solution in support of the energy transition. The dockside will manage operations from multiple all-weather locations, including demos from the likes of USV manufacturer OceanAlpha; ROV designer Blueye; and the hydrographic survey solutions provider Seafloor Systems. Visitors can also examine moored vessels on display such as the Kommandor Stuart from Hays Ships, plus vessels hosted by Magellan, Briggs and NORBIT Subsea. The latter's 14.25m catamaran, SV Thame, is fully equipped for high-resolution bathymetric and terrestrial surveys.

Meanwhile, the all-new Ocean Futures Theatre will be the flagship venue for the industry leading Oi22 conference programme. Headline presentations on The New Blue Economy, Energy Transition and Technology in Support of Science will feature distinguished guest panellists including Dr Rick Spinrad, US Under Secretary of Commerce for Oceans and Atmosphere & NOAA Administrator; Vladimir Ryabinin, Executive Secretary IOC-UNESCO; and Dr Ralph Raynor, Professorial Research Fellow at the LSE. Associated technical presentations by a prominent array of academics, technicians, engineers, CEOs, and scientists will be held during the show, covering important areas such as Ocean Observation, Energy Transition, Pollution & Low Carbon, Hydrography & Survey, and Uncrewed Vehicles.

"We have all had a challenging two years," says Oi Event Director, David Ince, "including not physically holding an Oi since 2018. I am thankful to both the RX team and all of the Oi exhibitors, visitors and stakeholders that have worked closely with us through the many changes and developments of Oceanology International. We have all missed the connections that are made through face-to-face interaction, and I am confident that March 2022 is the right time to once again provide the opportunity for this international network of ocean professionals to meet, socialise, forge relationships and conduct business, collectively propelling the ocean economy and environment in a sustainable manner."

For more information and to register for Oi22, see www.oceanologyinternational.com

Jupiter FLOT

FLYING LEAD ORIENTATION TOOL

The Jupiter Heavy Duty Flying Lead Orientation Tool (HD FLOT) interfaces to Jupiter Class 1-4 Hydraulic & Electric Torque Tools.

Seamlessly integrates with the Zetechtics range of Jupiter Subsea Control Systems, and also operates with other systems with suitable hydraulic interfaces.

Specification

- Pitch: +60° / -90° (from horizontal)
- Roll: ±15° (available roll torque 2,400N·m)
- Load Capacity: 318kg (700 lb)
  (nominally acting on the nose of the Torque Tool)
- Size: 753 x 420 x 493mm
- Weight: 104kg (air) / 82kg (water)
- Depth Rating: 3,000 msw

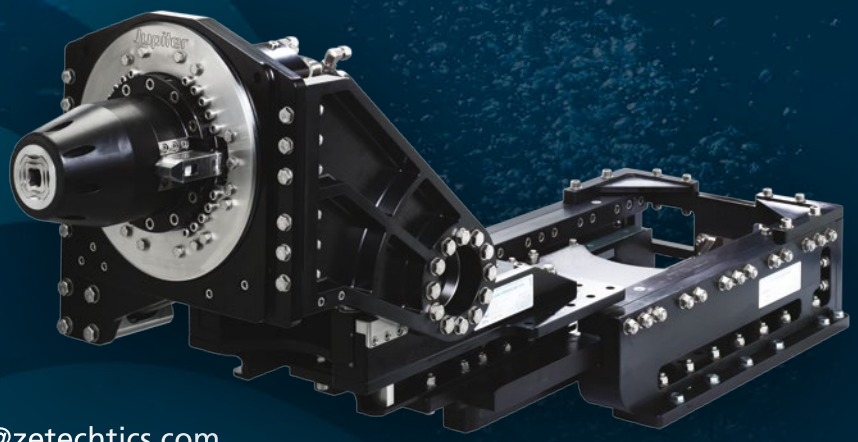


Image right shows FLOT mounted to optional Jupiter FLOT Extender, which can provide up to 300mm of forward advance.

For further information, contact sales@zetechtics.com

Jupiter™ SUBSEA CONTROL SYSTEMS

Tel: +44 (0) 1653 602020
www.zetechtics.com

SEA-KIT Maxlimer USV with port backdrop (Courtesy of SEA-KIT)

SEA-KIT AND FUGRO INK CONTRACT FOR NEXT GENERATION 18M XL USV

World leading Geo-data specialist, Fugro, has ordered a SEA-KIT XL Class Uncrewed Surface Vessel (USV) for future North Sea operations. The 18m USV, the first of its kind, will be built at SEA-KIT's expanding UK production facility on the Essex coast.

The SEA-KIT XL USV has a 7-tonne payload capacity and powerful bollard pull, making it suitable for towing spreads and larger sensors. The vessel can launch and recover a wide variety of remotely operated vehicles and payloads, has fully redundant station holding capability, Cat 0 operations for unrestricted use and a large lithium UPS supply for ship systems. This build will feature the latest developments in uncrewed systems technology, including the next generation of SEA-KIT's proven proprietary remote helm USV control and surveillance platform, G-SAVI.

SEA-KIT Remote Operation Centre (Courtesy of SEA-KIT)

So how is the 18m XL USV different from the previous 12m version? The vessel is 18m, 50% longer than the previous 12m version. It is however three times the displacement, at 45 tonnes, meaning that it can carry a significantly bigger payload – three times more in fact than the 12m X-class USV.

The operational envelope of the vessel allows it to be out in all weather conditions. It may not operate an ROV in high wind and adverse weather but is able to wait until heavier weather subsides – a very important feature when putting together a business case for such uncrewed operations. The USV can sit out storms and heavy sea states and still get a lot of work done. It can also be out there for a month at a time, which is quite impressive for an 18-metre boat.

When it comes to power, the 18m XL USV has 200KW that can be used for the payload, in comparison to the 12m USV that supplies about 36kW. This is significantly more power to be delivered to an ROV, which can weigh about 750kg. The power is supplied by a diesel electric generator, with a very significant lithium battery bank on board. A UPS, that activates in the event of a stalled generator, takes over the

SEA-KIT Maxlimer USV hydrogen configuration render (Courtesy of SEA-KIT)

SEA-KIT XL class USV render (Courtesy of SEA-KIT)

SEA-KIT Maxlimer en route back to Plymouth after Atlantic mission (Courtesy of Rich Edwards, ENP Media)

SEA-KIT XL class USV render (Courtesy of SEA-KIT)

supply to continue operations and data gathering. All operations on the ROV can be carried out using one generator, so there is 100% redundancy with regards to power delivery.

Operational depth is expected to be around 500m for Fugro's eROV on board. SEA-KIT's design means that the vessel is agnostic to payload and multi-purpose, so as well as carrying an ROV or other subsea vehicle, a Multibeam Echosounder (MBES) can be mounted on its gondola for ocean depth survey tasks.

The control functionality of the ROV and the LARS is operated by people in a Remote Operations Centre (ROC) that can be situated anywhere in the world. There are two enormous satellite domes on the vessel, effectively doubling the amount of data available for communication and allowing real time data for both the ROV and the vessel to be transmitted to personnel onshore for quality checks and processing.

The combination of the USV and the ROV enables intervention work to be carried out, for example valve opening and closing, as well as data gathering. SEA-KIT's 12m X-class USVs are already performing such tasks commercially. The new system however will offer enhanced capabilities, including higher speed pipeline inspection, with the USV tracking the ROV via USBL positioning and changing direction automatically to follow it. This combination will enable pipeline inspections to be completed at around 4 knots, which is quite impressive.

The submersible payload itself can also be changed. For the Shell Ocean Discovery XPRIZE SEA-KIT deployed a Hugin AUV. The utilisation of Saab Sabretooth is also an option.

When there are two bodies moving in the water the couple dynamics are complicated. If you run launch and recovery operations using a similar sized vessel (some AUVs are similar in size to the USV itself), they respond well to each other when it comes to the collection and retrieval of the AUV. This is especially true when you compare it to retrieving AUVs from a 60-70m ship; because the ship isn't moving but the small vehicles are moving a lot. Two small vehicles that move a lot are more in synchrony with each other and that aids the launch and recovery process when the submersible is collected at speed by the surface vessel. The submersible runs into a calm area at the back of the boat and then the retrieval onboard begins. SEA-KIT's launch and recovery system was developed in house.

SIMPLE AND RAPID DEPLOYMENT

There is a significant size difference between the two vessels. SEA-KIT's 12m USV can fit inside a standard shipping container and be deployed cheaply anywhere in the world – and still operated remotely. The larger versions take a little more effort to mobilise (although significantly less than a ship with crew). The XL class USV is still transportable by road with an escort. SEA-KIT is creating a range of different sizes of USV: fit for either quick deployment or as


SEA-KIT Maxlimer USV with HUGIN AUV onboard (Courtesy of SEA-KIT)


SEA-KIT with HUGIN AUV (Courtesy of SEA-KIT)

more permanent fixtures in port. After the 18-metre vessel the company also has a 22-metre vessel with a 20-tonne payload planned.

UNMANNED ATLANTIC SURVEY 2020

SEA-KIT's 12m USV design demonstrated true ocean-going capability on a live pilot exercise in 2020, when it spent 22 days offshore surveying ocean floor on Europe's continental margin. The vessel was operated from SEA-KIT's Remote Operations Centre in the UK, collecting, and checking high-quality multibeam data in real time using a Kongsberg MBES mounted on the vessel's gondola. This uncrewed Atlantic survey mission contributed to the goals of Seabed2030 – 100% of the ocean floor mapped by 2030. Another team in the USA was able to process the data gathered in real time.

During the 22-day mission, 391 hours of survey data consisting of 1.5 billion data points were collected. The USV travelled 1200 nautical miles and mapped over 1,000km² of previously unmapped ocean floor.

DEFENCE APPLICATIONS

The SEA-KIT XL USV is also a very promising system when it comes to defence applications, either as a high-endurance standalone asset or strong force multiplier in a larger fleet. Potential use cases include anti-submarine and mine countermeasure operations. SEA-KIT USVs are controlled using SEA-KIT's proprietary G-SAVI control and surveillance platform, which provides safe and secure remote operation. The reduced acoustic signature, allowing for quiet operations, is also a key benefit for security and surveillance tasks.

SEA-KIT's USVs deliver a mobile, extended endurance, stable sensor platform that can be deployed to extend the surveillance capability of maritime and border security systems. The platform can be configured to deploy a suite of maritime security sensors including hi-resolution radars, long range electro-optic and thermal cameras and intruder detection sonars. The vessel can quietly hold station for extended periods, enabling sensors to be deployed many miles from ports or the coast.

VISION FOR THE FUTURE

Fugro and SEA-KIT formed their ongoing partnership in March 2020, with a joint remit to improve safety and efficiency and to reduce the environmental impact of offshore operations. Work will start on the hull of the 18m USV in March with delivery scheduled for early 2023.

SEA-KIT is determined to reduce CO_2 emissions offshore. Reducing the size of offshore vessels is a key element of this, with a USV using 95% less fuel than a regular subsea support vessel. The next stage will be to remove fossil fuel burn completely.

SEA-KIT is currently working on a hydrogen fuel cell propulsion system for its USVs and plans to demonstrate the system later this year. SEA-KIT USVs have a dual diesel-electric hybrid drive, with propulsion from an electric motor powered by battery banks that are charged by diesel generators. This project will replace one diesel generator with new hydrogen fuel cell technology from Bramble Energy and demonstrate an offshore operation with zero carbon emissions. The application of a hydrogen fuel source to a USV will be a world first, putting the UK firmly in the lead on zero emissions uncrewed technology for sustainable maritime growth.

Ocean Robotics Planet

Powered by ROV PLANET

Please check out our website on:

www.oceanroboticsplanet.com

The DriX Unmanned Surface Vessel from iXblue (Courtesy of iXblue)

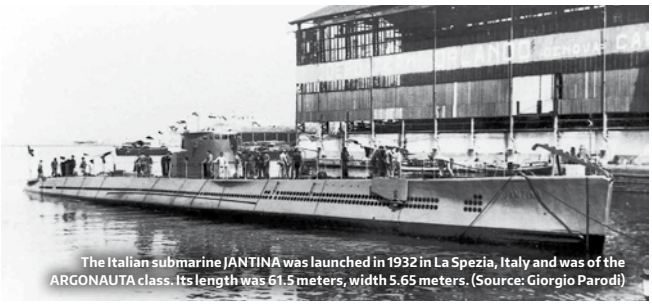
DISCOVERY OF WWII ITALIAN SUBMARINE WRECK JANTINA IN GREECE

The research and identification team included: Alexiades Platon, Vougidis Spyros, Thoktaridis Agapi Oceanis, Thoctarides Kostas, Koumarianos Nikos, Maganas Giorgos, Sippl Ricardo.

The Jantina is the fourth submarine that has been located and identified by Kostas Thoctarides and Planet Blue - ROV Services in the Greek archipelago. South of Mykonos at a depth of 103 m, the Italian submarine - that was sunk by a British sub on July 5th, 1941 - was found and identified by Thoctarides and the team. The discovery comes after the most recent submarine shipwreck, the Greek vessel Katsonis, was discovered in 2018 by Planet Blue - ROV Services at a depth of 253 m, using the same technology.

HISTORY OF SINKING AND THE FATAL ATTACK

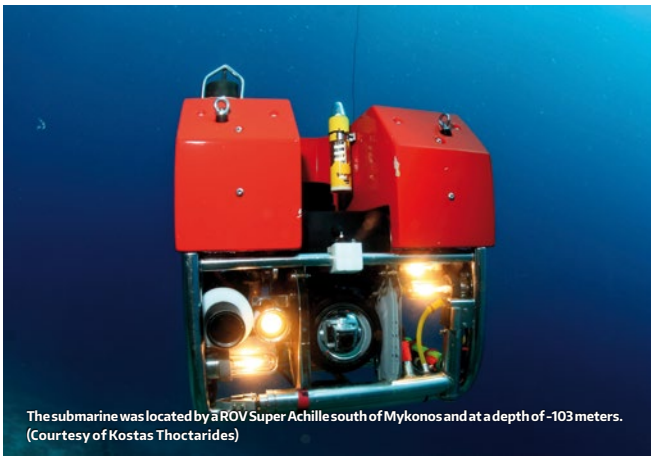
The Jantina was launched in 1932 in La Spezia, Italy. An Argonauta class submarine, the Jantina was 61.5 m long with a width of 5.65 m, and had a diving displacement of 810 tons. On the surface it had a maximum cruising speed of 14 knots, and was able to dive at 8 knots to a maximum operational depth of 80 m. Its armament consisted of 4 torpedo tubes in the bow and 2 in the stern, in addition to a 102/35 naval gun.



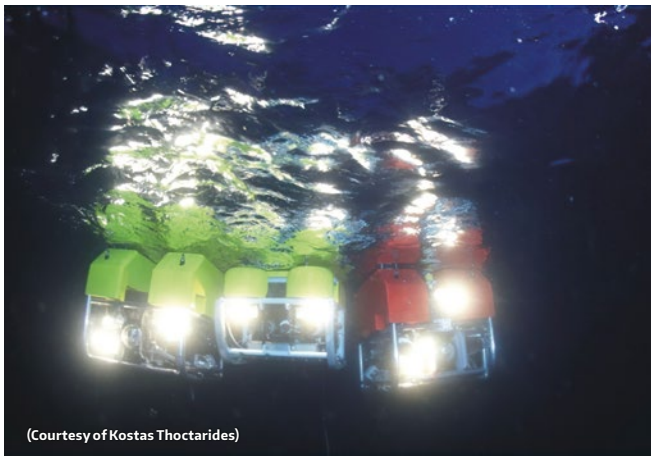
The Italian submarine JANTINA was launched in 1932 in La Spezia, Italy and was of the ARGONAUTA class. Its length was 61.5 meters, width 5.65 meters. (Source: Giorgio Parodi)

On the afternoon of July 5th, 1941, the Jantina sailed on the surface, south of Mykonos and heading west. It had sailed from Leros – a nearby island that was an Italian naval base in WWII – heading back to Italy for repair, and it was carrying a crew of 48. The vessel was travelling on the surface as it had recently suffered technical problems and was unable to dive.

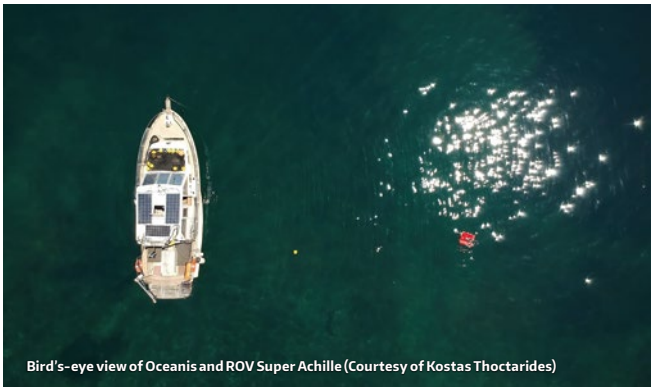
The Italian submarine JANTINA. Source: Italian Naval History Service (MARINA MILITARE UFFICIO STORICO).



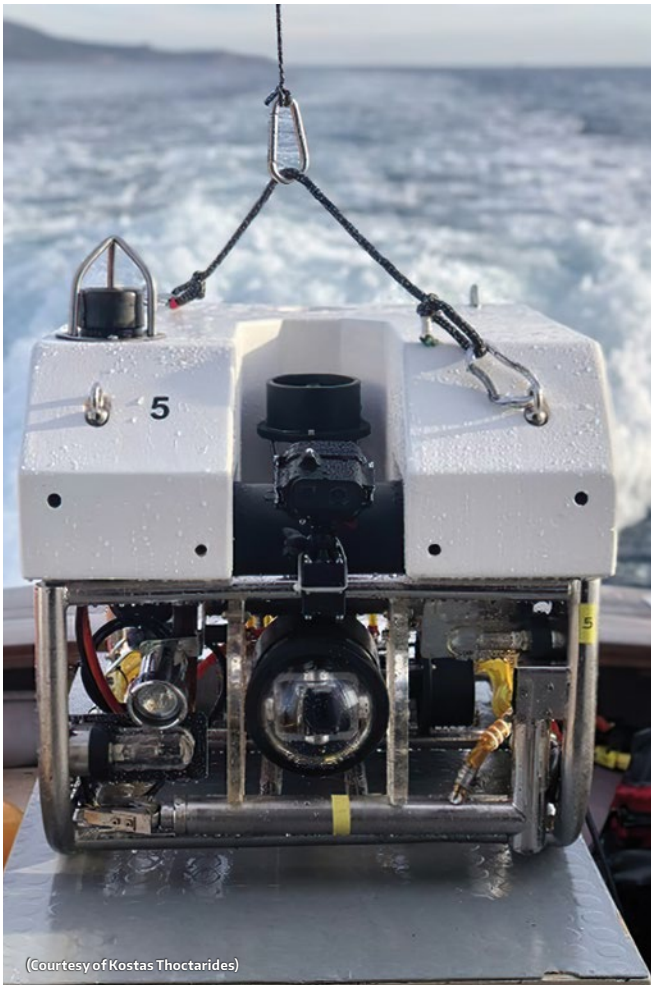
The submarine was located by a ROV Super Achille south of Mykonos and at a depth of -103 meters. (Courtesy of Kostas Thoctarides)



(Courtesy of Kostas Thoctarides)



Bird's-eye view of Oceanis and ROV Super Achille (Courtesy of Kostas Thoctarides)



(Courtesy of Kostas Thoctarides)

The British submarine HMS Torbay was located in the wider sea area. The Torbay had sailed from Alexandria, Egypt and was conducting its third offensive patrol in the Aegean. What was about to take place was notable for both its ferocity and rarity; the confrontation of two submarines is actually a rather rare naval event.

The Torbay, according to the war diary compiled by its commander immediately after the attack, located the Jantina from a distance of four nautical miles, sounded the alarm, and – being at a periscope depth – took up an attack position. At 20:16 she launched a torpedo attack with a set of 6 torpedoes from a distance of 1500 yards.

By the time the distinct sound of the torpedoes running through the water was noticed by the Jantina crew it was already too late. Despite the desperate efforts of the men there was no avoiding the oncoming torpedoes.

The first two passed in front of the Italian submarine without reaching a target. However, at 20:17, the second array of torpedoes found their target and created a huge explosion. The Jantina began sinking immediately and rapidly. Of the vessel's 48 crew members, only 6 people managed to survive, by swimming against difficult waters to the island of Delos.

THE SHIPWRECK TODAY

The Blue Planet team located the Jantina using a Super Achille ROV, just south of Mykonos at a depth of 103 m. Blue Planet – ROV Services is headed by Kostas Thoctarides. They specialise in underwater projects, offering an extensive array of services in marine and fresh aquatic environments. They currently have a fleet of 9 ROVs, all manufactured by Comex. The fleet includes one M3 Achille, three M4 Achilles, and five Super Achilles. They also have a small workshop where they can perform regular maintenance and small modifications to suit their needs.

All of the ROVs are in excellent condition. The team mostly work with the Super Achille model, which is fitted with Tritech sonars and manipulators. They also have EdgeTech ORE USBL on board, with an operational envelope of around 1,000 m and accuracy close to 0.5 m. These observation/

The Italian submarine JANTINA lies on the seabed with the left side. The turret and the 102 mm deck cannon can be seen. (Courtesy of Kostas Thoctarides)

light intervention ROVs are mostly used for inspection work and are usually operated from the small boat Oceanis. The Oceanis, named after Thoctarides' daughter, acts as a mothership for the ROVs.

Naval history is one of Thoctarides' passions. Previously, he served on the board of the Greek National Maritime Museum and has written many books about shipwrecks in the Mediterranean Sea. Sometimes he combines his work with his hobby, and the Jantina was the fourth submarine that he has discovered, the others being a British sub, a Greek, and a German.

Initially, Thoctarides and his team visited an area located south-east of Mykonos to perform inspection work on a subsea fibre optic cable that had some minor damage.

Thoctarides recalls the discovery, saying, "The visibility in the water was exceptional; between 10 and 30 m. Usually it's difficult to see a submarine of 100 m so clearly, but here it was very clear water. The problem in the area is that the wind on the surface was very strong, especially coming from the north. It's a well-known place for windsurfers. Despite the strong currents and waves the visibility for work was excellent.

"The depth was at 103m. We inspected the wreck using the Super Achilles ROV. Using the imaging sonar we recognised the target, because the area on the bottom is complete flat and it was the only large and clear target. We decided to go there to check it out. As we came closer, we recognised the tower and sails of the submarine with the gun on board. It was a very classic sight and easy to recognise. It was the only target and the only submarine that was lost in the area.

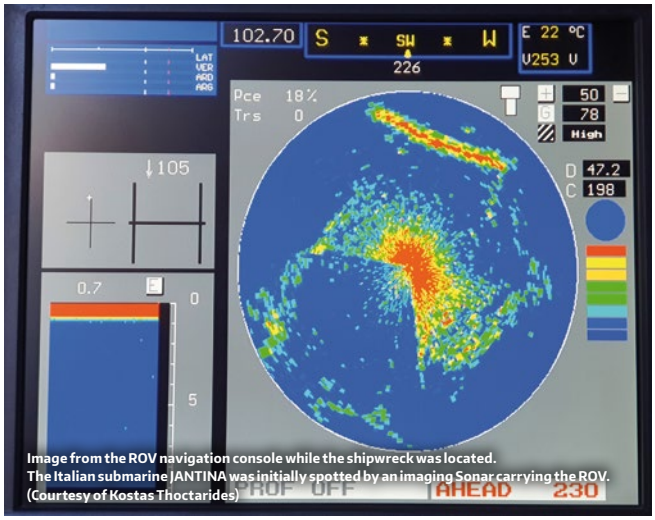


Image from the ROV navigation console while the shipwreck was located. The Italian submarine JANTINA was initially spotted by an imaging Sonar carrying the ROV. (Courtesy of Kostas Thoctarides)

On board Oceanis (Courtesy of Kostas Thoctarides)

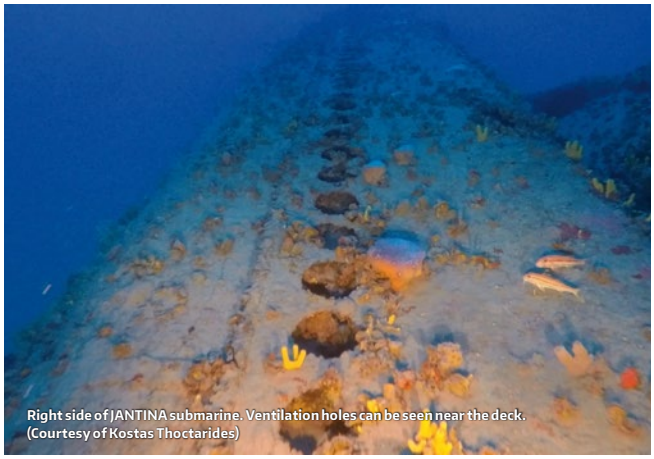
ROV Super Achille on board the Oceanis (Courtesy of Kostas Thoctarides)

Then we compared the image from the video with historical photos and records and we could confirm that they matched.

"Initially, the volume of the submarine was identified using a Tritech imaging Sonar from the Super Achille ROV. This was followed by a detailed visual inspection and video recording, before being identified as the Italian submarine Jantina. "

The submarine lies on the seabed, where the left side – with its turret and 102 mm deck cannon – can be seen. The periscopes are lowered, but the manhole of the turret is open. Part of the bow has been cut off from the rest of the submarine. The shipwreck and the surrounding area were treated with respect as a war grave.

The typical 102 mm naval deck cannon located in front of the turret. (Courtesy of Kostas Thoctarides)

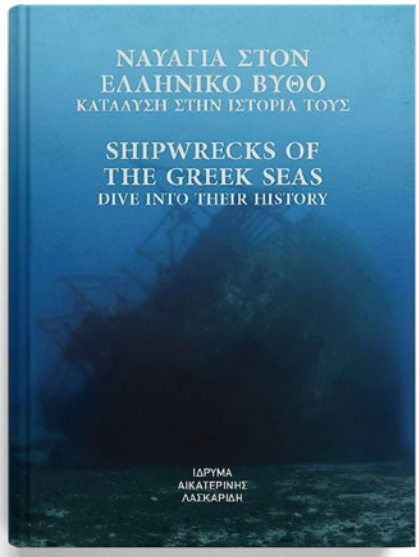


Right side of JANTINA submarine. Ventilation holes can be seen near the deck. (Courtesy of Kostas Thoctarides)

Historical Research

Data and material from the following sources were used for this research and article:

1. **Italian Naval History Service (MARINA MILITARE, UFFICIO STORICO)**
2. **British Archives in England (The National Archives)**
3. **German War Calendars (KTB - Aegean & Attica)**



To buy a copy of "Shipwrecks of the Greek Seas. Dive into their history" written by Kostas Thoctarides and Aris Bilalis, please click **here**:

SHIPWRECKS OF THE GREEK SEAS. DIVE INTO THEIR HISTORY

Authors: Kostas Thoctarides – Aris Bilalis

ISBN 978-960-99142-9-1

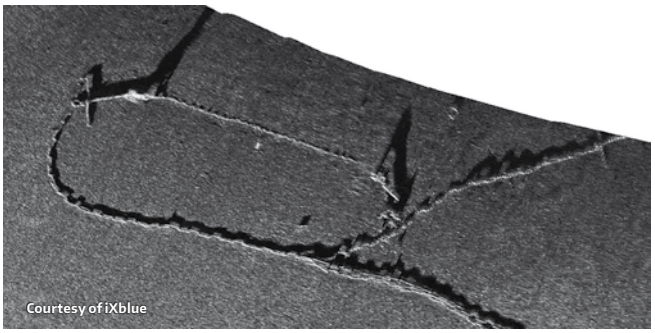
The "Aikaterini Laskaridis Foundation" presents its bilingual edition which concerns the history of twenty of the most famous shipwrecks of the Greek seas of the 20th century. Some became known for the large number of souls lost in their trunks and others for the glorious moments of bravery and self-denial of our Navy. Through the rich photographic material of the volume, their stories come to life.

Thousands of ships, commercial and warships of all kinds, sank in the Greek seas. A good friend once asked us what the most important shipwreck in Greece is. A question that can hardly be answered. We dealt with shipwrecks that were built from the steam age onwards, since the wooden remains of the wooden sailboats are kept visible on the seabed. A key criterion in the choice we made was to be able to dive in the wreck area, so that we can present to readers a satisfactory description of the situation they are in today. At the bottom of the Greek seas there is a vast museum where exhibits of almost all the ships that travelled on them are exhibited. Shipwrecks resting on the seabed are part of recent maritime history and we hope this book will help highlight and protect them.

Courtesy of iXblue

iXBLUE LAUNCHES NEW ROTV TO ENHANCE AUTONOMOUS SURVEY SCOPE

iXblue, a global leader in the field of maritime autonomy, announces the launch of its first Remotely Operated Towed Vehicle (ROTV), FlipiX. Designed to be operated autonomously from iXblue DriX Uncrewed Surface Vehicle (USV), or from a light vessel, FlipiX enhances autonomous survey capabilities and allows multi-sensor operations to be conducted in a single run, ultimately offering unmatched operational efficiency.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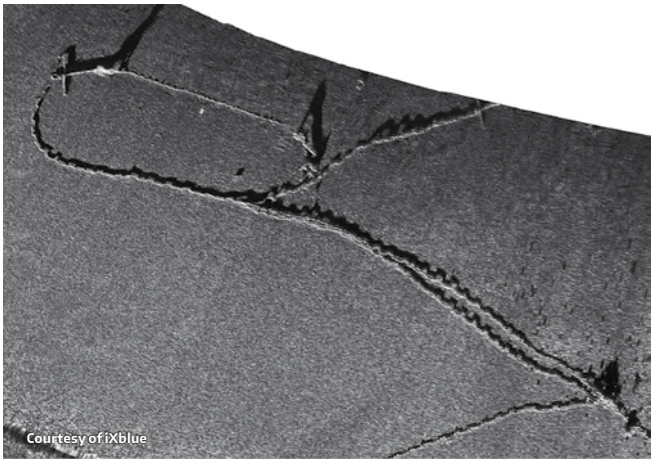
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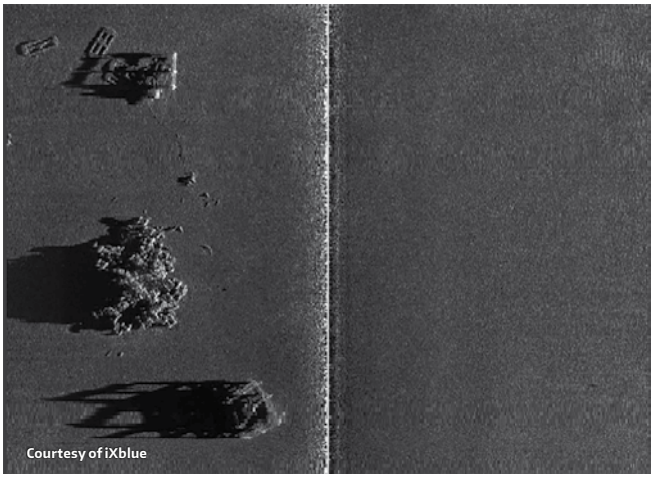
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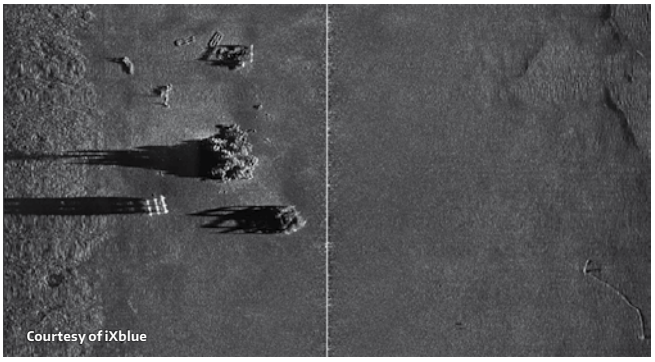
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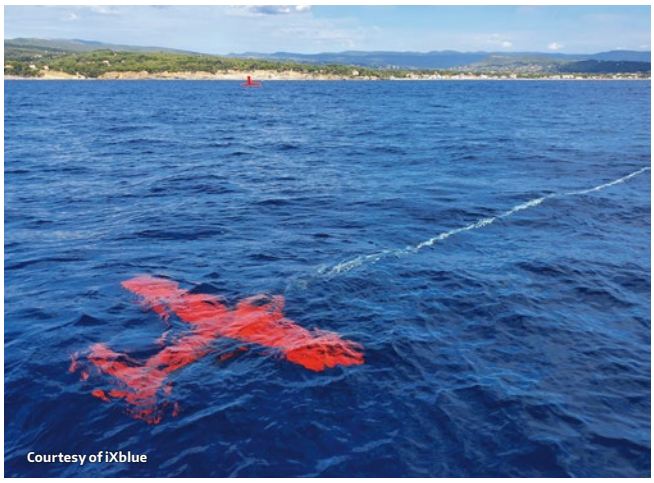
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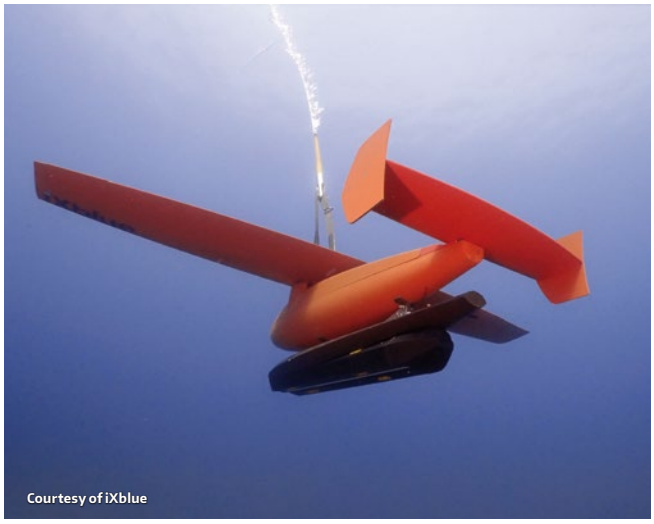

Courtesy of iXblue

iXblue already have the DriX, the leading autonomous solution for hydrographic applications, but their aim was to create an ecosystem of maritime autonomous solutions. They realized that there was a gap between solutions available on the market to support UXO operations. Many clients wanted to combine the traditional bathymetry sub bottom profiler and UXO operations on a single run using an autonomous solution. So, if you take the DriX by itself using its gondola you can feed multibeam, sub bottom profiler images in a very comprehensive package. However, what was missing was the ability to deploy side scan sonar and magnetometer while operating the DriX.

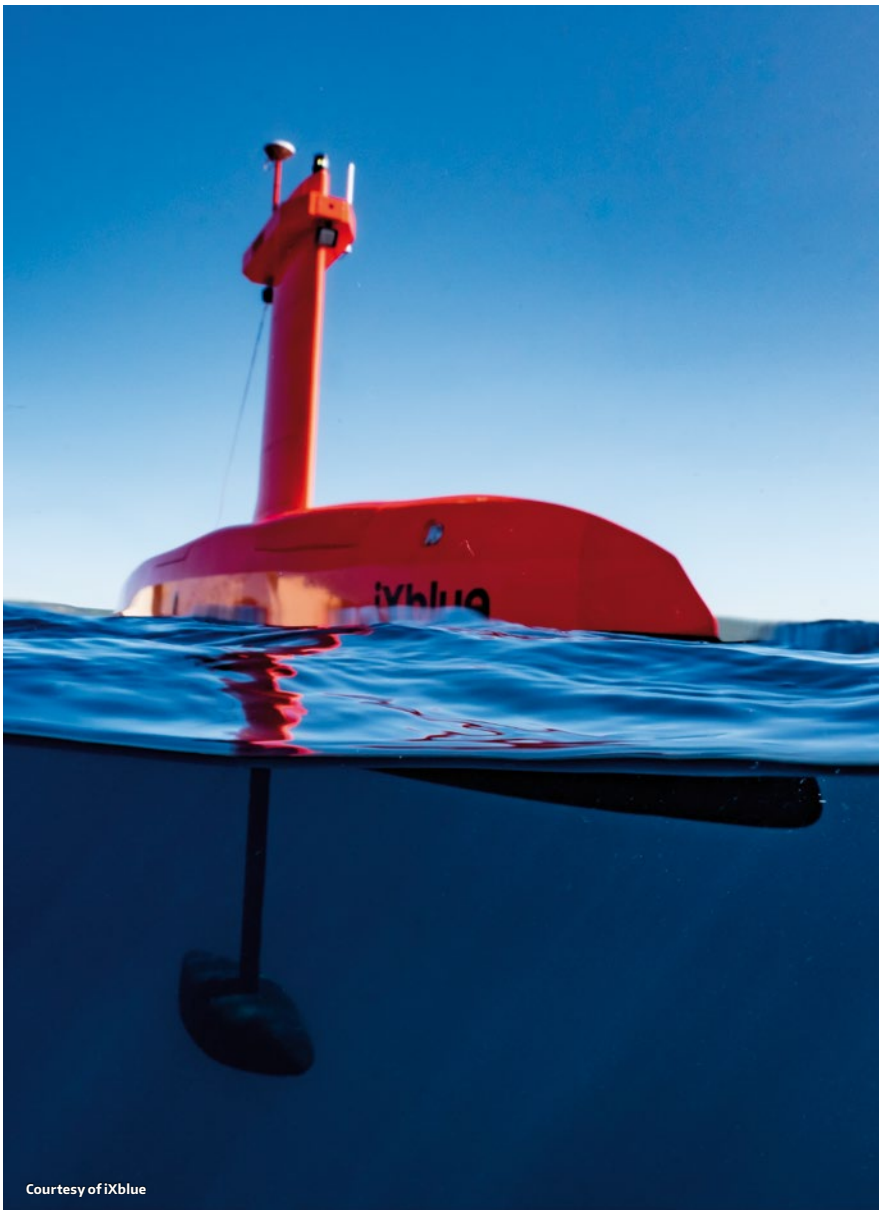
The sonar and magnetometer need to be fairly close to the seabed: only a few meters above. Therefore, FlipiX was designed as a ROTV that can easily be combined with the DriX and can be autonomously operated in a collaborative manner. The DriX conveys the multibeam, the Sub Bottom profiler, the acoustic positioning and tows the FlipiX behind it. The Side Scan Sonar is rigidly attached to FlipiX while the magnetometers are towed behind.

FlipiX is a very versatile platform that looks a bit like an underwater airplane. It's innovative, ergonomic, and the operator has full control of the altitude, pitch, and roll. The wings have two flappers, and all of this combines to give the FlipiX exceptional stability.

The pitch control is at the back of FlipiX, which makes it a very stable platform and much faster over traditional solutions. The operator also has full control of the depth


Courtesy of iXblue


Courtesy of iXblue


Courtesy of iXblue

especially when using side scan sonar. Roll control is very important, and active control of roll and pitch can really enhance the measurement quality. With these the time is minimised; it takes half the time compared to doing a survey line with two separate runs. By doing so we increase the operational efficiency.

Operating at towing speeds of up to 7 knots, the FlipiX ROTV altitude, pitch, and roll are autonomously controlled to maintain measuring instruments at a fixed attitude. This active motion control bestows the ROTV with increased stability and maneuverability, even during U-turns. This results in enhanced measurement quality in the most challenging maritime environments, and reduced survey time.

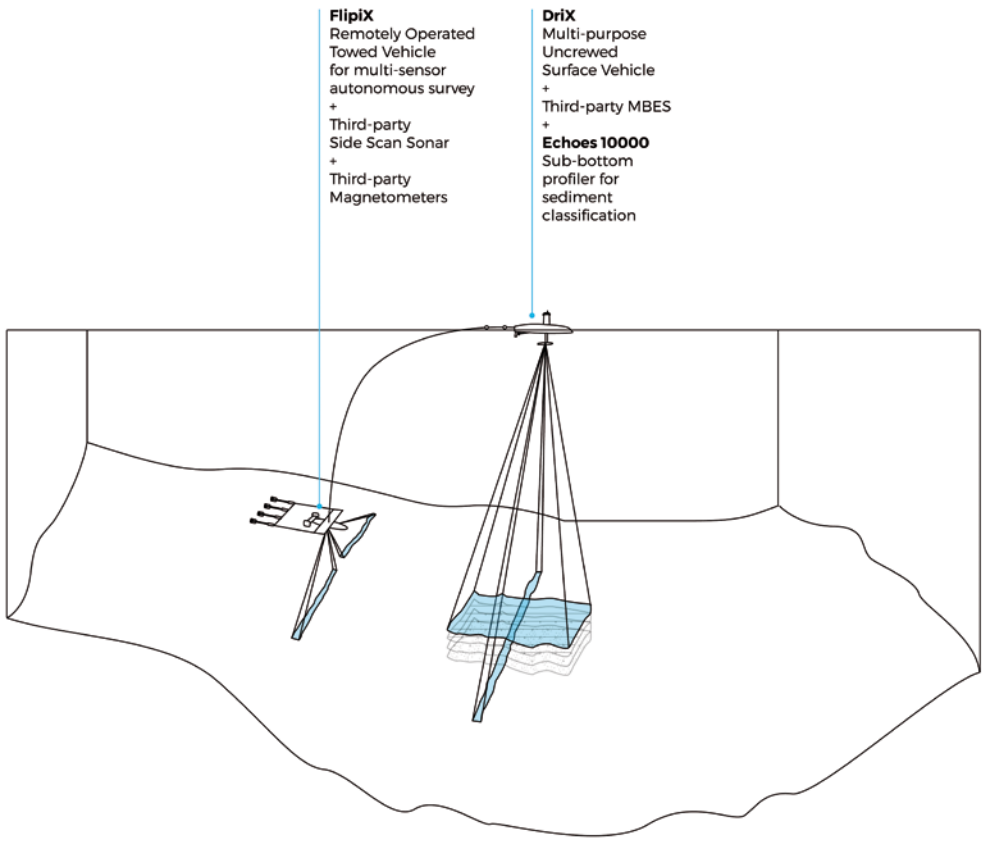
INNOVATIVE SURVEY DEPTH CONTROL

When combined with the DriX USV, FlipiX can operate down to 50 m water depths in its standard version and provides optimal positioning of measurement instruments for a data acquisition as close to the seabed as needed.

The DriX flies 200 m ahead of FlipiX, so it has the ability to build a Digital Terrain Model (DTM) on board the DriX and provide a high level of long-range situational awareness regarding the terrain changes. The FlipiX trajectory can adjust accordingly. It would have been too difficult to do this with on board sensors; whenever you are more than a few meters from the seabed, it's very difficult to get long-range sensing data required for elevation control, and to have enough time to react to changes in topography.

This is a great illustration of the advantages of combining all of these autonomous solutions together into one system. When we talk about collaborative autonomy, it's also the FlipiX that can rely on the DriX measurement to address its trajectory.

Part of the iXblue philosophy is to have a simplified and ruggedised design. Energy efficiency is also important, so FlipiX works as a passive vehicle with no thrusters and works solely through towing.



Courtesy of iXblue

UMBILICAL CONNECTION

An important feature of the cable is that it's positively buoyant. FlipiX is also positively buoyant, so whatever happens FlipiX will always come back to the surface. It also strongly facilitates the deployment.

On the communication side iXblue decided to go with ruggedised solutions: communication over power. The reason for this was that the electrical connections are much easier to maintain in the field than the fibre optic ones, which need to be sealed against water. Since there is a need to have a level of power delivered to the actuator in FlipiX there would always need to be an electrical line from the DriX. With the electrical cable you remain compatible with alternative cable solutions that are used on other survey vessels.

At this stage there aren't any cameras on-board, but they could easily be retrofitted depending on the client's needs. With these autonomous solutions there is often a level of customisation required. The need for cameras could be application dependant. It would also depend on the clarity and visibility conditions at the survey site for the camera to be efficient.

The launch and recovery would require only two people to work from the boat. If it was bigger with heavier equipment, then it would also require cranes, further adding to the cost. FlipiX can be launched from a RHIB, meaning the operational footprint is very small. What's the point of an autonomous solution if you need a big vessel to support it in operation?

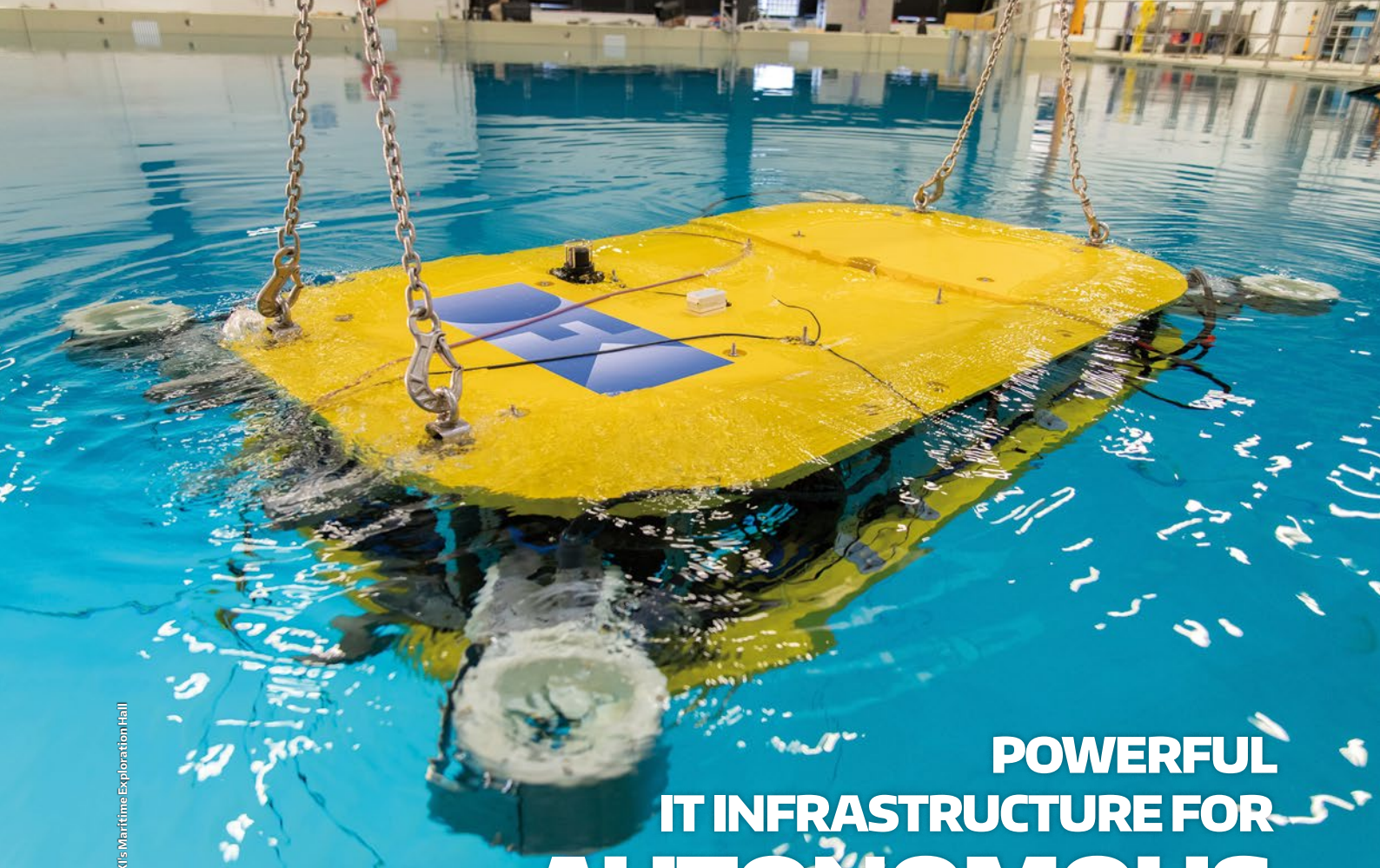
SURVEY DURATION

The duration of the survey would depend on DriX. FlipiX can also be used with traditional survey vessels to be towed around them like any other RTOV.

When towed behind the survey vessels the FlipiX has the ability to achieve higher depths compared to towing with a USV by using the more traditional coax cable with longer length (although a winch and LARS is required).

Stéphane Vannuffelen, Marine Autonomy Technical Director at iXblue, comments on the development of this new vehicle: "As a key actor of the maritime industry and a pioneer in the field of autonomy, iXblue has the ambition to support the industry in its transition towards autonomous operations, and FlipiX does just that. Leveraging our unique expertise in navigation, robotics, and shipbuilding, and benefitting from our extensive return on experience deploying our DriX USV on major projects for energy companies and hydrographic institute worldwide, we are committed to offer operators a more comprehensive ecosystem for autonomous surveying. We're convinced that our FlipiX ROTV combined with our DriX USV will bring high efficiency and cost-effectiveness to the industry. It has already gathered strong interest amongst major actors from the industry, confirming the strong relevance of our new autonomous solution."

This new addition to the iXblue autonomous systems family has many potential applications and complements the existing systems of the company. We look forward to seeing the DriX and FlipiX combo becoming a popular survey choice of the future.



The dual-arm AUV Cuttlefish is launched in the DFKI's Maritime Exploration Hall in Bremen. (Courtesy of DFKI/Thomas Frank)

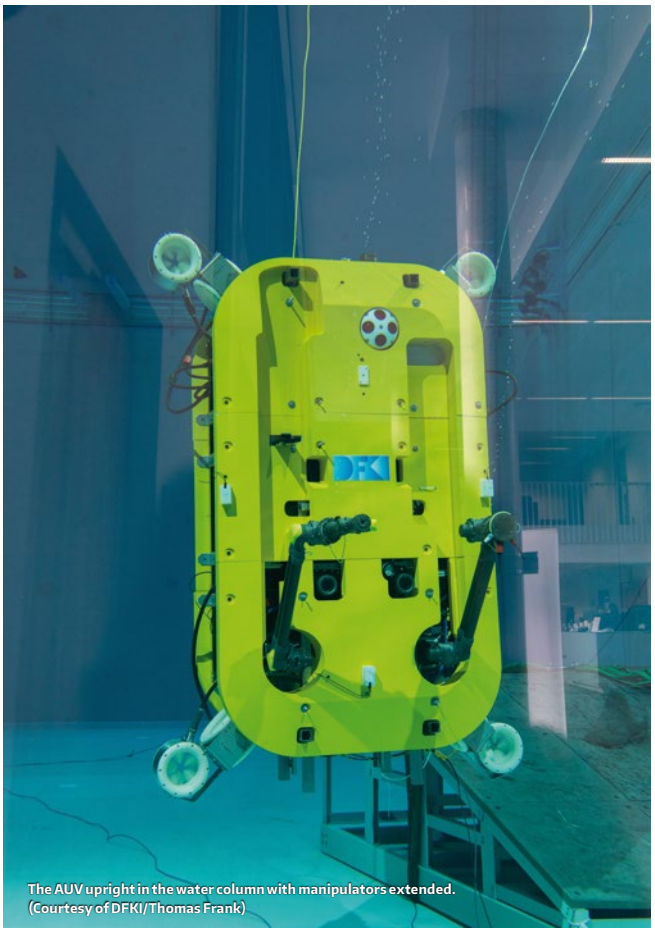
POWERFUL IT INFRASTRUCTURE FOR AUTONOMOUS UNDERWATER MAINTENANCE

WITH GROUND-BREAKING DUAL-ARM AUV

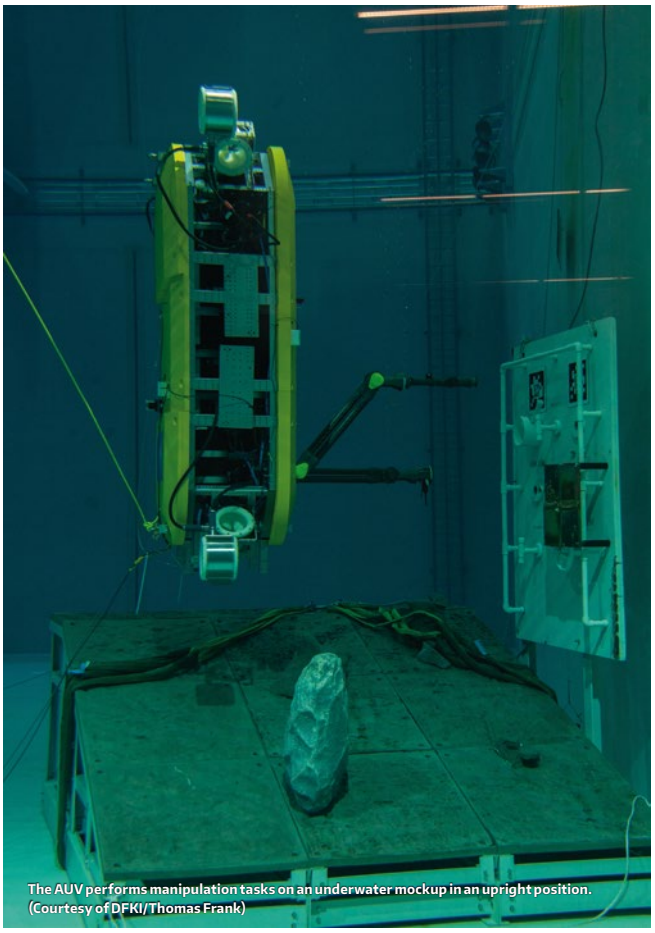
Autonomous underwater vehicles (AUVs), operated and controlled by artificial intelligence (AI) methods, inspect, maintain, and repair offshore installations underwater. A consortium led by the German Research Center for Artificial Intelligence (DFKI) developed a holistic solution in the Mare-IT project to make this vision a reality: an innovative, two-armed AUV for complex inspection and maintenance tasks, embedded in a powerful IT infrastructure that enables both intuitive control and monitoring of the system and effective information flow with the plant operator. The project was funded by the German Federal Ministry of Education and Research (BMBF).

To ensure the safety of offshore infrastructure such as wind turbines or oil and gas production facilities, regular inspection and maintenance is essential. However, the work carried out underwater is not only complex and expensive, but also involves considerable risks for the divers who perform it. Remotely operated underwater systems (ROVs) are already being used to monitor the condition of maritime assets. However, there is a tendency towards systems that remain in the water for long periods of time – so-called subsea resident AUV'S – and operate there autonomously and at the same time can be remotely controlled if necessary.

An important step in this direction has been taken by a consortium of leading companies and research institutions from the fields of IT, robotics, drive technology, and offshore under the leadership of the DFKI Robotics Innovation Center in the Mare-IT project. At the end of the project, the partners, including the DFKI research departments Cognitive Assistance Systems and Embedded Intelligence as well as WITTENSTEIN cyber motor GmbH, SAP SE and ROSEN Technology and Research Center GmbH, presented a holistic solution. This comprises a novel two-arm AUV that can operate both autonomously and remotely and, thanks to two integrated manipulators, can be



The AUV upright in the water column with manipulators extended. (Courtesy of DFKI/Thomas Frank)


The AUV performs manipulation tasks on an underwater mockup in an upright position. (Courtesy of DFKI/Thomas Frank)

used for maintenance work and repairs on underwater structures. In addition, the partners are providing a powerful IT infrastructure that not only enables intuitive control and monitoring of the robot underwater but also ensures the smooth bidirectional flow of information with the plant operators and allows integration into existing business processes.

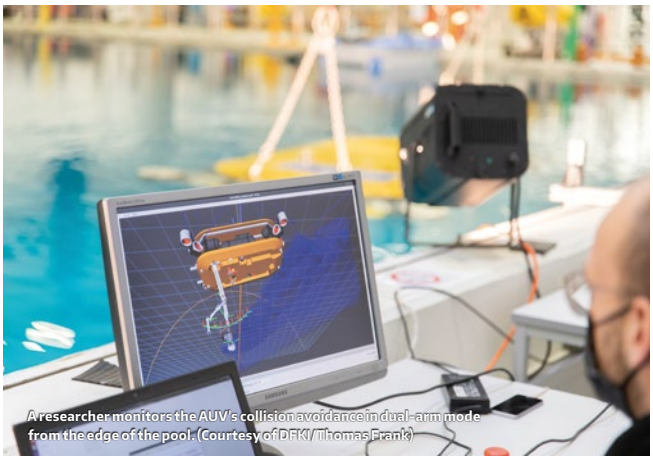
"With Mare-IT, we were once again able to demonstrate that the development of autonomous robots for complex underwater applications cannot be implemented without machine learning and artificial intelligence methods. Our research represents an important building block in making the vision of practical autonomous underwater vehicles in the offshore industry a reality. We are delighted that we were able to successfully complete the project, also thanks to the very good cooperation with our strong partners, despite the difficult conditions caused by the Corona pandemic.", said Prof. Dr. Frank Kirchner, Director of the DFKI Robotics Innovation Center.

INNOVATIVE DUAL-ARM AUV FOR AUTONOMOUS AND REMOTE INSPECTION AND MAINTENANCE

The DFKI Robotics Innovation Center has successfully designed and built the AUV "Cuttlefish" in Mare-IT as an intervention AUV that can be freely positioned in the water column. The innovative AUV has two deep-sea gripping systems attached to its ventral side that allow it to manipulate objects underwater. In doing so, thanks to its special design and AI-based control, it is possible to change the center of gravity and buoyancy during a dive and to adopt and maintain any orientation in a stable manner. In addition to fully autonomous operations, the vehicle can be operated in a hybrid mode – so-called supervised autonomy – using a fiber optic cable. The hybrid mode allows humans to intervene and remotely control the AUV during critical operations on underwater structures. For this purpose, in addition to the manipulators, the system is equipped with many sensors for environmental perception, e.g., sonar sensors, cameras, laser scanners, and magnetometers. To effectively process the large amount of sensor data, the researchers developed a special architecture concept that enables the decentralized analysis of data streams directly on board the robot. The researchers in Bremen were also responsible for implementing mission planning to carry out inspection or maintenance tasks. In addition, they developed a standard interface that enables bidirectional data exchange between the AUV, the control station and the internal business infrastructure.

VIRTUAL CO-PILOT FOR INTUITIVE TELEOPERATION OF THE AUV AND LOCALIZATION WITH ARTIFICIAL MAGNETIC FIELDS

A virtual co-pilot developed at DFKI's Cognitive Assistance Systems research department supports human personnel in the control station during teleoperation tasks. For this purpose, it is equipped with a Microsoft HoloLens, which can be used either in combination with the control station or as a lightweight separate interaction medium, e.g., on board a ship. Thanks to a holographic 3D representation on the

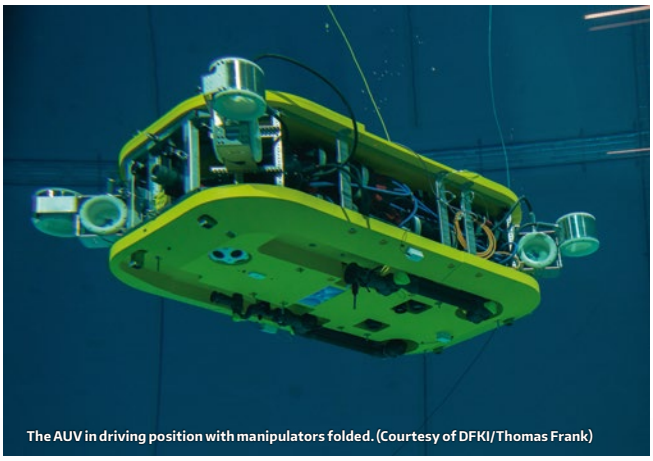

A researcher monitors the AUV's collision avoidance in dual-arm mode from the edge of the pool. (Courtesy of DFKI/Thomas Frank)

display, the operator is always informed about the status of the AUV and the underwater structure. Sensor information and measured values can be displayed, and warnings configured via natural voice interaction. In The AUV and its cameras can also be controlled via voice commands and, in combination with eye tracking, information can be retrieved on elements of the infrastructure that the person is currently looking at. Furthermore, it is also possible to define own voice terms during the mission and to use them as alias, e.g., for camera or docking positions.

In order to complement the innovative interaction technologies, the DFKI Embedded Intelligence research department in Mare-IT has developed a web application that allows the AUV to be controlled and change parameter settings via mobile devices such as smartphones or tablets. In addition, the researchers investigated the possible use of artificial, oscillating magnetic fields for localizing the underwater robot.

ROBUST THRUSTER DRIVES WITH INTELLIGENT CONTROL FOR EFFECTIVE LOCOMOTION OF THE AUV

WITTENSTEIN cyber motor GmbH developed and produced the highly robust thruster drives for the AUV's locomotion. These have a thrust of up to 500 newtons, are protected against seawater and are suitable for water depths of up to 6000 meters. No liquid fillers were used in the manufacturing process, which employed special potting technologies


The AUV in driving position with manipulators folded. (Courtesy of DFKI/Thomas Frank)

to avert chemical hazards to the environment. The servo inverters that go with the thrusters include sensorless control specifically matched to the thruster motor, providing accurate, highly dynamic speed control over the entire speed range up to standstill in both directions of rotation. The AUV is equipped with eight such thruster drives, which in the overall network enable highly precise movements as required for docking with underwater structures. The real-time communication required for this is carried out within the AUV using Ethernet/IP.

INTEGRATION OF THE AUV INTO THE IT INFRASTRUCTURE AND INTEROPERABILITY BY SHAPING THE MANAGEMENT SHELL

In Mare-IT, SAP investigated how and under what conditions autonomous systems such as AUVs can be integrated into IT infrastructures such as cloud systems. For this purpose, a vendor-independent integration of digital twins into business applications was realized by developing the management shell, a central component of the Industry 4.0 reference architecture. The management shell ensures interoperability across solutions from any manufacturer. It reduces integration costs and efforts, especially if several organizations are to access data of digital twins. SAP prototyped the management shell for planned and unplanned maintenance processes, such as the isolation valve of a subsea structure. The SAP Intelligent Asset Management cloud application can now initiate such maintenance via the isolation valve's management shell and receive execution status back from the underwater robot. Thanks to the management shell, any other systems from other parties can be added or replaced by others without much integration effort.

DEVELOPMENT OF MEASUREMENT TECHNOLOGY FOR NON-DESTRUCTIVE TESTING OF UNDERWATER STRUCTURES

In the project, the ROSEN Group, the leading global provider of integrity management solutions for large-scale industrial plants in the energy industry, developed four different measurement technologies for AUVs to check the condition of various subsea structures: Magnetic field sensors to detect ferromagnetic structures, sensors to measure electric fields of cathodic protection systems, and ultrasonic and eddy current sensors to measure local wall thicknesses using manipulators on the AUV. In addition, a communication buoy was developed to ensure data transmission from the robot through the water column to the central control station. ROSEN has successfully completed all four measurement technologies for use on the AUV, making an important contribution to autonomous underwater applications of complex sensor systems.

The Mare-IT project was funded from August 1, 2018, to November 30, 2021, by the Project Management Agency for Software Systems and Knowledge Technologies of the German Aerospace Center (DLR) with funding from the Federal Ministry of Education and Research (BMBF) of around 5.5 million euros.

NEUTRALIZING "WEAPONS THAT WAIT"

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

The headlines are as stark as they are disturbing:

> **"TANKER LOADING CRUDE DAMAGED BY FLOATING MINE IN YEMEN."**

> **"GREEK-OPERATED TANKER DAMAGED BY MINE AT SAUDI TERMINAL."**

> **"HAFNIA TANKER AT JEDDAH BECOMES LATEST MINE VICTIM."**

> **"OIL TANKER NEAR IRAQ FINDS MINE ON HULL AS GULF RISKS MOUNT."**

Sea mines have been a staple of navy-versus-navy conflict for centuries, but now they are being used as a weapon of first resort by some countries and non-state actors to threaten global commerce as nations and navies struggle to find an effective solution.

PERSPECTIVE

Few would disagree with the statement that mines represent one of the most vexing military challenges. Sea mines are perhaps the most lethal form of these weapons, as they are hard to find, difficult to neutralize, and can present a deadly hazard to any vessel—even those ships specifically designed to hunt them. These "weapons that wait" provide an adversary with an effective means to thwart even a major naval power.

The threat of mines can stop any naval operation dead in its tracks. The use of sea mines adjacent to maritime choke points presents a threat that is at once ubiquitous and deadly. Further afield, sea mines have broader repercussions for global maritime trade routes as well. Sadly, western nations have given insufficient attention to dealing with the threat sea mines pose to naval and merchant activities worldwide.

Few naval officers—of any nation—can forget the near catastrophic damage to USS Samuel B. Roberts (FFG 58), USS Princeton (CG 59) and USS Tripoli (LPH 10) during Operation Desert Storm. Here is how one serving U.S. naval officer, Lieutenant Commander Jon Paris, captured the threat of sea mines in a post on the U.S. Naval Institute Blog:

Mines are inexpensive. They present a fiscally efficient option to foes with a substantial return on investment. They are easy to deploy and are difficult to combat. They are stealthy and disrupt the world's sea lanes and are built to guarantee a mission kill. Just the threat of their use or the rumor of their presence has immediate tactical and strategic impact, whether it is merchants avoiding chokepoints or harbors, causing untold damage to the economy, or billion-dollar naval vessels held at arm's length, allowing belligerents to buy time and achieve objectives.

Nor is the threat of sea mines confined to the Middle East. NATO ships have been clearing mines for years. An article in Second Line of Defense, "NATO Mine Counter Measures Group One Works in Norwegian Waters," presented the challenge in compelling terms. More recently, the Latvian

Devil Ray T38 with Aft Mission Load (Courtesy of Jack Rowley)

Devil Ray T38 Flattop (Courtesy of Jack Rowley)

Public Broadcasting System article headline noted the ongoing mine threat: "NATO ships clear more than 50 mines from Baltic Sea."

The challenge posed by potential adversary mining capabilities is real and growing. The number of countries with mines, mining assets, mine manufacturing capabilities, and the intention to export mines has grown dramatically over the past several decades. More than fifty countries possess mines and mining capability. In addition, the types, sophistication, and lethality of the mines available on the world market are increasing.

STILL A NAVAL MISSION

For years, nations have depended on their navies to find and neutralize deadly sea mines. That remains true today, but with a finite number of ships, most navies, even working in concert with like-minded allies and partners, are stressed to perform the difficult and time-consuming mine-countermeasures (MCM) mission. For all naval ships performing this task, that ship must enter the minefield—at substantial risk to the ship and its crew—in order to hunt for and neutralize mines.

For all navies, there is only one way to completely, "Take the sailor out of the minefield," and that is to leverage unmanned technologies to hunt and destroy mines from a distance. In the past, unmanned systems were not mature enough to be considered to take on the complex mine-hunting and mine-clearing task. They are today.

Other navies can capitalize on the work that the U.S. Navy has already conducted as it has explored ways to use emergent commercial-off-the-shelf (COTS) unmanned technologies for the MCM mission. Given the severity of the mine threat, all navies would be well-served to leverage and build upon mature technologies that have been examined by commercial and other government agencies in the United States and elsewhere—and tested extensively in exercises, experiments, and demonstrations—to field a near-term autonomous MCM capability.

LEVERAGING UNMANNED MARITIME SYSTEMS

Today, one of the most rapidly growing areas of innovative technology adoption by military forces worldwide involves unmanned systems. In the past several decades, the expanding use of military unmanned systems (UxS) has created strategic, operational, and tactical possibilities that did not exist a decade ago.

While unmanned systems show great promise, most military professionals are keenly aware of the importance of not embracing every tool a technologist thinks might be of value. Employing unmanned systems in an ongoing series of exercises, experiments and demonstrations is a proven way of separating promising, but immature, technologies from those that will actually wind up in the hands of a warfighter as a proven capability.

One of the systems that performed well during these U.S. Navy events was the T38 Devil Ray unmanned surface vehicle. It is this USV that can be combined with surface and subsurface mine-hunting and mine-neutralizing equipment to provide an over-the-horizon MCM capability.

One of the key attributes of this USV is the fact that the T38 has an aft-mounted tow station which can house either a


Devil Ray T38.2 - On Trailer (Courtesy of Jack Rowley)

mine-hunting sonar system or a mine neutralization system (MNS) remotely operated vehicle (ROV).

The MCM mission will require two T38s to work in tandem. In a full minefield search scenario, multiple T38s with towed mine-hunting sonars will be supported by one or two T38s with the MNS neutralization payload. Additionally, each craft will have an onboard multi-beam sonar search capability to augment the towed vehicles.

The first sub-component of this mine-hunting system is a commercial-off-the-shelf technology that consists of a towed-body-mounted sonar. Several available commercial sonars for this mission have a resolution sufficient to search for mine-like objects (MLOs). An important feature these sonars possess is the automatic target recognition analysis software to classify and/or identify MLO anomalies.

The second sub-component of a commercial-off-the-shelf technology MCM solution is an MNS ROV. Once mine-like objects have been detected and verified, the MCM controller will recommend and program a route for the MNS ROV. When the area search is complete, the MNS T38 transitions from hunting to neutralizing through the launch of its onboard tethered MNS ROV.

The MNS ROV then performs the work previously conducted by various classes of ships as it provides real-time video validation of the mine-like objects previously identified. It then autonomously executes the MLO route for final classification, validation, and neutralization of each MLO. As this is taking place, the T38 shadows and supports it as an over-the-horizon communications link. This process is repeated until the field is cleared.

AN ACHIEVABLE SOLUTION FOR NATIONS AND NAVIES

Naval ships and sailors operate daily in harm's way, but they do not need to be put at extreme risk operating inside a minefield. Navies must accelerate their efforts to deal with deadly sea mines. The essential components for such a system exist today, and a robust COTS MCM solution can reach fruition in the near-term.

These commercial subsystems can be delivered far more rapidly than anything traditional acquisition systems can provide. The time is right to embrace an unmanned COTS solution to deal with sea mines. Once sailors see the COTS solution that can be delivered with the system described above, navies will have an effective way to defeat today's mine threat.


Devil Ray T38 High Speed Operations (Courtesy of Jack Rowley)

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WITH MANUFACTURERS FOCUSED ON IMPROVING TOMORROW, WHO IS CONCERNED WITH IMPROVING TODAY?

By Jai St.James

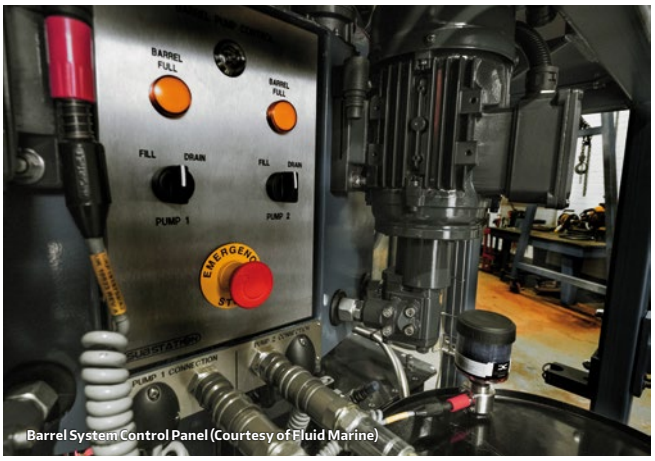
I recently visited a leading work-class ROV manufacturer's workshop and was presented with some of their operation's current front and centre projects. Suffice to say, it mainly involved electric-based WROV technology explicitly designed for an emerging future.

The Fluid Marine Substation™
www.fluidmarine.co.uk
(Courtesy of Fluid Marine)

It is understandable and necessary for industry leaders to focus on global climate concerns. However, it did make me wonder if such bold moves and grand designs often come with barriers to entry. The main obstacle is time and the industry's ability to adopt these newer technologies quickly. This same issue can be seen with electric cars. Electric cars have been here for some time, but only represent 2.2% of the global fleet. Similarly, with an estimated fleet of 900 WROV's worldwide, operators have a decision to make. Should they invest millions in emerging technology now and replace their current fleet, or should they work with what they have, try to extend the life of their fleet, and look at ways of being more efficient today?

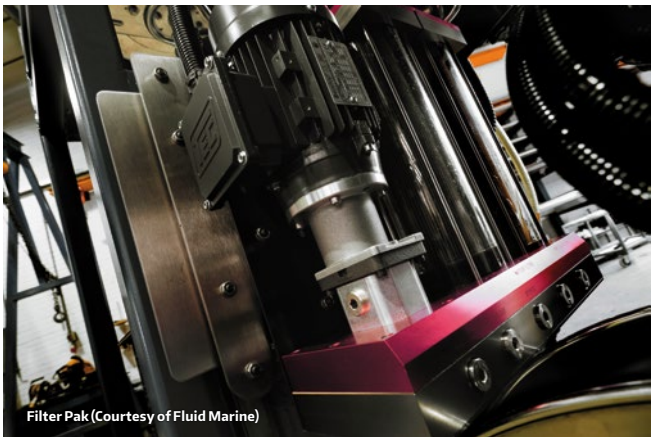
Whilst the future of energy efficiency is necessary, there are undoubtedly some cold truths for a warm planet.

ROV Maintenance (Courtesy of Fluid Marine)



Barrel System Control Panel (Courtesy of Fluid Marine)


Deck Pack Control (Courtesy of Fluid Marine)


Filter Pak (Courtesy of Fluid Marine)

THE CURRENT PROBLEM WITH OUR ROV FLEET

Keeping all work class vehicles operational is critical for operators to reduce overall emissions by 2025. Whilst ensuring that WROVs and similar subsea vehicles remain operational is crucial, it is not uncommon for un-planned maintenance and downtime to significantly impact an overall project. Each hour an ROV vessel is in operation, it can use between 250 and 450 litres of fuel whilst in DP mode. Therefore, each hour becomes more significant than you would think. Other than replacing all old WROV's with new ones, what cost-effective upgrades can we implement now to allow existing processes to be more efficient, reducing downtime and the environmental impact that a specific project has?

IDENTIFYING THE PROBLEMS

To yield solutions, we must first identify the problems. Looking specifically at WROV maintenance and downtime, it is clear that there are several processes that, when added together, cause a bottleneck in getting the ROV back in operation. These include anything from component accessibility to fault finding, all of which deserve an individual review to try and improve team efficiency overall.

One process caught my attention most of all. As far as I can tell, one of the most time-consuming areas of WROV maintenance is the filling and draining of compensators and junction boxes that house the ROVs electrical and other vital components. Oil transfer to JB's, generally carried out using a domestic garden sprayer, would appear very inefficient.

Upon closer investigation, I found that this practice had been an industry standard since the 1980s. The main reason for using such a basic, time-consuming tool is the fear of too much pressure inside the junction box, potentially causing damage to the box. This could be costly and is a significant problem in the middle of operations, so I understand the concern. However, with all the technical know-how and ingenuity within the industry, I was surprised that a common garden sprayer is still widely adopted.

SO, I ASK AGAIN, WHO IS CONCERNED WITH IMPROVING TODAY?

I trawled the internet, trying to find a possible solution with this question in mind. Among the companies attempting to streamline this process, I came across Fluid Marine Solutions Ltd who have quite an effective solution on its way to market in early 2022.

THE SOLUTION?

My fascination with this problem led me to a company whose objective is just that: making existing WROVs, trenchers, and ploughs more efficient, specifically in the area of maintenance. The very problem that I had identified appears to have been solved. I came across a video that directly compared filling a nine-litre junction box using two different methods. One uses the industry-standard five-litre garden sprayer, which takes 15 minutes, and the other uses a new product called SubStation, which completes it in 2.5 minutes. I was intrigued.

Jamie Higginbottom runs Fluid Marine Solutions. Their website states that Jamie has worked in the ROV industry for many years. He recognised that bug spray bottles used for filling junction boxes on ROVs are massively inefficient, and has worked on engineering a solution over the past few years.

As far as I can tell, SubStation operates as a multifunctional tool. It consists of a frame that houses a deck pack and a dual-barrel system that can deliver and retrieve oil directly to and from junction boxes, using a sealed hose system driven by an onboard motor. Part deck pack, part oil delivery system, it includes offline filtration and an oil particle counter. The product promises to do the job six times faster, with a one-person remote-control operation. It can do this whilst

regulating the pressure in the junction boxes. It also claims to be more environmentally sound, reducing oil spills and waste that typically occurs during this specific process.

I called to speak with Mr Higginbottom, and here's what he had to say: "The industry's direction towards the future is evident with the development of fully-electric powered and more efficient work-class ROV's combined with automation and onshore control capabilities. These technologies are a welcome step forward but, unfortunately, will not happen overnight.

"Based on my experience within the ROV industry, there are many ways to optimise commonplace procedures now, making our current ROV fleet more efficient. Our SubStation deck pack was born out of frustration more than anything else. In a breakdown situation, with the vessel on standby and added client pressure to get the ROV operational can be stressful, whilst also knowing that there is an additional hour needed to fill the JB with oil, once the fault is repaired."

He went on to say, "Fluid Marine is dedicated to optimising the essential tasks that are critical to ROV operations and maintenance. We have various products in the development stage, but we are pleased that we now have SubStation ready to roll out early this year. We are currently demoing the units to some of the industry's biggest ROV manufacturers.

"Ideally, we plan to firmly position SubStation to operate alongside the world's WROVs through purchase or rental, supporting any project. We believe that speeding up and streamlining maintenance SubStation will extend the life cycle of current WROVs to help both economically and environmentally during this inevitable industry transition."

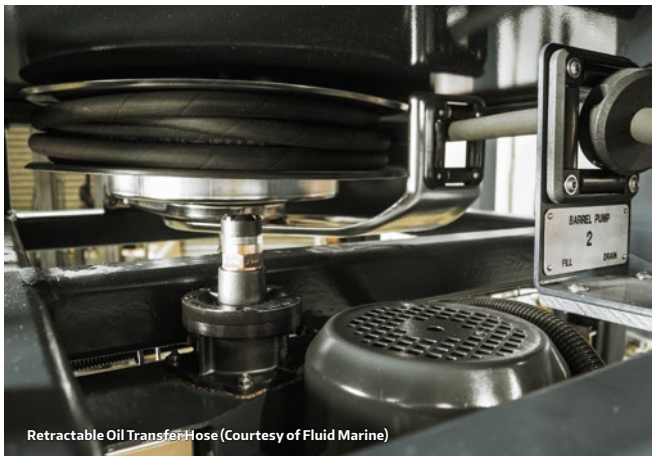
IT'S THE MARGINAL THINGS THAT MAKE THE BIGGEST DIFFERENCES.

Looking at the problems SubStation solves, it's clear that with some lateral thinking, there are options available that can tackle certain inefficiencies. Operators can adopt some cost-effective solutions today without immediately replacing their entire fleet.

Undoubtedly, more efficient ROVs are necessary and inevitable, but the widespread replacement of current WROVs is unlikely to happen in this decade without a hefty investment. This shift will be gradual and is a long-term solution.

Luckily, some companies are concerned with improving today, and operators should pay attention to optimising existing equipment and looking internally at their current processes. Whilst Fluid Marine's SubStation isn't going to solve the emission reduction problem independently, it certainly can be a cost-effective micro-addition to improvements in mainstream practices that, when added together, have a substantial impact on overall project emissions. In addition to the array of emerging technologies on the horizon, smaller, more immediate improvements should also be on the agenda if operators and companies genuinely want to improve things today.


Oil Filled Junction Box (Courtesy of Fluid Marine)


Retractable Oil Transfer Hose (Courtesy of Fluid Marine)

SubStation Remote Control (Courtesy of Fluid Marine)

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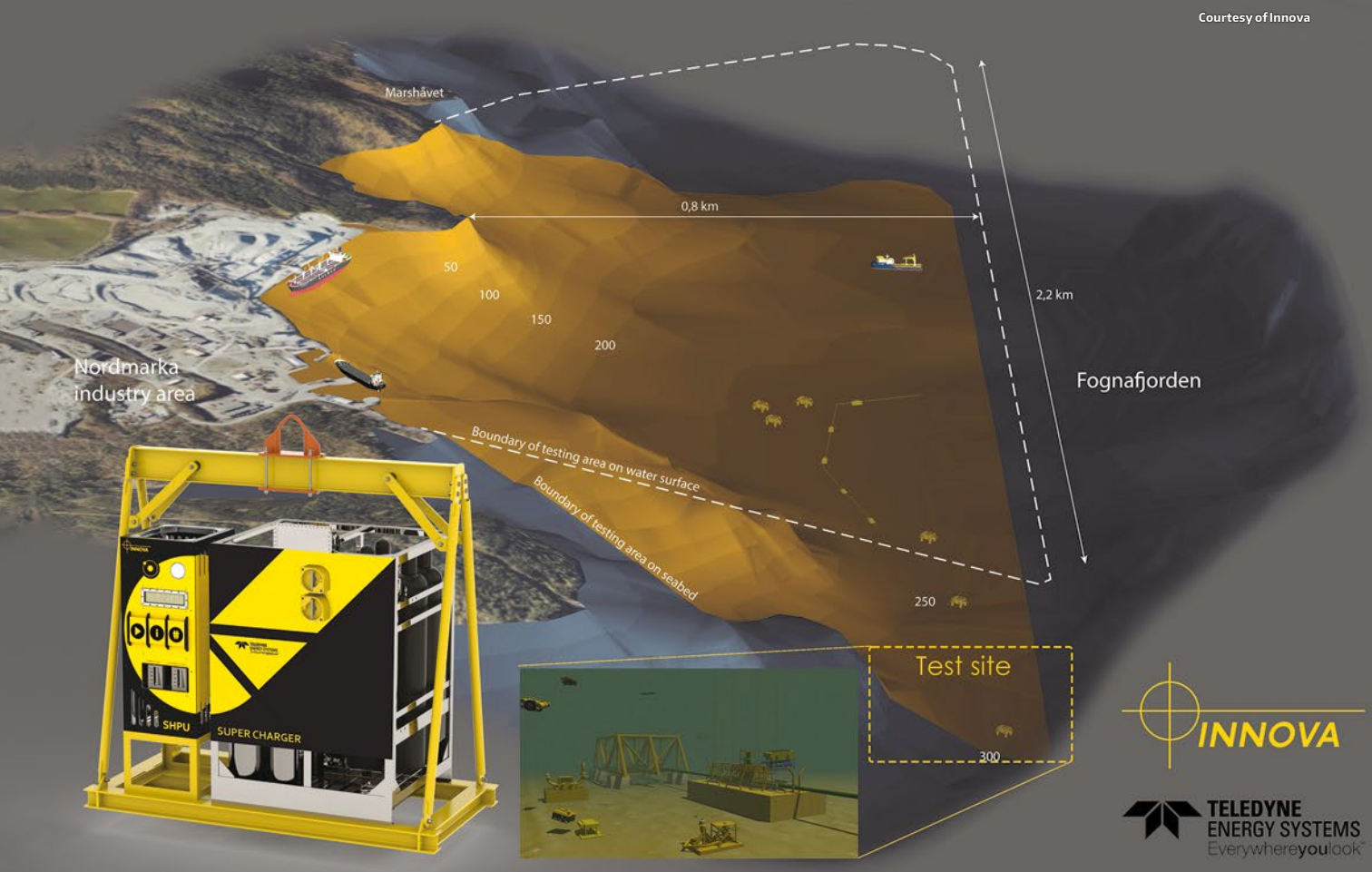
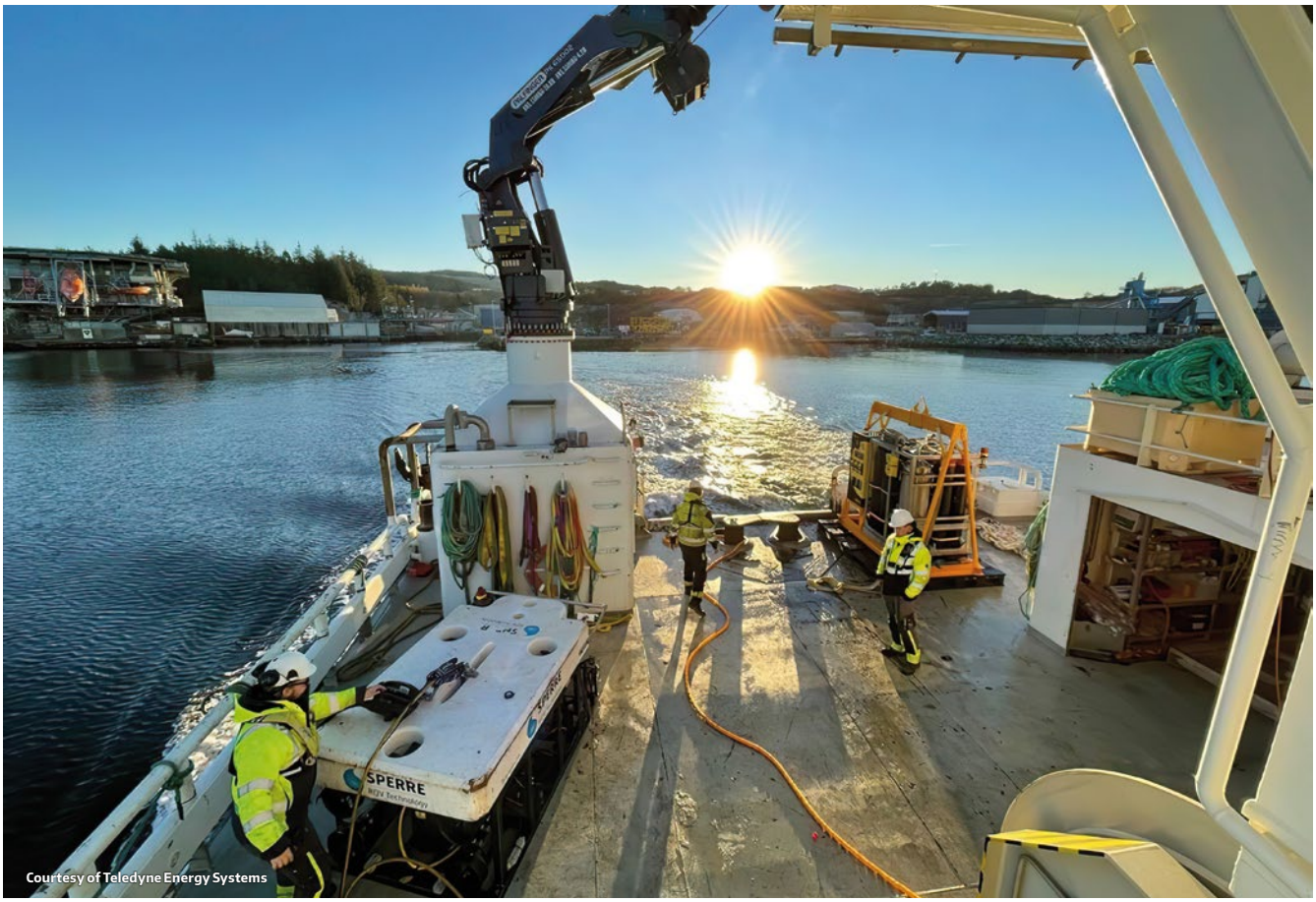
DEMO OF THE HYDROGEN POWERED SUBSEA HYDRAULIC POWER UNIT (SHPU) IN NORWAY

Innova and Teledyne Energy Systems have partnered to perform a demonstration of a hydrogen-powered subsea hydraulic power unit (SHPU) at the Tau Autonomy Center in Norway. The demo merges the capacity of Teledyne's supercharger subsea hydrogen fuel cell and Innova's electro-hydraulic pump for low viscosity. Teledyne's supercharger technology was developed with NASA for space systems and this event demonstrated the repackaged version of the very same stack but for subsea use at 230m of depth. The purpose of the fjord testing exercise was to show the customers that it can be done and to increase the TRL levels of both the subsea HPU and the supercharger. We talked to Kjell Vie, Development Manager from Innova, to find out more about this new technology.

Courtesy of Innova





Courtesy of Teledyne Energy Systems

RICHIE ENZMANN: What's the main purpose of the FuelCell Supercharger powered SHPU?

KJELL VIE: The Supercharger represent a new application of fuel cell technology. Combined with a Subsea Hydraulic Power Unit (SHPU), a standalone subsea hydraulic power source can be provided without connection to any grid or infrastructure. Full scale and realistic testing subsea provided valuable data for both units as well as system performance.

RE: In your opinion what will be the application of such technology?

KV: In principle the Supercharger technology may be used for any subsea application without access to a power infrastructure. Also, where a redundant power source is required. The SHPU is designed for use with subsea control fluids typically used to operate valve actuators on subsea installations as well as down hole valves. One example of application is to use the fuel cell as a redundant power source for controlling a hydraulic safety valve.

Both technologies have individual applications. The combined, integrated test demonstrated system integration as well as capacity and performance under realistic conditions.

RE: Would this technology be suitable for AUV charging on the seabed?

Courtesy of Innova

Courtesy of Innova

KV: The electrical energy produced by the fuel cell may be used for any consumer that need charging or continuous electrical power. AUV charging is one application that has been evaluated.

RE: How would the hydrogen powered subsea power unit be different from other battery solutions?

KV: The reactants (hydrogen and oxygen) in a fuel cell will not have any time or temperature degradation. Nor any self-discharge as batteries. System complexity suggest that the fuel cell technology has benefits for larger energy applications.

RE: What kind of power and current can the Subsea Supercharger provide?

KV: The Subsea Supercharger can be scaled up to 30MWh of energy. The system tested provided 100kWh. The power output was 8kW with voltages in the range of 24 to 600 Vac/Vdc.

RE: How is the SHPU and the supercharger connected?

KV: In the simplest configuration the two systems are only connected by a DC power cable. The Supercharger monitors the power consumption and start producing electricity based on the load. The SHPU (or any other load) can operate without constrains as long as the energy or power consumption is within the defined capacity of the Supercharger. In the fjord test performed at TAU autonomy centre (Norway), the capability to handle an intermittent load from the SHPU was demonstrated. Obviously, if the supercharger can communicate with the load or other system, more advanced functionality can be implemented. Typically, several consumers connected to the same Supercharger may require means of power management. Both units have embedded control and monitoring and support network communication with each other or a host system.

RE: Please tell us how are the local subsea controls powered?

KV: All power required to operate the two units is provided by the Supercharger. To save energy when the load is idle, the fuel cell is not active. An internal battery maintains power to control computers when the pump idle. This is charged from the fuel cell when required and when a load requires the fuel cell to be active. This way continuous power is available to the consumer even if the fuel cell is not producing electricity.

The fjord test was designed so that once started, the program was running autonomously. The predefined test program consists of repeated HPU operations with intermediate rest periods until a defined energy was consumed. Both units were configured with ROV interfaces to be able to verify system status by occasional ROV presence. The Supercharger had LED status indicators and main power switches for ROV intervention. The SHPU has 3-button touch switches and test display to provide system status info and means of interrupting the test program at site.

Finally, according to energy forecasts and analysts, when the power requirements go above 4-500kWh, then a fuel cell solution could be cheaper compared to the traditional underwater battery solutions that are out there. Another advantage of the technology that its self-discharge rate is practically zero, meaning that it is expected to be operational underwater even beyond 10 years.

Courtesy of Innova


Courtesy of Innova

DEFENCE CORNER

UDT PREVIEW: UNDERSEA TEAMWORK AND UNDERSEA WARFARE TRENDS

We sat down with Captain David Wilkinson (Ret.) for a briefing on the trends of subsea warfare and possible themes of future defence conferences as excitement is building up to this year's UDT. Captain Wilkinson is a recently retired officer with 38 years of experience in the British Royal Navy who is now working as an advisor for Clarion Defence and Security. He started his career as marine systems and electronics engineer in the Royal Navy before moving on to be a warfare officer, military diver, and principal underwater warfare officer fighting in the underwater space. His expertise includes mine warfare, anti-submarine warfare, working with other submarine officers on submarine-on-submarine warfare, and maritime aerial surveillance.

RICHIE ENZMANN: Please tell us a bit about UDT 2022. What can we expect this year?

CAPT. DAVID WILKINSON (RET.): The theme of UDT this June in Rotterdam is about the challenges of operating in the Gray Zone. The Gray Zone is a complex political, strategic, and operational space, and one that demands much of our technologies and people. Underwater operations have always operated in a type of Grey Zone, but this year's theme seeks to explore the subject in the modern era. Detection, tracking, and classification is always difficult in this battlespace but ahead of a declared conflict these become more important.

Courtesy of Clarion Defence

It is a very challenging scenario, and we will be debating how networks, humans, systems, and uncrewed vehicles work together in times of tension and in conflict to provide the clearest of operational pictures. In the Gray Zone tactical misunderstandings have significant strategic implications.

This conference is unique. There are lots of people that get together and talk about the operational side of underwater warfare, but there are not many people that put submarine technology at the centre of an event. My ex-engineering background is alive and very excited about that, but I'm also bringing my tactical and operational experience to look at things slightly differently. I'm a technically minded warfare officer who looks at the future of submarine warfare with as much excitement as in the past.

RE: I remember the last UDT conference I attended was held in Stockholm, Sweden. I found the presentations focused on submarine technologies very much interesting as the exhibition itself. Why was Rotterdam chosen as a location for this year's UDT?

DW: UDT 2022 Rotterdam is a fantastic location with a long maritime heritage. We have a strong connection with Koninklijke Marine (The Royal Netherlands Navy) and they been fantastic in supporting us. Indeed, the Admiral who will be hopefully giving the keynote address commanded a submarine that helped me hone my anti-submarine


Courtesy of Clarion Defence


Courtesy of Clarion Defence

warfare skills – it will be great for me to finally meet him! The Koninklijke Marine, along with many of their neighbouring nations and navies, are undertaking an exciting re-equipping programme and therefore they are an ideal partner for UDT. I do know they will bring along a lot of contemporary challenges and thoughts for us to consider. Rotterdam is a place where the importance of the sea and the protection of maritime interests are well known. UDT is all about bringing together the operator, the maintainer, and the inventors & designers, and after COVID it will be fantastic to see everyone reunite in the UDT space.

On day 2, we are going to talk to subject matter experts which is exciting, but there are also some very big companies exhibiting such as BAE Systems, Atlas Elektronik, TKMS, and then also small companies with amazing technologies, such as Shark Technologies, showcasing diver technologies that you can wear on your wrist. This is a good place where you bring together the very high end and the interesting new off the shelf (COTS) technologies that may have started their life as civilian, or even leisure applications and now they are being brought to the military customer. It will be very exciting to see some of these smaller stands.

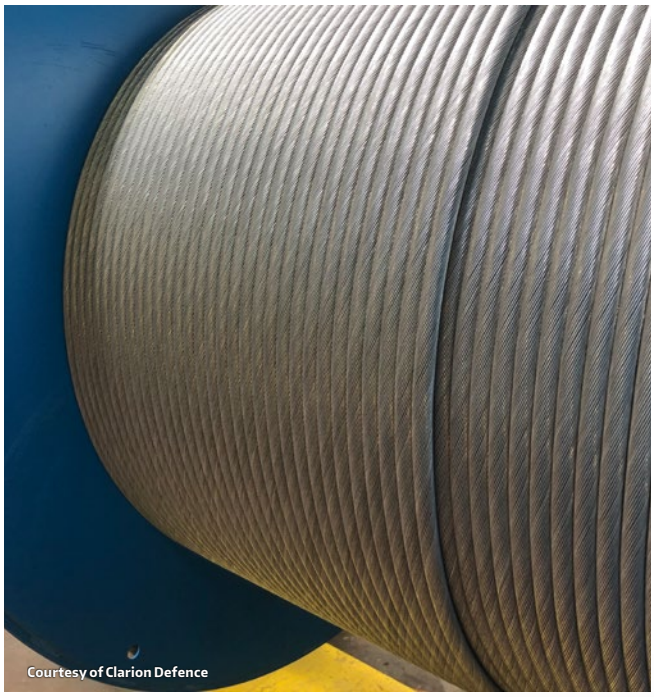
RE: How did underwater warfare evolved over the years? And how do you see the continuation of this evolution in the near future?

DW: The first use of underwater warfare we know about was around 400 B.C., when divers with little reeds swam across to attack the ships on the other side. This is a very traditional space that has come along a long way, where we did not have a revolution but an evolution of tactics. What we use now may not have been much of the surprise to the Peloponnesians in the diving front, but we are at a very interesting divide whether we continue to evolve or going into a revolution of ROVs, uncrewed vehicles, and bringing together sophisticated technology. Can we make this undersea space transparent? The integrated technology of communications and teamwork required to do that is just incredible.

Now we are seeing the coming together of civilian type equipment with military applicability. This is a very different time in innovation, because if we wind the clock back a few hundred years, the most complex machines on the planet were warships. This has changed now with the complexity in different environments often lead by the civilian sector with military people looking at it and thinking: "I know how I could use that!".

RE: That is very interesting! I always had the impression that the defence sector was way ahead of the civilian developments when it came to technology. Is that not the case anymore?

DW: If we look back even 10-20 years ago, defence was in these massive programmes building huge submarines – and yes, those still exist. If we look at Holland, Germany, Belgium, UK, Canada, Australia, these countries are all now in big undersea warfare development programmes for big kit and I think they will always be the same. Where we are starting to see this leading edge of civilian technology is in the robotics space. What we are seeing is that companies being able to show us what their ROVs and other autonomous vehicles can do and then for us to apply military technology to it. And we are at a moment when potentially militaries get to grip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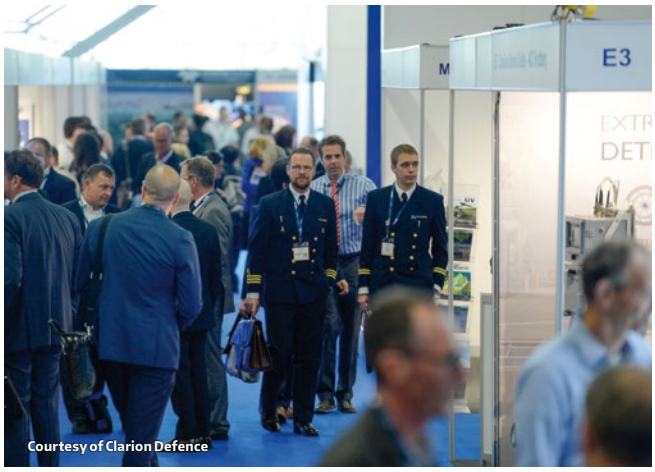


Courtesy of Clarion Defence

with the full capability and opportunity of this advanced technology. We are probably rightly allowing the commercial side to lead from this perspective.

If you look at some of the ROVs for the oil & gas industry, they could have direct applications when we start looking at defending something in the underwater space. Traditionally we are thinking about submarine versus ship, or submarine versus submarine. However, many people are starting to think that undersea defence will be about network protection, looking at protecting underwater cables, underwater infrastructure. So, we are looking at something from seabed to surface and then when you include Maritime Patrol Aircraft (MPA) you are talking about in the sky as well.

It is very difficult for the military to develop all these kinds of technologies. If we are looking at ROVs in the oil & gas sector, then we can start to think how that might be used in a military set, not necessarily militarily, but to be used by security personnel to provide the protection to data cables, pipelines, and underwater infrastructure.

RE: Looking in the future do you see an increase in the number of nations operating submarines and unmanned systems? How do you see the trend in the UK and on international level?

DW: We are seeing new nations all the time entering the submarine space. There is an expansion of new diesel submarines and an increasing number of new nations operating them. Obviously conventional submarines are a lot easier to get to grips with, not many nations enter at a purely nuclear level like the UK. There are emerging nations coming through that are very much looking at the conventional space. For example, Iran is on that journey looking at systems and tactics very differently. There is over £8 billion expected to be spent in the UK underwater space until 2030, so this is a big space. A conventional submarine operated can be quite tricky especially close to land, it's not easy the oceanology, the noise in shallow water. Perhaps an uncrewed or autonomous systems or static systems could also be useful for us.

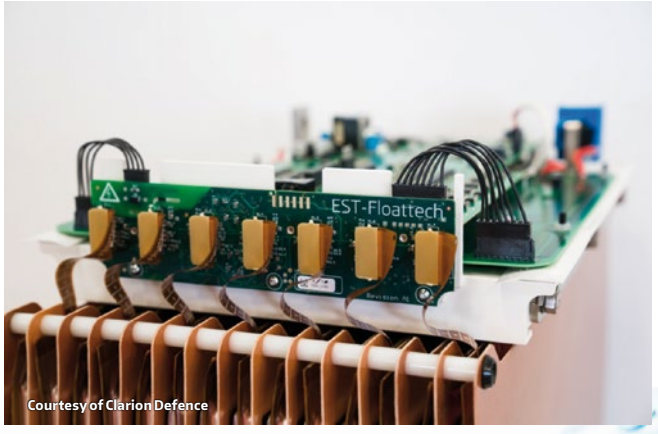
We also have many "players" in this underwater space. We have state versus state actors, but we also have non-state actors also looking at these technologies. Then the question is how we are going to defend against them. For example, when the Suez Canal was blocked by a merchant ship because of losing control of its engine, then we start to see the world differently. So much of the worlds trade is reliant on the shipping lanes and the water space creating an environment for other people to operate in and we need to be aware of that. We need to be able to do simple protection of those sea lines, all the way up to state on state warfare. The actors are many: lone wolf guys, organised terrorist groups, and state militaries.

Everybody talks about cyber space and the internet these days. But one torpedo, one limpet mine, one floating mine, one diver can change things strategically – and that Is why this space is so exciting.

We must guard the sea. It is a very unregulated space. Opposed to the airspace that is a highly regulated and highly transparent space. In the underwater space the technological and physical demands are different. You got to be able to use those sensors even if we are talking about a submarine, a warship, or an unmanned system. Therefore, the theme of teamwork came from. You got to put that together and be able to communicate.

RE: Teaming also implies that the use of low-cost systems won't necessarily make all that heavy kit obsolete, but what we can see in the future is a synergy of these things working together.

DW: In the middle, the nucleus of all of this is the ships and submarines, but they are connected by communications, remotely operated or autonomous unmanned technologies,



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satellites, airplanes, a whole thing. All these things work wonderfully though, until the communications stop working, or the computer control doesn't work. So bringing together all that teamworking I'm very used to organising all that using voice, so you have to have those traditional skills, but also have to have to incorporate that super modern thinking. Unless you are able to harness all of that the opposing submariner, or the fanatical terrorist can get around. You got to understand that teamwork space, the technology and what you are going to achieve. Either trying to protect an aircraft carrier moving at 25 knots and launching jets, you got to think differently. And UDT allows the war fighter to look at that. Yes, it's technology, but the war fighter like me needs to understand that, because unless you can bring it altogether you can't hope to be superior in this space – it's too complex.

RE: Yes, as we know complexity is in inverse proportion to reliability. The more complex a system, the more difficult it is to make it reliable and as a result it becomes more vulnerable too.

DW: And this is the question how we are bringing together that system of systems. Can we challenge technology to use geo fencing underwater? Can seabed sensors do? How do we put this system all together? As we are advancing to this new age of autonomy using uncrewed and crewed systems. But equally we are still going to have divers and submarines. How do we start to employ technologies of having the vehicles

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several thousand miles away but the operators in Europe or in the USA? We are on this cusp of traditional manned systems to all the way through these autonomous systems at range and being operated by teams of people thousands of miles away in an operating centre.

What we are trying to do at UDT is to challenge thinking. The UDT pillars challenge the different environments whether they be the weapons, or sensors, or the teamwork, or the operational aspect, and more importantly getting the young engineers and designers thinking in that space of the non-traditional ideas. These themes will take us on a journey and push the boundaries of thinking: the technology, the tactics, and the strategic thinking all wrapped up in some of these themes at future UDT conferences.

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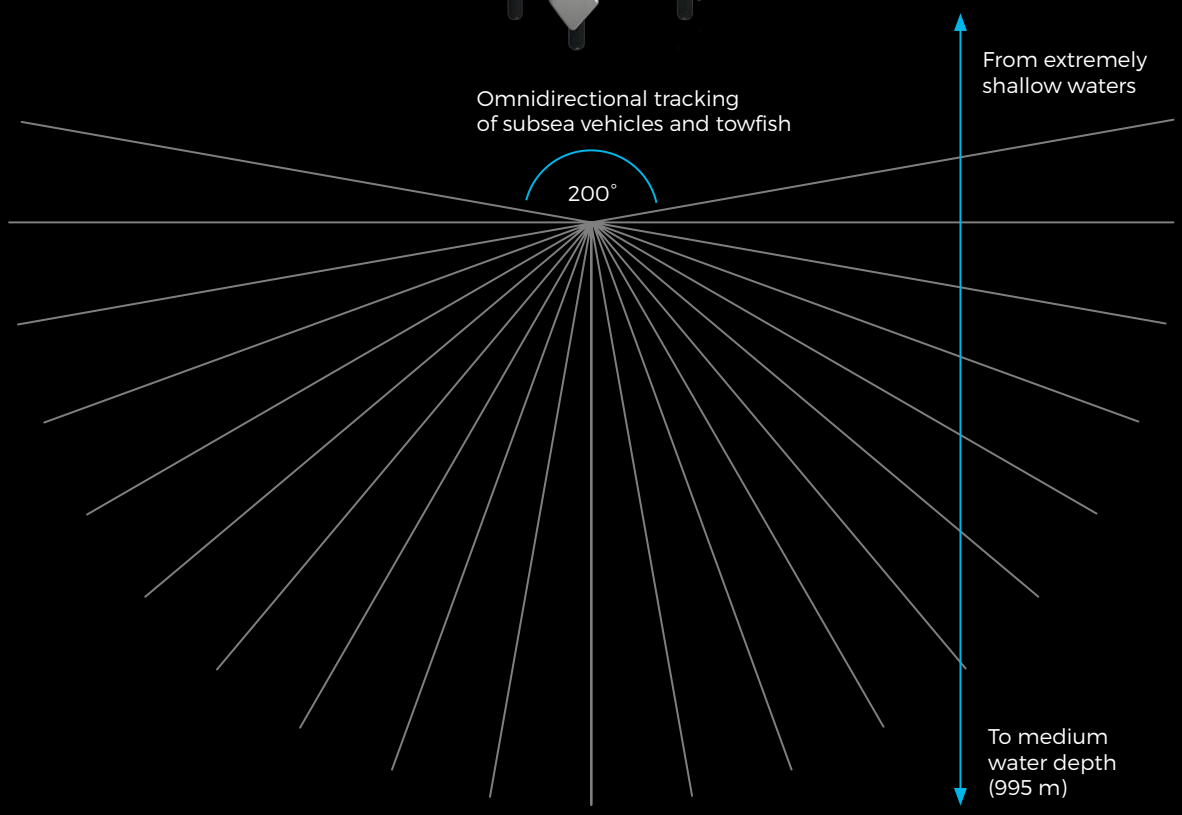

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