



PLANET



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7.

**Bulgin Connectors  
Providing the Vital Link**



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**Ocean Exploration in Style  
with Cookson Adventures**



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**ISSUE**

Q4 / 2021



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## EVENTS CALENDAR

For more information about all events visit [WWW.ROVPLANET.COM](http://WWW.ROVPLANET.COM)

### JANUARY 2022

#### IXBLUE USERS CONFERENCE

Saint-Germain-en-Laye, France (25 January 2022)

### FEBRUARY 2022

#### SPE OFFSHORE EUROPE

Aberdeen, UK (1-4 February 2022)

#### MTS/IEEE OCEANS'22

Chennai, India (21-24 February 2022)

#### SUBSEA EXPO

Aberdeen, Scotland, UK (22-24 February 2022)

### MARCH 2022

#### OCEANOLOGY INTERNATIONAL

London, UK (15-17 March 2022)

### MAY 2022

#### OFFSHORE TECHNOLOGY CONFERENCE (OTC)

Houston, TX, USA (2-5 May 2022)

### JUNE 2022

#### UNDERSEA DEFENCE TECHNOLOGY (UDT)

Rotterdam, The Netherlands (7-9 June 2022)



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

# WELCOME TO ROVPLANET!

Dear Reader,

In this issue we take a connector focus and feature two very different companies that develop underwater connectors. Bulgin have been very active supporting competitions for the next generation of underwater robotics students. They have generously supported many teams with their underwater connectors helping students to achieve their goals building new types of underwater robots. On the other hand, Northrop Grumman which is traditionally a large defence contractor, have come up with a completely new technology for connectors and are looking for connector companies and organisations to licence their technology to.

There is exciting news about new ROV systems coming onto the market. One of them is the eWROV from Saab Seaeye. Seaeye were able to create a vehicle that delivers the same working capability as a traditional 250HP hydraulic ROV. The new vehicle only requires 60% of the energy which significantly reduces its fuel consumption and CO<sub>2</sub> emissions. Ten of these new eWROVs were ordered by Ocean Infinity, who are very conscious environmentally and are looking to transform the way offshore operations are performed using a fleet of unmanned robotic ships operated from remote onshore control centres.

Finally, this will be the last issue of the "ROV Planet Magazine". We started the magazine in 2014 and first debuted it at the MTS/IEEE OCEANS conference in St John's. From onwards we gradually gained a loyal readership and following. Although our core readership has always been Atlantic based (mainly in the UK/EU/Scandinavia and North America), we have visited and exhibited at many exciting events all over the world: from Aberdeen, to London, Southampton, Amsterdam, Houston, San Diego, Singapore, and so on.

However, the good news is that we are not actually going away. The magazine will live on, because "ROV Planet" is rebranding as "Ocean Robotics Planet" from the start of 2022 to reflect the ongoing changes in the ocean space. With the advancement of unmanned systems, electrification, digitisation, and robotisation of the underwater domain, we felt that the new title would be more suitable for this new digital age. See you as Ocean Robotics Planet in 2022!

Best regards,  
**Richie Enzmann**

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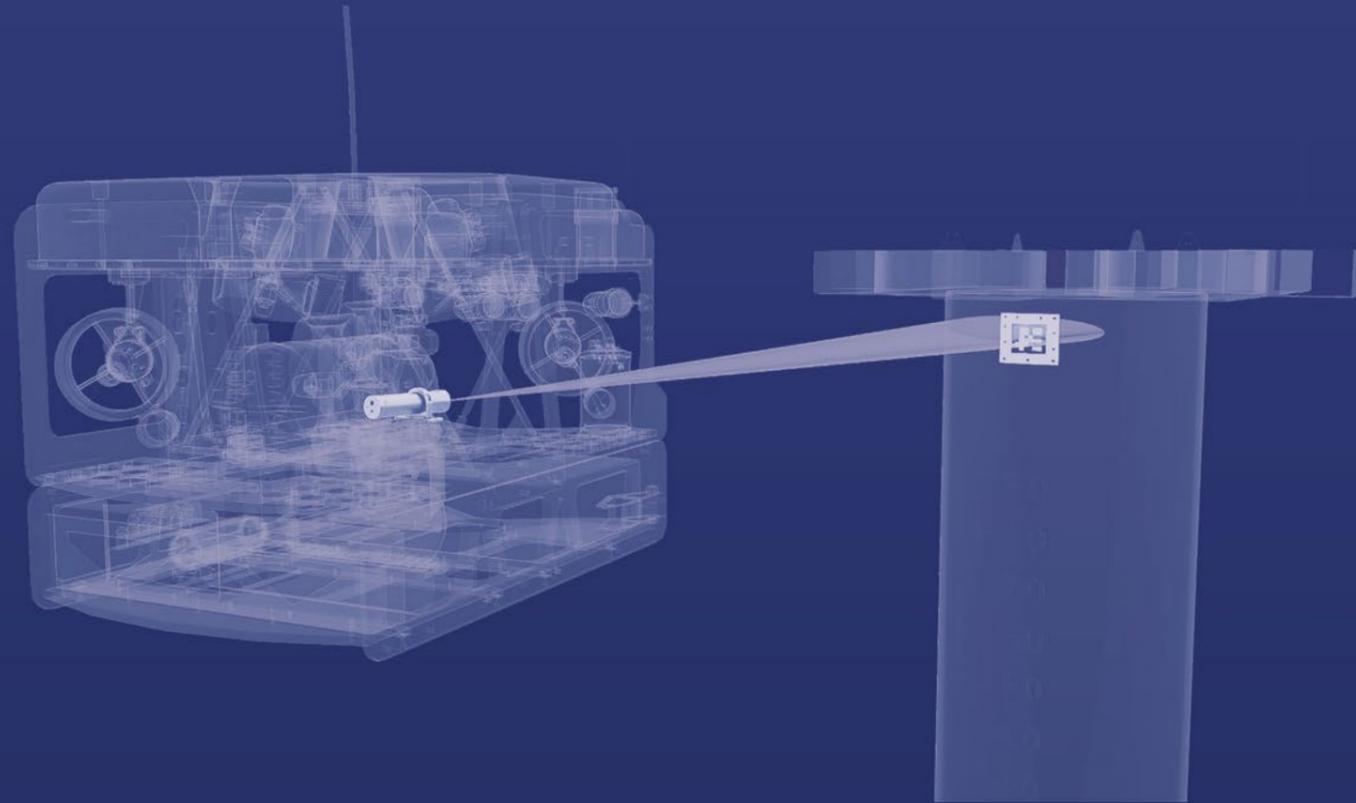
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Courtesy of MATE



## BULGIN CONNECTORS PROVIDING THE VITAL LINK FOR FUTURE GENERATIONS OF UNDERWATER ROBOTICS

By Richie Enzmann, ROV Planet

Bulgin is the widely recognised leading manufacturer of environmentally sealed connectors and components, and are a primary sponsor at the MATE 2021 and the RoboNation Robosub 2021 competitions this year. The company is a promoter of STEM subjects, and are enthusiastic about enabling the future generation of engineers and roboticists by supporting underwater robotic themed events. This year they showed their support by offering free samples of connectors to the competition's teams.

### THE MATE ROV 2021

The MATE ROV Competition is an underwater robotics challenge that engages a global community of learners each year. Organised by the Marine Advanced Technology Education (MATE), the competition is supported by the Marine Technology Society's ROV Committee, the National Science Foundation, and other technology and education-related organisations. They include the Schmidt Ocean Institute, the NOAA Office of Ocean Exploration, and the National Marine Sanctuary Foundation.

This year, the competition challenged students to tackle problems that impact the entire world: plastics clogging our rivers, lakes, waterways, and ocean from the surface to the bottom of the Mariana Trench; as well as climate change raising ocean temperatures, affecting the health of coral reefs; and contaminants in our waterways. You can find these scenarios from Pennsylvania to Portugal, Florida to Australia, the Western Pacific to the Mid-Atlantic, and Indianapolis to Indonesia. The theme of this 2020/2021 season therefore was "Excite, Educate, Empower: Students engineering solutions to global problems".

This year the "client" was us – our global community – and the request for proposals was simple: to design and build

an ROV and the necessary sensors and tooling to tackle the problems of plastics in our ocean, climate change's impact on coral reefs, and the consequences of poor environmental practices on our inland waterways.

Teams from all around the world have gathered in Johnson City, Tennessee to compete against each other in the finals from the 5-7th August 2021. Participants were able to compete live in Tennessee or via videos of their ROVs performing tasks while presenting virtually. People could also watch the competition live-streamed on Twitch. From the 53 teams, 28 made the trip to Eastern Tennessee, with the remaining teams participating in the telepresence category.

This robotics competition is unique in that it takes place underwater. Student teams competed using underwater ROVs that they designed and built, then presented to judges who represent science, technology, and engineering fields. Teams from K-12, community colleges, and universities competed in either the EXPLORER or RANGER class. Judges evaluated teams on the design, construction, and performance of the ROVs; the members' ability to communicate; and how they developed the ROVs.



Courtesy of Bulgin



Courtesy of Bulgin



Courtesy of Bulgin



Courtesy of Bulgin



Courtesy of Bulgin

One of the teams supported by Bulgin was the Georgia Tech Marine Robotics Group. They said, "Bulgin's waterproof connectors have enabled the Marine Robotics Group at Georgia Tech to refit the main WAM-V electronics box in preparation for RobotX. The box has seen a lot of wear & tear, and is in desperate need of new and reliable waterproof ports. The connectors are looking to be a great fit for our needs... passing both power and data to our computers and other electronics." Sean Fish, Georgia Tech Marine Robotics Group.

Another Team supported by Bulgin was Mizzou Student Underwater Robotics Foundation. They added, "Right now, on our submarine "Jelly", there is a thick tube of wires that connects our battery tube to the main electronics bay of our robot. We plan to use Bulgin's waterproof connectors to eliminate the need for the tube by connecting the wires directly from the battery tube into the main electronics bay of our sub. Using Bulgin connectors will greatly reduce the amount of space, weight, drag, and instability that our current tube causes due to its size and volume. Bulgin connectors will also allow us to easily make changes to the submarine by not having to feed wires in and out of the tube. Instead, we will just be able to plug and unplug them when needed. In a competition where constant changes are necessary, Bulgin makes it easy to keep improving our sub!"

### THE ROBONATION-ROBOSUB COMPETITION FOR AUVS

Another competition Bulgin took part in was the AUVSI (now RoboNation) RoboSub Competition held annually in July in San Diego, California. RoboSub is an international competition where student teams from around the world design and build robotic submarines, otherwise known AUVs. The behaviours demonstrated by these experimental AUVs mimic those of real-world systems, currently deployed around the world for underwater exploration, seafloor mapping, and sonar localisation, amongst many others.

The students also build real-world skills that they'll need in the workforce and in life. Experiential learning is the foundation of students' confidence. Competition brings that out, challenging students to transform their theoretical knowledge into practical solutions. But they're learning so much more than that. Students need to work as a team and take on a slew of other real-world challenges. They learn to re-investigate intricate details of theory, harness their technical communication skills, and build valuable leadership skills. Along the way, students are also learning self-reliance and jump-start innovation; encouraging intelligent risk-taking as they exercise their growing STEM skills.

### THIS YEAR 54 TEAMS FROM 12 COUNTRIES PARTICIPATED IN THE ROBOSUB COMPETITION.

One of the teams supported by Bulgin was AUV-IITB based in India. The team is comprised of hard-working technocrats, ranging from bright-eyed freshmen to driven senior undergraduates and tech-experienced post-graduates, spanning various branches of engineering at the Indian Institute of Technology, Bombay.

The AUV-IITB were very grateful for the support from Bulgin, and in their opinion the company has greatly contributed to their success at the competition. They have used Bulgin sealed connectors for their vehicle in varied applications. These secure and robust connectors are designed to provide robust and watertight connections in industrial and harsh environments.

"We believe that Bulgin provided us with user-friendly and quality connection interfaces that were durable. We are grateful for their support and assistance, and are looking forward to further collaborations with Bulgin in the future.", said Nakul Randad, the team leader of the AUV-IITB.



Courtesy of Bulgin



Courtesy of Bulgin



Courtesy of Bulgin



Courtesy of Bulgin

Another team, Caltech Robotics (from the California Technical University) has extensively used Bulgin connectors and other parts for their vehicle design. "Bulgin products provide a broad selection of very attractive components. In particular, Caltech Robotics Team has found the variety of switches particularly useful for our applications. These switches can be potentially used for our central kill switch, battery switch, motors, thrusters, or many other possibilities. Currently in the development phase of building another submarine, we are looking forward to different ways of incorporating Bulgin products.", said Sandra M. Chea, Leader of the Caltech Robotics Team.

One of the teams was AGH Marines from Cracow, Poland. They've been using Bulgin connectors for their electrical connections on their ROV and control pods.

The DTU-AUV team noted some of the positives during their inspection of the connectors and their design. The Bulgin connectors were much more compact and durable in comparison to our previous connectors. Their flexibility was better in terms of the variety of connectors with trusty waterproofing. The connectors can withstand rough conditions and were easier to use and connect, with a more suitable locking mechanism compared to previous connectors. Furthermore, they matched the high current requirement of their systems. Previously, the DTU-AUV team used in-house solutions with epoxy for waterproof connections, but disconnecting those connectors took a very long time. This made debugging a tedious process. Previously our cables would wear out with time and proper IP68 cables or waterproof connectors were expensive. However, Bulgin provided them with a cost effective and reliable solution.

Based on preliminary testing, Bulgin connectors have made the prototyping of our communications stack much more robust and have given us no issues with waterproofing. These attributes make Bulgin connectors an ideal choice for our vehicles. We look forward to the association of Bulgin and DTU-AUV in the upcoming years and hope that we can take strides towards making meaningful developments in the underwater domain.

At UFRJ Nautilus, they are currently developing a brand new AUV called "Lua". Through the RoboSub partnership, they have selected a few of Bulgin's connectors for evaluation and use on their new project. Bulgin was selected for many reasons. The PX0931 for example was chosen as their connector for

motor power because of its sturdiness (as they've had issues with breakage of connectors in the past) and its great electrical properties, as exemplified by the 32 Amp rating. And the PX0800 Mini Buccaneer was chosen for more delicate tasks, with the new actuators and sensors their project now includes.

Through Bulgin's partnership with the RoboSub competition, they were able to obtain a few samples at no cost and – considering their budget – the products they received provided a great benefit when compared to the price. Unfortunately, due to the prolonged effects of the pandemic, their samples have not been properly installed yet, but they look forward to the day they'll be in the pool again, after finally witnessing how well Bulgin's products can handle the task at hand.

Bulgin is widely recognised as a leading manufacturer of environmentally sealed connectors and components. With over 95 years of experience in the industry, Bulgin continues to innovate and develop products and services to cater for its global customer base across a variety of markets. Bulgin offers a vast range of connectivity solutions for harsh environments. To find out more visit: [www.Bulgin.com](http://www.Bulgin.com)



Courtesy of Bulgin



Courtesy of MATE

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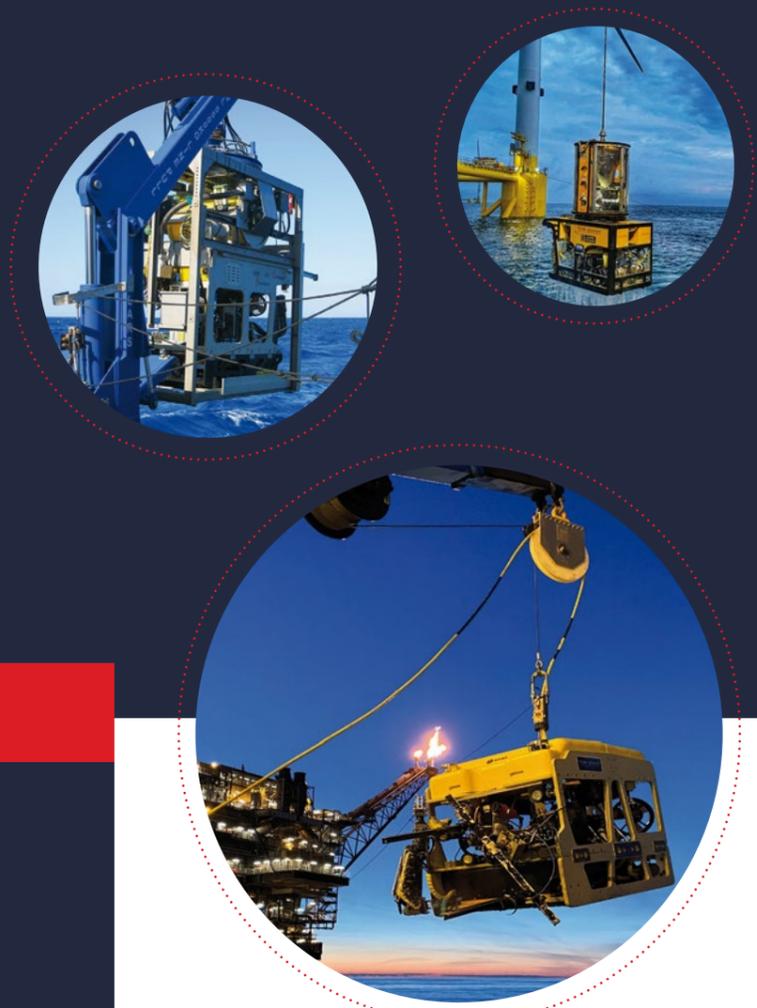
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# OCEAN EXPLORATION IN STYLE WITH COOKSON ADVENTURES

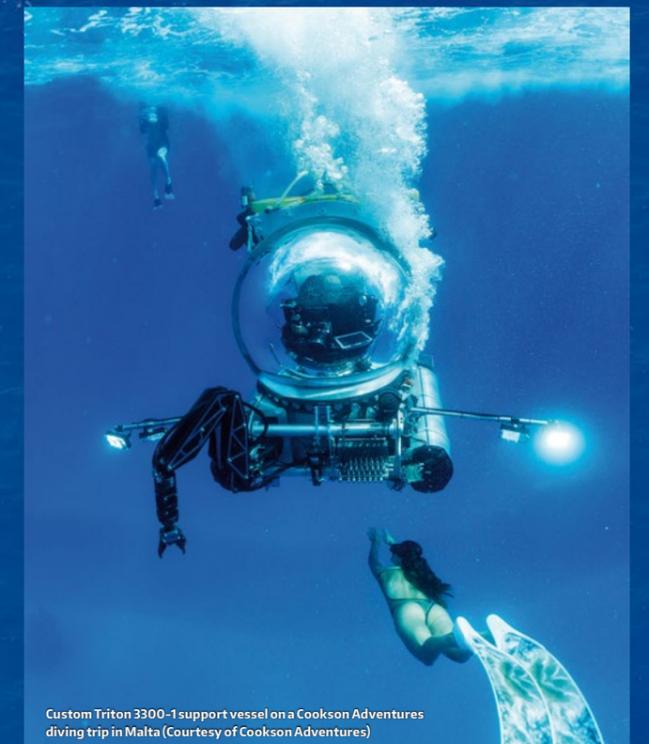
Henry Cookson has created innovative new services in the luxury travel industry, bringing the first private submersible to Antarctica, working with remote tribes in Asia and Africa, and personally curating and hosting many of the adventures himself. Henry founded Cookson Adventures in 2009. His passion for exploration reached new levels in 2004, as he prepared for the Polar Challenge and then the Pole of Inaccessibility, for which he now holds a world record.

Cookson Adventures are leaders in experiential luxury adventure travel. They specialise in taking clients to explore isolated, bio-diverse ecosystems in typically unreachable regions and climates, without compromising on style and comfort. Whether discovering unknown Roman shipwrecks by submersible, or organising the most complex multi-yacht expeditions in Antarctica of the modern-era, they continue to pioneer the concept of world-first discoveries in travel.

Each one of their adventures is ultra-personalised to each client, built from the ground up by a team of in-house experts who range from British Army captains to global event planners. They also draw on an international network of contacts that includes ice pilots, research scientists, and marine biologists, all of whom add their unique and expert insight into their experiences.

**PRESERVING AND PIONEERING**

Having rehomed hundreds of giant tortoises in the Galapagos and discovered a new species of orca off Cape Horn, conservation is at the very heart of Cookson Adventures. They operate no single-use plastic yacht operations, and in 2020 they committed to delivering completely carbon neutral expeditions and experiences. Cookson Adventures worked with Carbon Footprint Ltd to build a bespoke carbon calculator to



Custom Triton 3300-1 support vessel on a Cookson Adventures diving trip in Malta (Courtesy of Cookson Adventures)



Cookson Adventures explore a shipwreck by submersible in Malta (Courtesy of Cookson Adventures)

model the emissions from their logistically complex trips, and then partnered with them to source audited and measurable carbon offset and reduction projects around the world. These projects include tree planting, the provision of clean drinking water, and stimulating the growth of clean energy.

As a company, Cookson are at the forefront of underwater exploration, and they incorporate submersibles into many of their expeditions across the globe. They offer a wide range of services; they can advise clients on purchasing a private submersible, and then also offer a full management service on top. Every client is different, and their USP is that they are flexible and can tailor a solution that works best. They also charter these vessels from private owners or from submersible manufacturers themselves to lease to other clients.

### BESPOKE ADVENTURES INTO THE DEEP

Each adventure is bespoke to the client's interests and requirements. Cookson Adventures will often undertake an in-depth recce of the location before the client's arrival. That way they can ensure that they've identified the best dive sites and built relationships with local personnel, to help create the most productive and rewarding experiences possible.

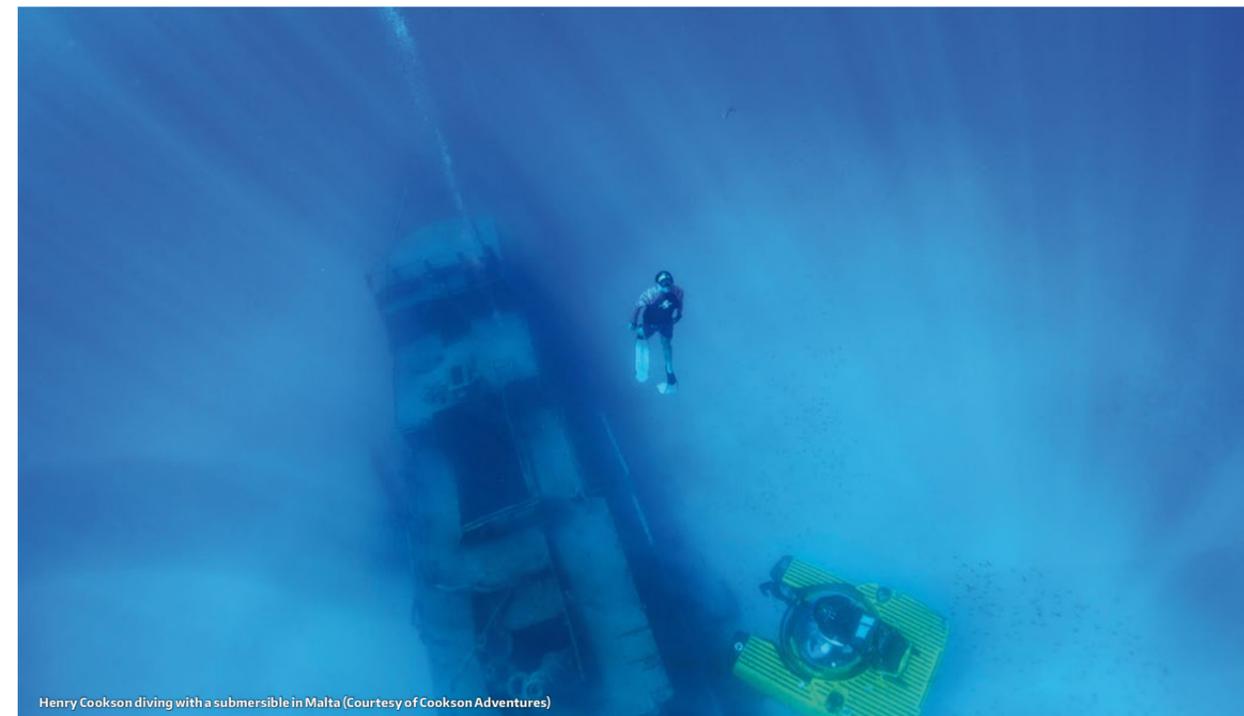
On a previous trip, they took a family sub-diving in the Solomon Islands. As they had young children, the parents were keen to use the sub experience as an engaging educational tool, so the kids could learn about both the history of the war and about ocean conservation. With the Solomon Islands' strategic importance during WWII, there are several interesting wrecks lining the seabed, frozen in time. The wrecks have a wealth of stories to tell, and we were able to bring this incredible history to life through our network of experts that we brought on-board.

Ahead of the trip, Cookson Adventures deployed a multi-beam sonar array to map the sea floor and produce 3D high resolution renderings and surface-models of four wrecks and four geographic features that had never before been mapped at these depths. This information and data will impact maritime archaeology and safety, as well as contributing to global projects to better understand our seabed and marine environment.

In 2019, they also undertook a series of dives off the coast of southern Italy and found a rare type of coral thought only to grow in tropical seas, as well as an undiscovered ancient Roman shipwreck filled with amphora.

### SUBMERSIBLES FOR UNDERWATER EXPLORATION

Cookson Adventures work with a variety of subs depending on whether they are owned by the client, or if they are chartering a sub on their behalf. This will often be one of the three main submersible companies: Triton, U-Boat Worx, or SEAmagine. Their partners in the Mediterranean use a custom Triton 3300/3 submersible, which is capable of reaching depths of 1,000 metres, and seats 2 guests and a pilot.



Henry Cookson diving with a submersible in Malta (Courtesy of Cookson Adventures)



By ice and sea - Explore in a submersible in Antarctica (Courtesy of Cookson Adventures)



Submersibles give freedom to any explorer to plunge far beneath the waves (Courtesy of Cookson Adventures)

They also dive with a custom Triton 3300/1MD one-man support craft, which provides an extra layer of security. It also features additional lighting and can shoot high-quality 4K film footage. The support craft acts as a guide to the main vessel, as well as a videographer, capturing the excitement of each expedition for clients. In addition to the one-man sub they dive with a ROV (a Ageotec Perseo GTV) as a backup for each dive, which is piloted by an expert above water.

The industry is constantly innovating and as it's such a growth area with huge demand in recent years (waiting lists of up to a year to start production are common), they're also excited to work with the new compact lightweight subs that are being designed specifically for superyachts. Launching a submersible is a big operation; a yacht needs a crane capable of hoisting, landing, and recovering the submersible in the ocean. They are extremely heavy, but these more lightweight options will make it significantly easier from a yacht-operational perspective.

Cookson Adventures don't have submersible pilots on the team, but they do connect the most experienced and highly trained pilots in the world to their clients on expeditions. They manage submersibles for some of their clients, and part of that service is providing and managing the best suited sub team. They also oversee and handle the logistics of transporting submersibles to use on adventures around the world, as well as chartering them for specific missions and operations.

### THE ROLE OF ROVS IN THE MISSIONS

Regulation as well as good practice dictates that you should have a back-up solution, for example having an ROV in the vicinity of the launching vessel. The safety systems are hugely capable, but the also ROV operates with a cutter and camera; in the highly unlikely scenario that it becomes entangled, it can easily be cut free. They have also implemented a system whereby the ROV hooks a special spectra line onto the sub, which can then be hoisted to the surface using the yachts anchor winch.



World first 7-seater submersible dive in the Solomon Islands with Cookson Adventures (Courtesy of Cookson Adventures)

Furthermore, the ROVs act as a backup line of communication between the sub and the lead vessel, so the sub's location is always clear to the team above water. If any dangers present themselves in the area, it ensures that the pilot will always know whether it is clear for the sub to make its way to the surface.

**THE FIRST ANTARCTIC MISSION USING A PRIVATE SUBMERSIBLE**

The team at Cookson Adventures have crafted and delivered arguably the most complex private Antarctica expeditions in the modern era. They were the first travel company to take a private submersible to Antarctica in 2012, and have unrivalled expertise in exploring this area while designing creative adventures for their clients who wish to explore its myriad wonders.

In the 2018/19 season, Cookson had three vessels working together for a single family, utilising two helicopters, a pair of submersibles, and a 30-strong team of experts. Using a submersible, they could take clients to explore the megafauna beneath the waves in sites that have never been dived before. There is a surprising amount of wildlife thriving in its icy depths, from otherworldly jellyfish and rarely seen invertebrates, to penguins and seals. Clients can savour uninterrupted views thanks to the subs ultra-clear acrylic hull – which connects passengers seamlessly with the ocean around them – and state of the art LED lights for illuminating darker waters.

With an explorer yacht as a base, one has a fantastic platform for adventure, enabling our team to design a non-stop creative itinerary of land and ocean-based experiences. Cookson Adventures take clients from the yacht and safely onto the ice with their expert polar guides, to ice-climb new

ascents, heli-ski untouched routes, and watch breaching humpback whales from a sea-kayak. They can also arrange private audiences with scientists at climate-change research centres, to learn more about the vital conservation work they are doing in the area.

Antarctica is one of their favourite sub-diving destinations, but they've also organised submersible trips in remote destinations as far reaching as Cocos Island off Costa Rica, the Solomon Islands, and French Polynesia. For their European clients, they can organise longer or shorter submersible diving experiences from a superyacht or from land as part of a wider itinerary in locations, with interesting diving sites such as Malta, Croatia, and Italy.

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A submersible with a smoking Stromboli in the background (Courtesy of Cookson Adventures)

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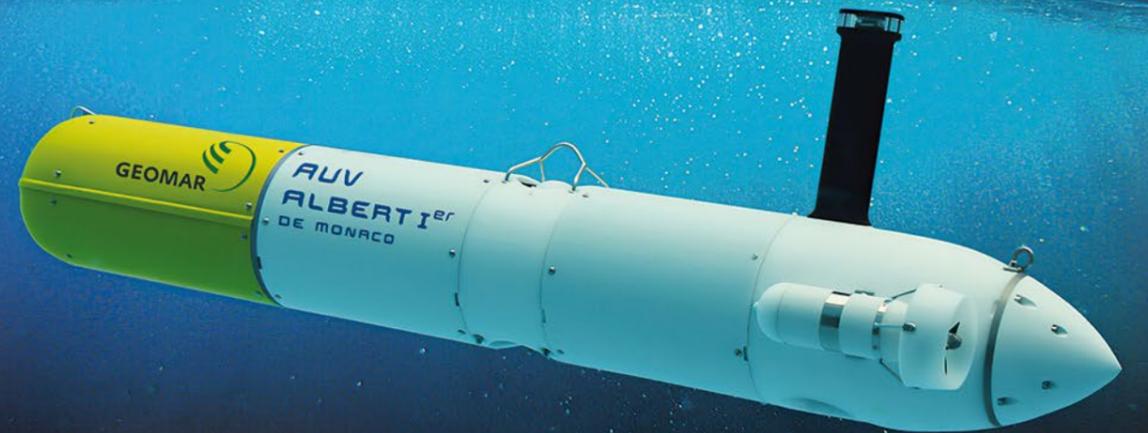
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AUV Albert I of Monaco. (Graphics: C. Kersten, GEOMAR.)



# H.S.H. PRINCE ALBERT II OF MONACO CHRISTENS UNDERWATER VEHICLE AT GEOMAR

For more than 100 years, the Principality of Monaco and Kiel have been closely connected in the field of marine research. At the beginning of the 20th century, Prince Albert I of Monaco and the Kiel marine researcher Otto Krümmel jointly designed international research projects in the Mediterranean. As an expression of their long-standing and close ties, H.S.H. Prince Albert II of Monaco recently christened the new autonomous underwater vehicle Albert I. de Monaco at GEOMAR Helmholtz Centre for Ocean Research Kiel.



GEOMAR Director Professor Katja Matthes and H.S.H. Prince Albert II of Monaco at the christening of the AUV Albert I de Monaco. (Photo: Thomas Eisenkrätzer / Courtesy of GEOMAR)

Prince Albert I of Monaco was a regular and fond visitor of the Kiel Week, as well as a pioneer of marine research. More than 100 years ago, he established a close connection between Kiel and the Principality of Monaco; he invited Professor Otto Krümmel, marine scientist from Kiel to his newly opened Oceanographic Museum. Together with experts from Italy, Spain, and France, they designed a strategy for the exploration of the Mediterranean: the nucleus for the Scientific Commission of the Mediterranean (Commission Internationale pour l'Exploration Scientifique de la Méditerranée, CIESM).

GEOMAR Helmholtz Centre for Ocean Research Kiel has been cooperating with various scientific institutions from the Principality of Monaco for several years. In 2016, H.S.H. Prince Albert II of Monaco received the German Ocean Award at the 41st CIESM Congress in Kiel for his commitment to researching, preserving, and protecting the oceans. In 2017, he visited the new Ocean Science Centre Mindelo of GEOMAR on Cape Verde to present the "Monaco Explorations Campaign", which was supported by researchers from Kiel.

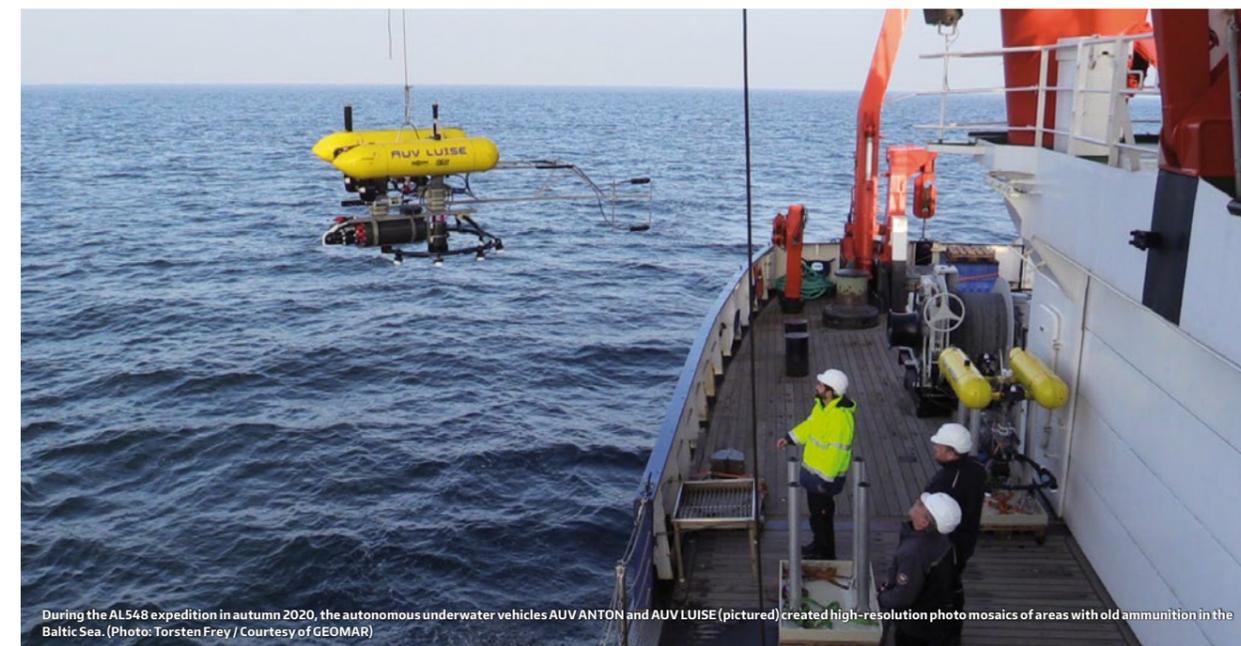
In commemoration of the long-standing relationship between his home country and the Northern German city, H.S.H. Prince Albert II of Monaco christened a new Autonomous Underwater Vehicle (AUV) with the name of his great-great-grandfather – AUV Albert I. de Monaco – at GEOMAR.



H.S.H. Prince Albert II of Monaco with GEOMAR Director Professor Katja Matthes, Minister for Education Karin Prien (right), GEOMAR Administrative Director Frank Spiekermann (left) and Lord Mayor Dr Ulf Kämpfer (2nd from left). (Photo: Thomas Eisenkrätzer / Courtesy of GEOMAR)



H.S.H. Prince Albert II of Monaco at GEOMAR. (Photo: Thomas Eisenkrätzer / Courtesy of GEOMAR)



During the AL548 expedition in autumn 2020, the autonomous underwater vehicles AUV ANTON and AUV LUISE (pictured) created high-resolution photo mosaics of areas with old ammunition in the Baltic Sea. (Photo: Torsten Frey / Courtesy of GEOMAR)

"We find at the heart of the ceremony which unites us today, the same faith in science, in its promises of progress, in its capacity to change the destiny of mankind and that of the Planet", said H.S.H. Prince Albert II. "This Autonomous Underwater Vehicle Albert I of Monaco is, I believe, the incarnation of this."

### SMALL, FAST, AND FLEXIBLE UNDERWATER ROBOTIC SYSTEMS AT GEOMAR

The new AUV Albert 1st of the SPARUS II type (built by IQUA robotics) has been available from GEOMAR since June 2021. It can be launched by just one person, and neither a boat nor a ship is required. This means that it can be used in a very flexible way. With a maximum operating depth of 200m, it's primarily designed for use in shallow waters such as the Baltic and the North Sea.

This AUV can be used in a variety of different ways. In contrast to LUISE and ANTON (Girona 500 type) also built by IQUA, it can cover longer distances with higher speeds and thus also map larger areas with a multibeam echo sounder or a side scan sonar. Its structural features and a central vertical thruster also allow for slower speeds, and thus the recording of data with more detail. In terms of underwater communications and positioning, the AUV is compatible with Girona 500 AUVs as well as with the AUV Poseidon, which is currently under construction. AUV Albert can also communicate and position itself in respect to the ship or to the other AUVs via the BELUGA software platform, which is integrated in all the underwater vehicles at GEOMAR.

Initially, the AUV Albert will be equipped with an oxygen sensor and a sonar system. Thus, it can be used for seafloor mapping and for measurements in the water column e.g., to detect low oxygen areas that can have an important impact on marine ecosystems.



AUV Anton is released to map old ammunition in the Baltic Sea. The BASTA project is, among other things, about better processing and interpreting the data collected during the ammunition search. (Photo: Iason-Zois Gazis / Courtesy of GEOMAR)



Photo mosaic with old ammunition on the sea floor, created during the AL548 expedition with the help of AUVs ANTON and LUISE. (Photo: AUV-Team / Courtesy of GEOMAR)



Ammunition boxes on the bottom of the Baltic Sea, optically mapped by AUV ANTON. (Courtesy of GEOMAR)

Currently there is no specific expedition or cruise planned for the AUV Albert, but it will be used as a test platform since it requires fewer logistics. One of its first projects will be the development of a backseat driver, which is driven by a sensor. That means that GEOMAR will work on an adaptive mission to map chemical anomalies.

### CHEMICAL ANOMALIES MAPPING EXPEDITIONS OF GEOMAR

The seabed of the western Baltic Sea is polluted throughout large areas by old ammunition, which was sunk there, especially following the end of World War II. During an expedition (AL548) carried out in autumn 2020 under the direction of the GEOMAR Helmholtz Center for Ocean Research Kiel, the munitions-contaminated areas in the western Baltic Sea were examined again. In October 2018, extensive water samples were taken from the research ship ALKOR in order to determine the exposure to carcinogenic explosives. A real-time analysis system was used for the first time, which is being developed as part of the EU-funded ExPlOTect project at GEOMAR. In addition, the aim of the trip was to test methods for object verification using AUVs.

In order to make large accumulations of mines and sunk ammunition boxes visible, photo mosaics of several thousand square meters were generated. In addition, targeted magnetic measurements were carried out at suspicious points. Both proved to be very fruitful, whereby the rapid and successful implementation of the magnetic sensors on

the AUV LUISE surprised even the researchers working in the BASTA project. The project was supported by a cache of magnetometers loaned by Sensys GmbH. Seabed photo mosaics of several 1,000 m<sup>2</sup> in size were generated. In addition, targeted magnetic measurements were carried out at points of suspicion. The expedition found considerable amounts of ammunition, particularly in the Bay of Lübeck, that were outside known exposure areas.

Where does it go from here? Further project applications focusing on ammunition deposits are currently being prepared at GEOMAR. The ProBaNNt (AI-based evaluation of clearance methods) and AMMOTRACE (in-situ explosives analysis) applications are in the final approval phase. An application for the development of a clearing and temporary storage system will be submitted shortly under the name CLEAR with SeaTerra GmbH in Seevetal. The aim is to develop an environmentally friendly technology for clearing ammunition dumping areas.

GEOMAR is planning another project alongside the Thünen Institute, the Institute for Baltic Sea Research, the University of Rostock, the Federal Environment Agency, the Alfred Wegener Institute, Senckenberg am Meer, the Global Climate Forum, the Toxicological Institute of the University of Kiel, and the Kiel company EGEOS GmbH to determine the ecological effects of chemical pollution of ammunition in the Baltic and the North Sea.

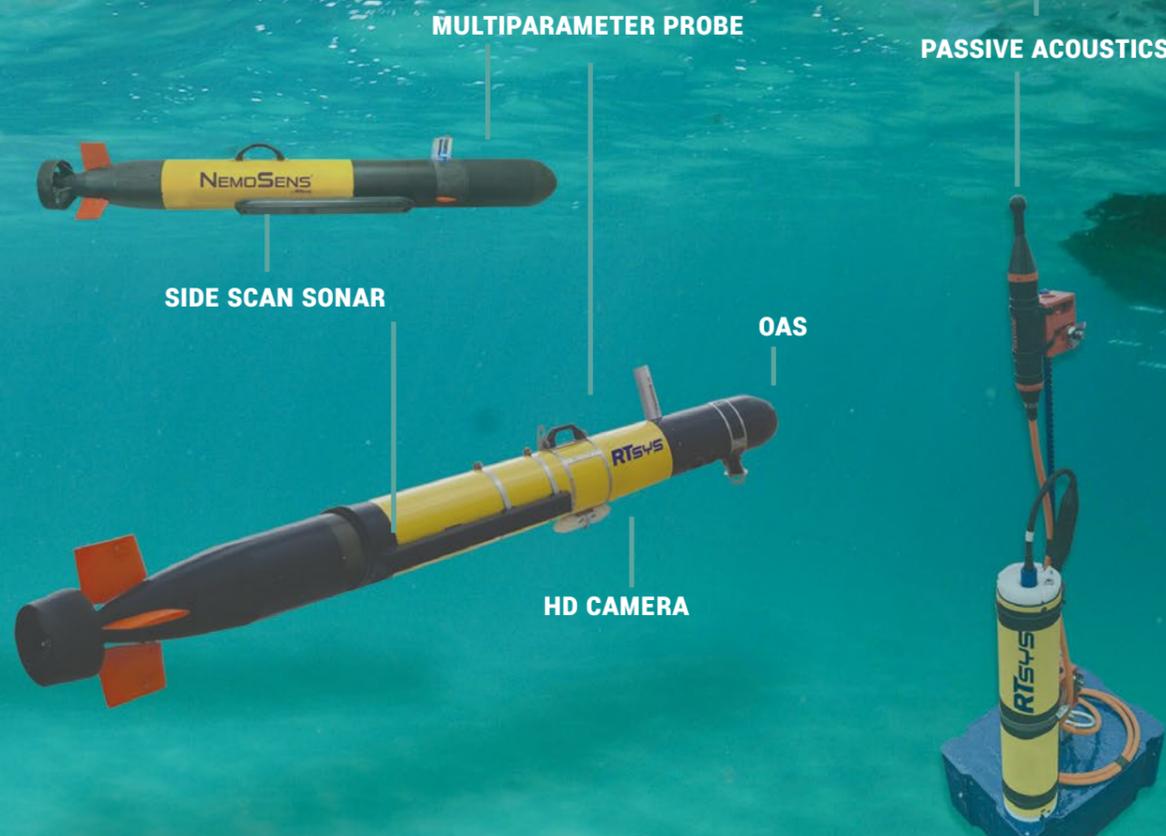
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# FROM DE-RISKING TO VALUE CREATION: FIRST CANOPUS & RAMSES LBL SOLUTIONS DEPLOYMENT ON AN O&G PROJECT

Deploying a new technology for the first time is always challenging. But with careful planning, teamwork, and the drive to deliver customer satisfaction, these challenges can be overcome. This is how UTEC - the lead brand for Acteon's Geo-services segment - approached the deployment of a new sparse Long Baseline (LBL) positioning system using iXblue's proprietary technologies. Working in partnership, the companies successfully delivered the first deployment of iXblue's Canopus and Ramses positioning system on a commercial project in the energy industry.

In the summer of 2021, UTEC and iXblue collaborated to successfully provide deep-water remotely operated vehicle (ROV) positioning services for a complex pipelay and structural installation offshore from East Africa for a major subsea contractor.

The project was unique for two reasons. This was the first time that UTEC had used the iXblue sparse LBL solution to position ROVs. Moreover, the project saw the first deployment of iXblue's proprietary sparse LBL technologies for a commercial project in the energy market.

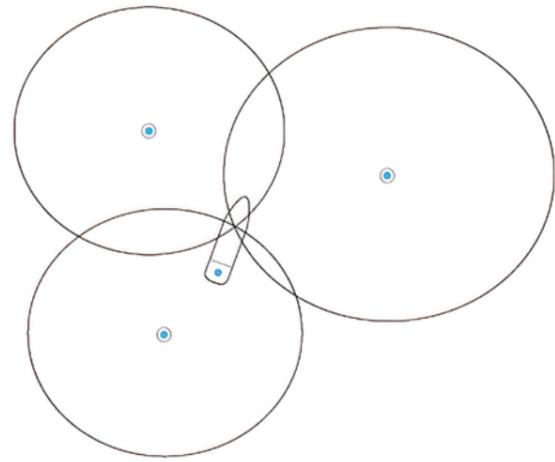
**SPARSE LBL: INNOVATIVE SUBSEA POSITIONING**  
Sparse LBL is a method that uses inertial navigation system (INS) equipped subsea vehicles and achieves similar or better positioning performance than traditional LBL while using fewer transponders. This is made possible by merging the precise range measurements to an acoustic transponder with the very precise short-term movements from an INS to optimise navigation accuracy.

UTEC has 15 years of experience providing positioning and survey support for hundreds of pipeline and structural installation projects around the world, and has developed industry-leading knowledge and capabilities in subsea positioning systems. This has included supporting the development of sparse LBL positioning, including the use of prototype systems. UTEC recognised its potential to provide clients significant cost savings over conventional LBL positioning systems.

Sparse LBL positioning only became feasible with the development of commercially available INSs. These use gyros and accelerometers to measure motion. When combined with acoustically measured ranges from seabed transponders, this can provide high-accuracy ROV positioning.

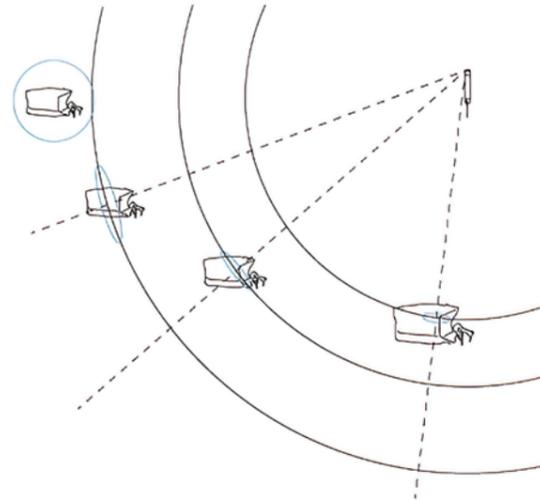


Courtesy of iXblue



Classical LBL

Figure 1: How sparse LBL works (Courtesy of iXblue)



Sparse LBL principle

iXblue is a leading manufacturer of fibre-optic based gyro systems, subsea acoustic positioning systems, autonomy systems, and sonar systems. The company's subsea inertial navigation systems (Octans, Rovins, and Phins Subsea) have become standard fit on many ROVs and autonomous underwater vehicles (AUV). iXblue is therefore well placed to offer a complete sparse LBL positioning system. The sparse LBL system works by integrating this hardware and the data as follows:

1. Initially, the vehicle's INS position has a large error ellipse, represented by the blue circle surrounding the ROV in Figure 1.
2. The ellipse error is then updated thanks to an iXblue Ramses transceiver measurement of the range, first to the beacon and then its transmission to the INS. The position on the axis between the vehicle and the transponder is now well known.
3. As the ROV moves along the route, the INS measures precise relative movement between acoustic interrogations.
4. As the vehicle moves relative to the beacon, the error ellipse progressively improves on multiple axes, gradually resulting in a more accurate position.

Following this principle, each range measurement helps in computing a new position, as opposed to classical triangulation algorithms, for which at least three simultaneous range measurements are required to establish a position. It is therefore possible to navigate with fewer transponders without making any compromise on performance.

iXblue's sparse LBL positioning system is based on its Canopus transponder and ROV-mounted Ramses transceiver, and their seamless integration with INS. Canopus offers exceptional power efficiency, which enables it to operate up

to three or four times longer than competitors' transponders. Thus, it reduces the time (and money) spent swapping out exhausted units. Sparse positioning also means fewer transponders to be deployed and recovered, with associated vessel time savings.

### A UNIQUE PROJECT

In 2019, UTEC had the opportunity to propose a sparse LBL solution for a project following an invitation to tender from a major subsea contractor. It specified the need for conventional LBL positioning. However, UTEC also presented a proposal based on a sparse LBL solution, which interested the client; they had also been evaluating the value of sparse LBL systems for future projects.

iXblue supported UTEC's sparse LBL proposal and also met with the client to discuss how Canopus and Ramses could unlock time and cost savings on this and future projects. UTEC evaluated competitor sparse LBL positioning solutions and concluded that the iXblue system had clear technical and commercial advantages, including the longer battery life backed up with proactive support. This combination would achieve the most cost-effective solution for UTEC's client.

Through a combination of a solid technical proposal, an attractive commercial offer, and support from iXblue, UTEC was awarded the contract, now based on the use of sparse LBL positioning. There was a clear stipulation from the client; the choice of the sparse LBL system and its use on the project was UTEC's responsibility. This placed a greater emphasis on iXblue's technologies to deliver as promised. Although Canopus and Ramses LBL systems had been presented to the industry during trials and demonstrations and used on a North Sea rig move in 2018, neither had been deployed on an actual commercial project within the energy industry, and UTEC would be the first user of the system.



Courtesy of iXblue

This presented significant risks for both iXblue and UTEC. Failure of the system to deliver would result in delays and extra costs for the client, while UTEC would also incur replacement costs and suffer reputational damage, and thus potential loss of future work. Equally, failure could damage the reputation of iXblue's new LBL technology leading to loss of trust from the market.

### RISK ASSESSMENT AND MANAGEMENT

Project failure was never an option. Working together, UTEC and iXblue surveyors, engineers, and senior management sat down and - in a risk assessment process - identified four key risks that could negatively impact the project: manufacturing delays; the absence of necessary system capabilities; a lack of adequately trained personnel; and design or manufacturing faults leading to system failures.

### MANUFACTURING CONSTRAINTS

UTEC was concerned that iXblue would be unable to manufacture the required number of Canopus and Ramses units in time for the project start date. Consequently, a delivery date was imposed so that, if necessary, there was sufficient time to change to an alternative supplier and redesign aspects of the project. Despite impacts from the COVID-19 pandemic, the required number of units were successfully delivered by the iXblue teams on schedule.

### SYSTEM CAPABILITIES

Both UTEC and iXblue had concerns that the Canopus and Ramses systems could not perform some of the complex positioning tasks required by the project. UTEC surveyors listed the necessary positioning tasks for comparison with the capabilities of the system and identified the missing capabilities, all of which were already on iXblue's development roadmap. Consequently,

iXblue prioritised their development and implementation. The new capabilities were successfully proven in tests offshore iXblue's La Ciotat base in the South of France. UTEC personnel were unable to attend in person owing to COVID travel restrictions. However, they did successfully witness the tests arranged by iXblue via remote access to the positioning computers and live video streaming from the test vessel.

### TRAINED PERSONNEL

As this was the first time that the Canopus and Ramses systems were being deployed, UTEC field personnel needed training in how to operate the systems. Lockdown and travel restrictions due to the pandemic presented a major challenge, resulting in training having to be done remotely.

iXblue designed a programme consisting of two training sessions, feedback from which identified changes necessary for easier operation. For instance, field staff felt that the user interface for the system was inefficient. They provided a list of improvements that were subsequently implemented by iXblue's software developers. The improvements were then successfully tested by some of the field staff operating the software on iXblue's test vessel via a remote-control link.

Further actions included the deployment of an iXblue engineer on the installation vessel to oversee the initial stages of the programme. Additionally, a satcom link was established between onshore iXblue specialists and the actual Ramses units fitted to the ROVs. This enabled the onshore support team to configure and operate the system directly should the offshore personnel encounter problems. Although the link was not required, it was proven operational and thus provides an option for reducing the number of offshore personnel needed on future projects.



Courtesy of iXblue



Courtesy of iXblue

### RELIABILITY

When deploying new systems for the first time, there is always the potential for reliability issues. UTEC and iXblue considered the consequences of multiple failures caused by design or manufacturing faults, and implemented several measures to minimise the risk of potential failures. One of these was ensuring that more spare units than normal were on the vessel.

More importantly, iXblue's design and manufacturing procedures were audited by UTEC using a process more rigorous than those typically used for routine audits. Again, these audits had to be carried out remotely. However, iXblue's electronic quality assurance and control systems enabled them to run smoothly and provided assurance of system reliability.

### PROJECT OUTCOME

By undertaking a detailed risk assessment and implementing mitigation measures, UTEC was able to successfully deploy the Canopus and Ramses positioning system on the project. And the system performed excellently; predicted time and cost savings were achieved, and a wealth of experience – to be used on future projects – was gained by all parties.

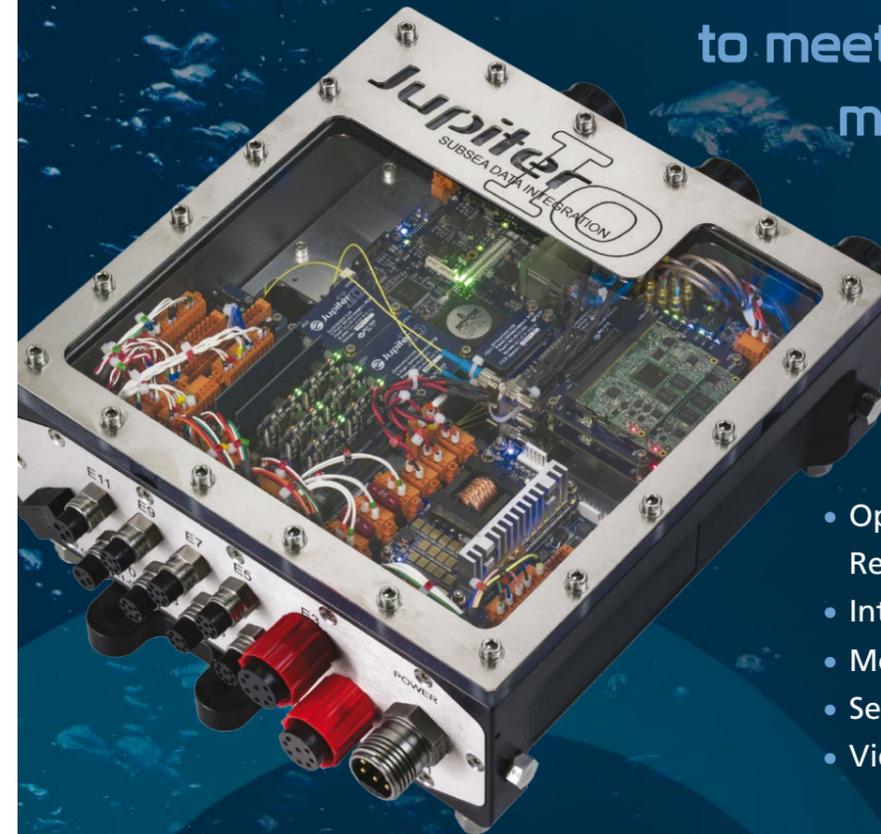
"Both UTEC and iXblue had to commit the people and time to ensure a successful first-use of Canopus and Ramses. We now have the knowledge and experience that enable us to offer this system for other projects. The risk assessment process will be applied to future first uses of new systems. We anticipate that this will enable us to provide additional cost-saving solutions for our customers," comments Paul Smith, Group Managing Director at UTEC.

Olivier Cervantes, VP Energy Market at iXblue, adds, "I agree with Paul and add that I was impressed by the commitment of the UTEC teams in the quality audit of our system and how they have challenged our technical teams. Converting risk taking into value creation through a careful assessment of potential issues was one of the challenges: all of this during a historical global pandemic. Spirit of teamwork, trust, and the willingness to work towards an improved solution allowed us to push the limits of the technologies, bringing an "open architecture" Sparse LBL to the market standard."

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Courtesy of Ocean Infinity

# OCEAN INFINITY ARE DEVELOPING THEIR ROBOTICS FLEET THE RIGHT WAY

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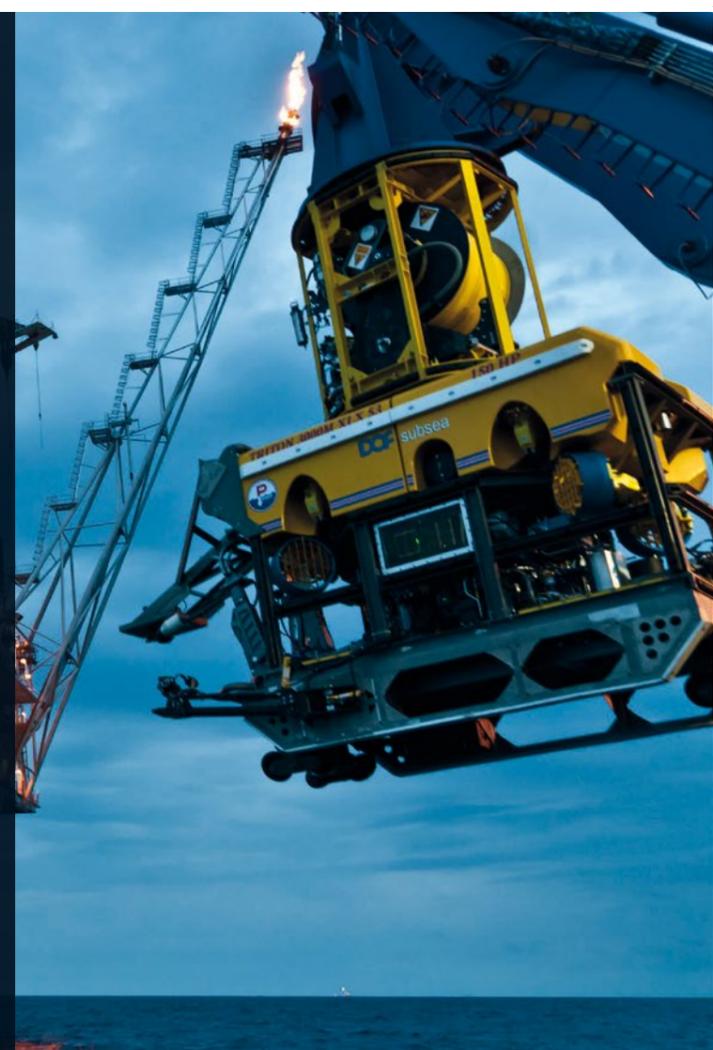
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Ocean Infinity (OI) went through several acquisitions over the course of this year. These were all acquisitions for a strategic purpose to enable the company to transform the industry and offshore operations. Therefore, the aim was to acquire these companies to leverage their capabilities and expertise for the transformation of operations at sea in a more environmentally friendly and sustainable manner. Ocean Infinity is determined to create and develop its robotic fleet the right way, and not the easy way.

### STRATEGIC ACQUISITIONS TO ACHIEVE OCEAN ROBOTICS EXCELLENCE

The first such acquisition was MMT; Ola Oskarsson's company has deep expertise and established track record as a distinguished marine survey and data analytics provider that Ocean Infinity can utilise to support their clients' data acquisition needs.

Then followed the acquisition of Abyssal. Abyssal develops and implements proprietary software solutions for the offshore industry geared towards improving the safety and efficiency of subsea operations. Abyssal's technology ranges from a managed cloud data platform, synthetic environments, advanced 3D visualisation and operation management system tools. With artificial intelligence enabled digital

twinning core to its services. As part of Ocean Infinity, the team will play a key role in shaping the enlarged group's software development capability. Integrating Abyssal's software expertise with Ocean Infinity's robotic fleet will further underpin the company's safe and secure data acquisition operations through the development of operational simulation, fleet management and cloud data tools.

Ocean Infinity also acquired Ambrey, the maritime services company. The acquisition combines Ocean Infinity's robotic vessels, data, cyber, artificial intelligence, and low emission operations with one of the leading brands in the maritime security sector.

Then came the acquisition of Geowynd, a geotechnical analysis services company with expertise in developing smart site investigations, advanced laboratory testing strategies and optimised de-risked foundation design and installation solutions. Whilst Geowynd will continue to operate under its own brand and service its well-established client base, the acquisition will present opportunities to combine Ocean Infinity's robotic vessels, data, artificial intelligence, and low emission operations with Geowynd's geotechnical expertise to provide sustainable, data-driven services to the renewables sector.

Finally, the acquisition of Red Rock, a company spearheading the development of digital and autonomous solutions to revolutionise lifting and handling both onshore and offshore, combines Ocean Infinity's 'Armada' robotic vessels and low emission operations with Red Rock's ability to develop hardware and software solutions for remote and autonomous handling. Together, the two businesses will transform port operations and shipping through artificial intelligence-enabled, safe, low emission movement of vessels and cargo.

### AMMONIA BASED FUEL CELL SYSTEM TO ACHIEVE NET-ZERO

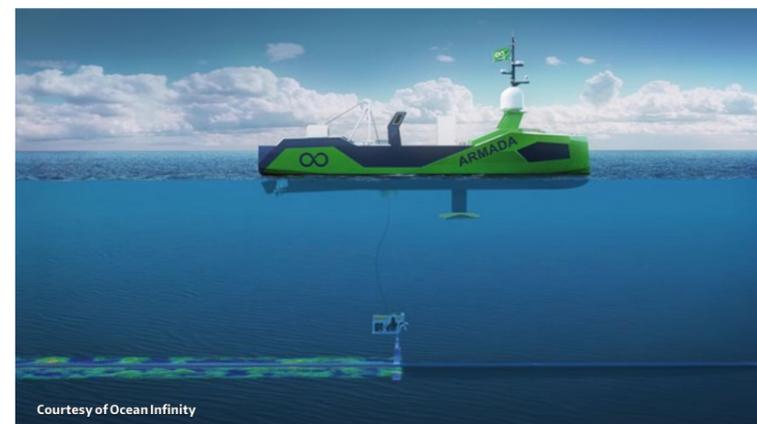
Currently, most vessels use Green House Gas intensive internal combustion power systems. Directly targeting key elements of the UK Government's 2050 Clean Maritime Plan, Ocean Infinity and its partners are introducing innovative

new technologies and techniques for clean vessel propulsion, expecting to make a meaningful contribution towards the UK's net-zero greenhouse gas commitment.

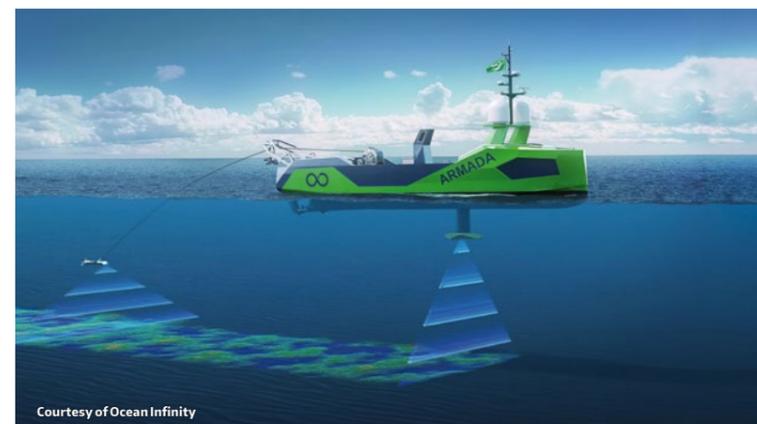
Ocean Infinity was announced the winner of The Clean Maritime Demonstration Competition, enabling the Company and its partners to build a Marine Propulsion Test facility, with an integrated Ammonia Marine Propulsion System (AMPS). The test facility will demonstrate clean-fuelled technology eventually capable of powering Ocean Infinity's Armada fleet, using an innovative ammonia-based fuel cell system. This project, due to deliver a zero-emissions marine propulsion system, is crucial for developing a robust understanding and thus optimisation of an AMPS, suitable for integration into Ocean Infinity's Armada fleet and beyond. With Ocean Infinity acting as lead partner, the company is combining forces with UK-leading experts in clean fuel cell technology; maritime logistics; deployment and operation of remote and autonomous technology; and the development of operational regulations.

The main advantage of the ammonia cracking technology over hydrogen is the energy density of 3:1 compared to hydrogen.

Furthermore, the company is very conscious environmentally. Their strive for more environmentally responsible operations is a key driver behind the development of Armada. All their environmental and social goals align with the United



Courtesy of Ocean Infinity



Courtesy of Ocean Infinity



Courtesy of Ocean Infinity



Courtesy of Ocean Infinity



Courtesy of Ocean Infinity

Nation's Sustainable Development Goals. Ocean Infinity are joining the call for action by all countries to promote prosperity while protecting the planet. For this purpose, the company has ambitious targets to achieve zero waste to landfill by 2025 and Net Zero carbon by 2040. Their facilities and remote-control centres will be powered using renewable energy. Furthermore, the company has planted 73,500 trees in Scotland and is involved in seagrass planting projects in the Solent, nearby Southampton.

### THE ARMADA FLEET UPDATE

Ocean Infinity is leading the industry's transition away from traditional offshore operations towards greener and cleaner alternatives. The company's Armada fleet will be the world's largest fleet of uncrewed robotic vessels. Set to revolutionise the maritime industry, Armada will enable OI to provide

sustainable services that offer up to 90% emissions savings over a conventional vessel performing a similar offshore task. The fleets are equipped with robotic vehicles, sensors and navigation technology and can operate down to 6,000 meters depth. The fleet will comprise 17 robotic ships that will be operational by the end of 2022. To fulfil client demand in the meantime, Ocean Infinity alongside MMT is operating a fleet of conventional vessels equipped with robotic technology; ROVs and AUVs, and will transition to Armada as the fleet comes online.

Currently there are 17 vessels on order with further options, and all these vessels will be UK flagged:

- | 4x21m (all being built at GMV Norway)
- | 5x36m (all being built at GMV Norway)
- | 8x78m (all being built by Vard)



Courtesy of Ocean Infinity

Unfortunately, because of the global pandemic causing material and supply chain issues, the company's ambitious vessel delivery schedule was also impacted by delays in the construction yards. However, they are on track to see the first 21m long vessels in 2022. These two vessels are planned to be utilised in geophysical survey activities.



Courtesy of Ocean Infinity

OI has adopted a "modular payload" approach for all vessels for improved flexibility. These modular payloads would consist of ROVs, AUVs, and geotechnical equipment, depending on the needs of projects. To facilitate the safe and effective operation of the complex payload set ups, the company has developed a completely new Dynamic Payload Control (DPC) system to deal with the unique challenges they have with remote vessels and the need to have so much different equipment on board.

### REMOTE OPERATION CENTRES (ROCS) AND THE FUTURE

Currently, OI is integrating some of the technology at its bases. They are also working on their remote operations centre in Austin, TX, and Southampton, UK. From these remote operations centres, which are almost up and running, Ocean Infinity will be able to safely operate Armada anywhere in the world support of sustainable offshore operations.

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# SAAB SEAEYE'S NEW UNDER- WATER ROBOT TO JOIN OCEAN INFINITY'S ARMADA

Saab Seaeeye, a world leader in underwater robotics, has agreed a deal to sell 10 of its new electric work remotely operated vehicles (eWROV), including further options, to leading marine robotics company, Ocean Infinity. Due to this and further future contracts Saab Seaeeye is also to expand by 70% to an additional 3,236m<sup>2</sup> (34,832 ft<sup>2</sup>) site in Fareham, UK, by March 2022 and is currently recruiting.

The new eWROV product, is the world's most capable and intelligent all-electric, work-class underwater robot, that will be built in Saab Seaeeye's new facility in Fareham within the Solent Freeport. The eWROV is the latest addition to Saab Seaeeye's underwater portfolio used across a variety

of offshore energy sectors, ocean science and defence. It is the culmination of four years of research and development, resulting in a larger and more powerful ROV compared to those designed for light work and observation tasks. eWROV benefits from Saab Seaeeye's iCON™ intelligent system architecture, making it capable of fully autonomous operation.

Advanced control solutions and enhanced reliability reduces the requirements for humans to be offshore in support of the eWROV operations; this substantially improves health & safety, and significantly reduces operating costs.

By leveraging their latest advances in power electronics, Seaeeye were able to create a vehicle that delivers the same working capability as a traditional 250HP hydraulic ROV. The new vehicle only requires 60% of the energy which significantly reduces its fuel consumption and CO<sub>2</sub> emissions.

### THE EWROV SYSTEM OVERVIEW

Requiring less maintenance than ever, the eWROV system is inherently reliable. Electric thrusters are the key to electrifying WROVs; capable of generating 560 kgf, the eWROV's power efficiency is far greater than hydraulic systems, with better acceleration, braking and reversal.



Saab Seaeeye's new eWROV. (Courtesy of Saab Seaeeye)



Jon Robertson, Managing Director Saab Seaeeye, explaining features of the new electric work robot. (Courtesy of Saab Seaeeye)

Conventional high-voltage AC power transmission systems result in large, heavy subsea transformers on the ROV and PDUs on the surface. State of the art DC power transmission system enables significantly smaller and lighter units, both topside and subsea. It also allows the use of smaller diameter umbilicals and existing client-owned umbilicals.

Electric manipulators are enablers for electrifying WROVs, and support the whole electrification ethos. They offer significant advantages over hydraulic alternatives, including more precise positioning with force feedback, increased dexterity, lower water weight and greater reliability – expanding the potential for more autonomous and resident applications. Featuring an advanced control system with an open interface, they allow both manual and automated operation. Highly accurate, modular electric joints enable enhanced arm control, path planning solutions and actuator re-use.

The intelligent control of nodes (iCON) system is the backbone of the system. Pioneered by Saab Seaeeye, iCON is an intelligent architecture of configurable hardware and software modules for creating smart underwater robotic solutions. iCON's modular network of distributed devices and software provides real-time system control and feedback from the heart of every subsystem, making it ideally suited to ever more remote and autonomous operations.

A complete common technology ecosystem, operation, training, and maintenance is made simpler and more efficient with the expandable and future-proof iCON.

### EWROV OPERATIONAL MODES

In addition to conventional local offshore control, the eWROV is compatible with three types of operational concepts which are being adopted by the industry.

**ONSHORE CONTROLLED:** The eWROV has the in-built capability to be operated from onshore command and control centres, advancing the potential for long-distance control. A reduced need for on-site personnel brings considerable savings to the user, as well as improving safety and boosting eco-credentials further by removing the need to fly in personnel using helicopters.



The new robot is fitted with Saab Seaeeye's all-electric seven-function high-precision manipulators. (Courtesy of Saab Seaeeye)

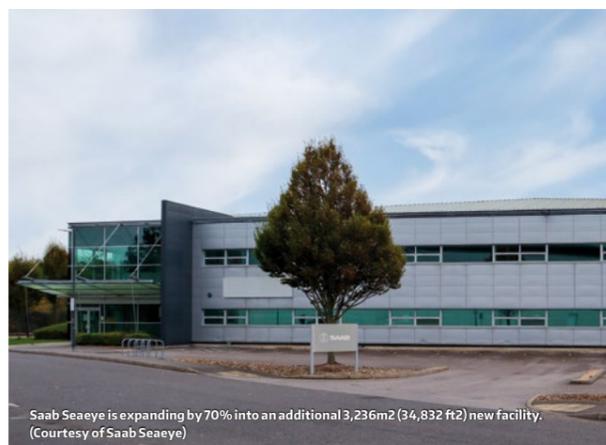
**RESIDENT-READY:** The eWROV is capable of long-term immersion and can remain submerged at an underwater docking station until its next mission.

**AUTONOMOUS:** Autonomous capability is an existing and mature technology already used in the Saab Seaeeye Sabertooth platform. As the eWROV uses the same iCON control system, full autonomy is possible.

### OCEAN INFINITY'S ARMADA AND HOW THE EWROV PLAYS IN THEIR FLEET

Ocean Infinity is developing the world's largest fleet of uncrewed robotic vessels and will be the eWROV's launch customer as both companies share the passion for underwater robotics in the oceans. The eWROV will play its part in Ocean Infinity's mission to use innovative technology to transform operations at sea, enable people and the planet to thrive. Armada is set to revolutionise the maritime industry, delivering sustainable services that offer up to 90% emissions savings over a conventional vessel performing a similar offshore task.

The eWROV's electrification is the key to its improved performance and sustainability-related attributes. As well as being more efficient, electric systems use little or no oil, making the eWROV significantly more environmentally friendly than equivalent hydraulic work-class systems.



Saab Seaeeye is expanding by 70% into an additional 3,236m<sup>2</sup> (34,832 ft<sup>2</sup>) new facility. (Courtesy of Saab Seaeeye)

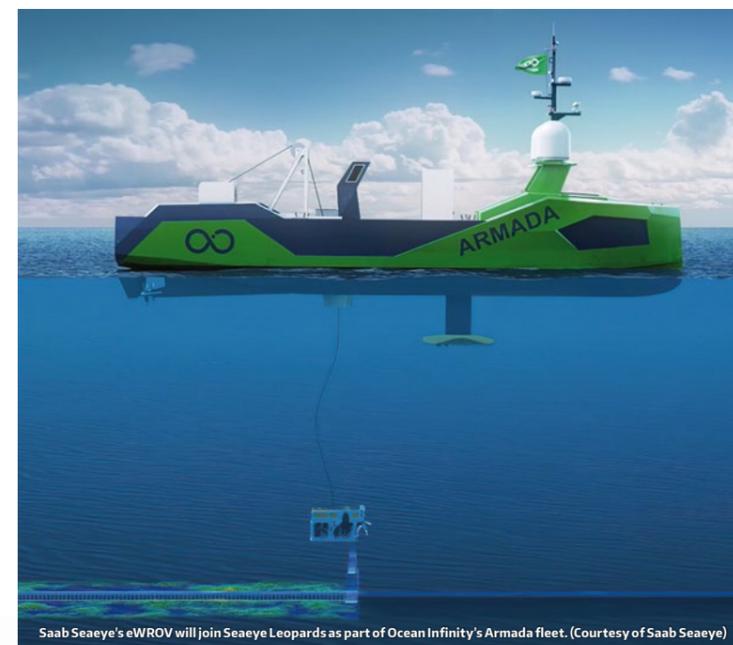


Saab Seaeeye's new eWROV is the world's most capable and intelligent all-electric, work-class underwater robot. (Courtesy of Saab Seaeeye)

The combination of Seaeeye's eWROV and Ocean Infinity's Armada of robotic ships is a significant step change in sustainable delivery of offshore and subsea services. Demand for underwater operations is growing significantly. Safe, environmentally friendly, low-cost solutions need to address this demand, which present opportunities for all those involved.

The Armada fleet is going to be the largest fleet of marine robotics: a mixture of uncrewed ships, eWROVs, and many other forms of robotics all integrated in a proprietary Armada operation system.

Ocean Infinity is setting out to transform operations at sea by using a mix of innovative technology and new thinking for operations at sea to take place. They are pushing hard to reduce the scale of the ships they are deploying to allow for much lower carbon footprint and other emissions and to do that they are using robotics extensively across that fleet. From the outset the eWROV has been designed with the vision to integrate the vehicle into Ocean Infinity's control system.



Saab Seaeeye's eWROV will join Seaeeye Leopards as part of Ocean Infinity's Armada fleet. (Courtesy of Saab Seaeeye)



Electric thrusters are the key to electrifying WROVs, capable of generating 560 kof, the eWROV's power efficiency is far greater than hydraulic systems, with better acceleration, braking and reversal. (Courtesy of Saab Seaeeye)

Ocean Infinity are also developing a remote operations capability. They have one of the world's largest remote operations centres in Southampton and are going to be building further operation centres around the world. These operating centres will be where the majority of Seaeeye's eWROV work will be operated from rather than using the traditional model of operating them at sea.

The company will have people sat there piloting ships and eWROVs subsea and operating them in several different types of operations. Once Ocean Infinity receive the first eWROVs they will be integrating a different payload to these systems to enable them to perform survey activities, inspection activities in various subsea use cases, and even intervention in the future as they develop smarter software.

**Currently, the focus is on the integration and qualification of the eWROV vehicles with Ocean Infinity's control solutions and vessels. Once that's been achieved Saab Seaeeye will move into series production of these new types of vehicles.**



Jon Robertson, Managing Director, Saab Seaeeye. (Courtesy of Saab Seaeeye)



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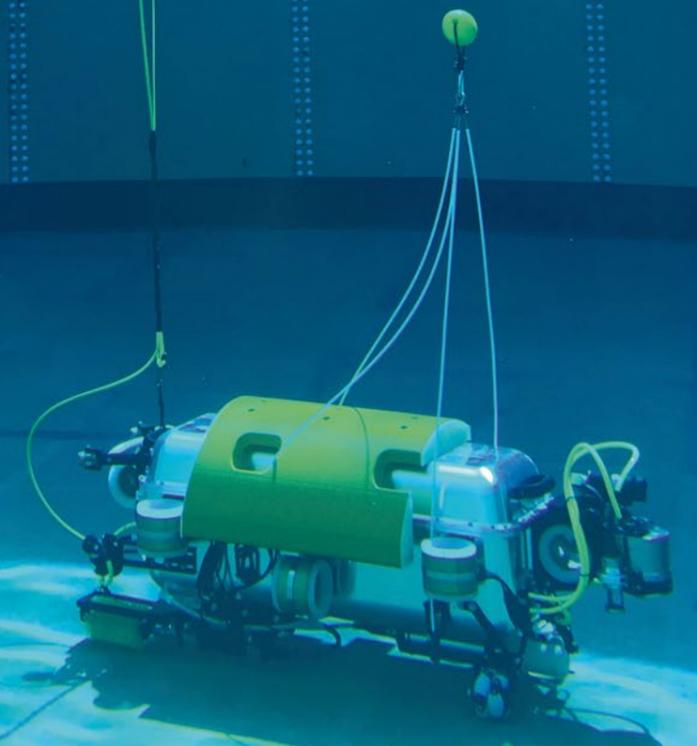
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# BRINGING NAVIGATION ACCURACY TO TANK INSPECTION ROBOTS DEPLOYED IN A HARSH ENVIRONMENT

A pioneering autonomous robot with a high-performing DVL is revolutionizing fuel tank inspection – while eliminating potential operational hazards.



Testing the Square Robot vehicle in a test tank filled with water. The DVL1000, seen on the right, is mounted so it can work unobstructed, while maintaining a minimum distance from the floor. (Courtesy of Square Robot)



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The Square Robot vehicle with the four-transducer Nortek DVL1000 mounted at the extreme left. The vehicle deploys ultrasonic testing, HD cameras and other non-destructive methods to assess tank wear and tear; the assessment depends on the DVL for pinpoint positioning. (Courtesy of Square Robot)



Courtesy of Square Robot

Nortek's Doppler Velocity Logs (DVLs) are already established as industry-leading instruments for velocity calculations in subsea applications. But pioneering Boston-based company Square Robot has now successfully deployed them in a very different and challenging environment.

Square Robot is helping to change the face of the oil and gas industry through its development of an innovative robot that can provide detailed assessments of the conditions in above-ground petroleum storage tanks. Using the robot eliminates the need to empty the tanks of liquid so that humans can enter to carry out detailed inspections – a costly, time-consuming, and potentially hazardous procedure still used in most tank assessments.

Founded in 2016, the company took just two years to design and build a highly robust autonomous robot certified to operate in these hazardous environments. Five versions of the robot are now being deployed by leading firms in the US petrochemical storage sector.

### ROBUST AUTONOMOUS ROBOT FOR FUEL STORAGE TANK INSPECTIONS

The "Square Robot", from which the company takes its name, is essentially a highly robust, autonomous robot laden with sensors, able to fit through the 24-inch "manway", the standard-size portal fitted to the top of storage tanks. The robot is then able to navigate through the liquid-filled tank –

typically gasoline or diesel – to detect damage such as corrosion on the tank floor. The tanks, a familiar sight for many, are typically 10–30 m tall and 15–80 m in diameter.

"The robot essentially performs a floor inspection of the tank that would otherwise have to be done by a human. During a traditional out-of-service inspection, the tank is emptied, cleaned to make it safe for entry, then inspected by personnel. All of this downtime means a significant loss of revenue for the tank owner. Our robot gets rid of all that – your tank is still in service and full of product," says Amy Underwood, Senior Robotician at Square Robot.

The vehicle is innovative in that it carries out tests in a way that won't damage the tank – so-called non-destructive testing (NDT) – using technologies such as ultrasonic testing (UT), which can characterize the thickness and internal structure of a surface using high-frequency sound waves. Additionally, the robot is capable of hovering, unlike "crawler" robots sometimes used for basic inspections.

### HIGHLY ACCURATE VELOCITY MEASUREMENT FOR PRECISE POSITIONING OF ROBOT

But in order to precisely examine and map areas of concern, the robot needs to know exactly where it is in the tank. That requires highly accurate velocity measurement to aid navigation in a critical way – neither of which is straightforward in an enclosed tank full of liquid product.

To solve the problem, the company looked to its roots in the subsea industry. Square Robot's founders and several other team members previously worked at a leading AUV developer and have had long careers in the subsea industry. So, they already knew what worked well for velocity measurement in the ocean and wondered whether it could be made to work in the harsh environment of a storage tank.

DVLs use the Doppler effect to calculate velocity by measuring the shift in wavelength between acoustic pulses transmitted to and reflected back from particles in a liquid or a surface such as a seabed.

The team were familiar with Nortek's Doppler velocity logs, which had a reputation for being highly accurate, reliable, and straightforward to use for underwater navigation, as well as offering the compact form needed to fit into the restricted space of the robot.

Crucially, Nortek's 1 MHz DVL1000, the instrument Square Robot decided on, could operate accurately at a distance of only around 20 cm from a given surface – often the seabed, but in this case the tank floor. That is closer to the floor than many other DVLs on the market are capable of operating accurately, and a prerequisite for the inspection vehicle to do its job properly. The fact that this DVL performs so well in such a difficult environment can be attributed to Nortek's proprietary bottom-tracking algorithm.

### A DVL OPERATING ACCURATELY AT EVEN SMALLER DISTANCES FROM THE FLOOR

While the Nortek DVL already works closer to a surface than many other instruments on the market, Square Robot is looking forward to technological advances now being rolled out by Nortek, which will enable it to operate accurately at even smaller distances from the floor.

Meanwhile, Square Robot is seeking to expand its operations both in the US market, where it currently operates, and internationally. The robot is currently deployed through Square Robot's subsidiary inspection services company Veritank.

The company's five models of the robot have differing, customizable payloads, which could be adapted for a number of uses, including subsea inspection and in the shipping industry.

The successful use of the DVL in this novel environment is further evidence of the accuracy, reliability, and versatility of one of Nortek's most popular and recognized technologies.



Robotician Amy Underwood lowers the Square Robot through a 24-inch manway into a petrochemicals-filled storage tank. (Courtesy of Square Robot)

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# UNDER THE QUSTOM

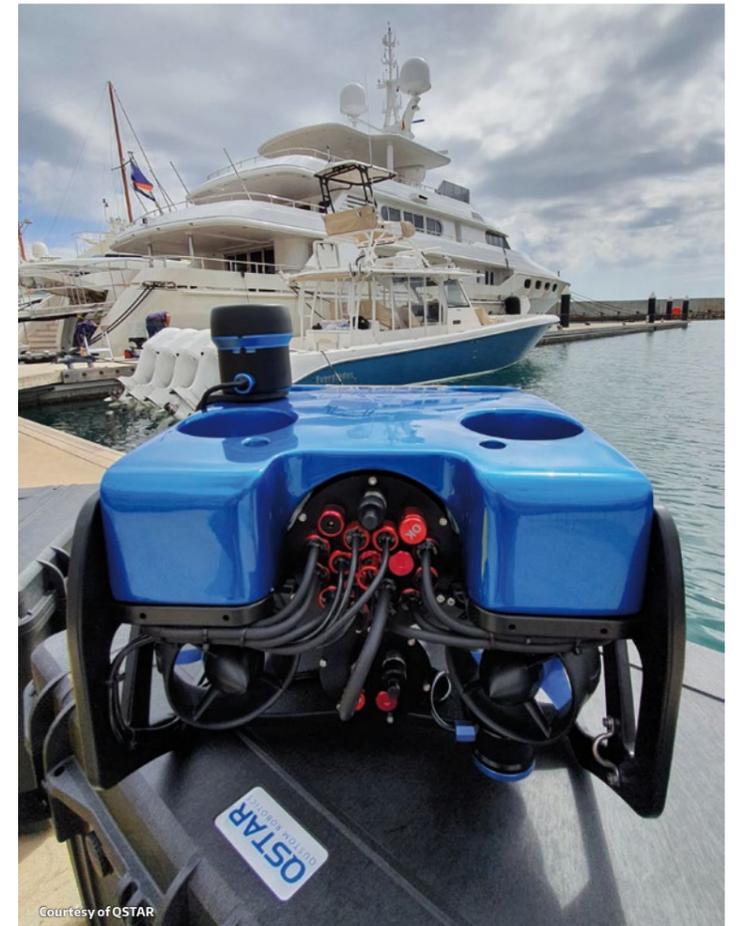
## ROBOTICS BRAND

**Qustom Robotics is the new brand under which QSTAR markets its own customized ROV vehicles, based on the BlueROV2 design from Blue Robotics. They have recently presented the evolution of their latest ROV model, which is more versatile with more capacity and adapted to the new needs of the commercial user.**

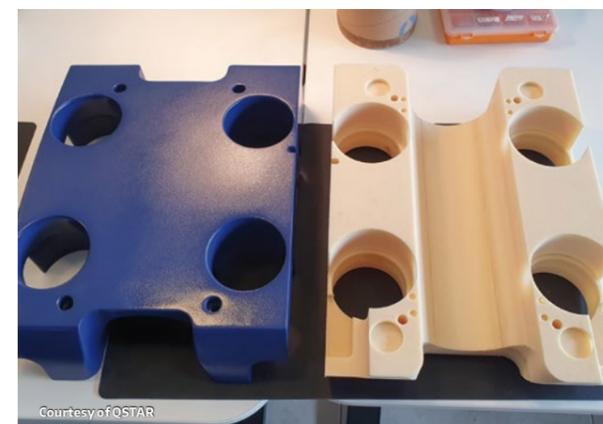
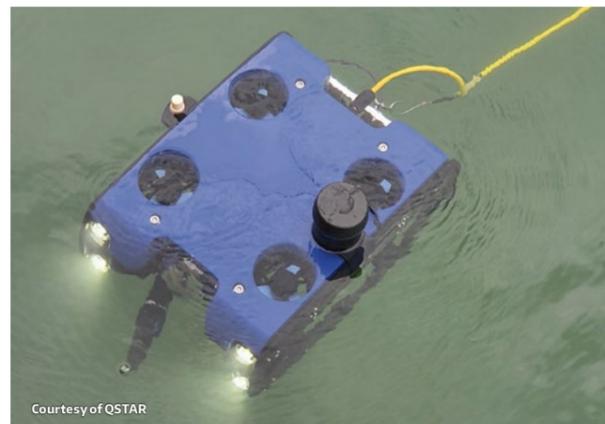
These units are sold fully assembled and include integrated custom CNC syntactic buoyancy blocks, underwater connectors, Ethernet, and fibre optic tethers up to 2,000 meters, specific tooling and sensors, dual batteries, surface power system option, and many other technical specifications required by the client.

### QUSTOM ROBOTICS FIBRE OPTIC KIT SOLUTION

The fibre optic (FO) kit options are fully integrated in a ruggedized transport flight case with wheels that can hold a fibre optic tether of up to 2 kilometres in length. Inside the case there's a built-in winch with a slip ring for the fibre and a subsea bottle integrates the FO multiplexer. The ROV tether is a 4.6mm neutrally buoyant single mode fibre optic (4 fibres 9/125), double sheath (PUR foam and PUR sheath) with a breaking strength of 300kg.



Courtesy of QSTAR



This FO tether kit solution gives the ROV the capability to perform long distance navigation as per for pipeline inspection, deep dives, and working in areas of currents, since it offers very little resistance to drag, and it has neutral buoyancy. Also, the fibre increases the bandwidth capacity for sensors and tooling integrations like imaging sonar heads, and 4K cameras among other systems. The kit comes with all the necessary components that is needed for the integration into the BlueROV2.

### TOOLING AND SENSORS

In collaboration with manufacturing companies QSTAR are offering the following tooling and sensors to integrate into their newly designed ROV systems.

**WATER LINKED** underwater GPS and DVL to explore more of the subsea world with full confidence in the positioning data the operator receives with the Underwater GPS G2, subsea modems and DVL.

**CERULEAN SONAR:** a cost-effective DVL solution for medium accuracy positioning and velocity measurement of an ROV.

**UWIS ROV POSITIONING SYSTEM:** UWIS is an underwater navigation, communications and surveillance system that utilises the triangulation principle. UWIS System is an efficient tool for real-time ROV tracking and route verification.

**ROV MANIPULATORS BY BLUEPRINT LAB:** The world's most lightweight, dexterous, and smart robotic manipulator for portable ROV operators. The Reach Alpha is the ultimate lightweight manipulator for portable ROV operators in the new era of close inspection and complex intervention.

**BLUEPRINT SUBSEA IMAGING SONAR:** The Oculus M series multibeam sonars are a new generation of imaging sonar, designed for use across a wide variety of underwater applications.

Also, they offer a full range of underwater connectors like BIRNS, Bluetrail Cobalt and recently the Baromax connector range.

### MORE FUNCTIONALITY IN THE NEW QUSTOM ROBOTICS

This new model incorporates a syntactic foam buoyancy module (rated to 300 and 600 meters), custom machined with CNC (computer numerical control) and finished with epoxy paint layers (customized in the client's preferred colour).

The characteristics that make it uniquely different from other models on the market is that it has integrated 8 thrusters and a payload with capacity to load a dual battery configuration, imaging sonar, altimeter, external temperature sensor and 3 function manipulator arms.

### CUSTOM NAVIGATION SOFTWARE

After a collaboration agreement with EIVA, QSTAR now offers a complete navigation software solution for the BlueROV2 ROV operations with the NaviSuit Mobula, which is a complete topside software for your ROV. NaviSuite Mobula comes in different variants allowing the users to upgrade to make use of sonar features, horizon control, station keeping, displace control, waypoint navigation, video overlay, VSLAM (camera derived point-cloud), and dive log/playback.

### RUGGEDIZED TRANSPORT FLIGHT CASES

Also, they have designed ruggedized transport flight cases to suit all the BlueROV2 model range including the Custom versions. The transport cases can hold the vehicle, the winch, and accessories like the surface unit, HCU, laptop, tooling, and the rest of the peripherals, being a very compact and portable equipment.

### NEAR FUTURE UPCOMING PROJECTS

QSTAR recently supplied a military grade ROV system for the Naval Defense Forces fully equipped with an imaging sonar, positioning system, fibre optic tether and a 4 DOF manipulator as a complete solution for "SAR" Search & Recovery ROV Operations, but also to be used for Mine Identification & Destruction. QSTAR is currently working to integrate a 3D photogrammetry high-accuracy camera to capture a 3D point cloud with accurately scaled reconstructions of underwater infrastructures.



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Since 2008 we also offer a full Hydrographic Survey Category B curriculum as defined by the FIG/IHO/ICA International Advisory Board on Standards of Competence for Hydrographic Surveyors (IBSC). Our Cat B training is normally an intense 30 week course (a 13 weeks e-learning programme, 1 week safety training, 12 weeks training in The Netherlands, followed by a 4 weeks Field Training Project).

However, as the development of the COVID-19 pandemic is still unpredictable, we saw no realistic possibility to deliver traditional on-site teaching this year. With approval of the IBSC all lessons that can be delivered on-line will therefore be taught using digital formats for the upcoming 26th class. Workshops, practical assignments and exams will be held in The Netherlands, in line with IBSC regulations, in April 2022.

We can offer you this modified program at a substantial lower rate than our regular on-site program. With both the health and safety of the students and staff and the IBSC regulations in mind, we trust this is an appropriate way to become a Category B Hydrographic Surveyor during this pandemic.



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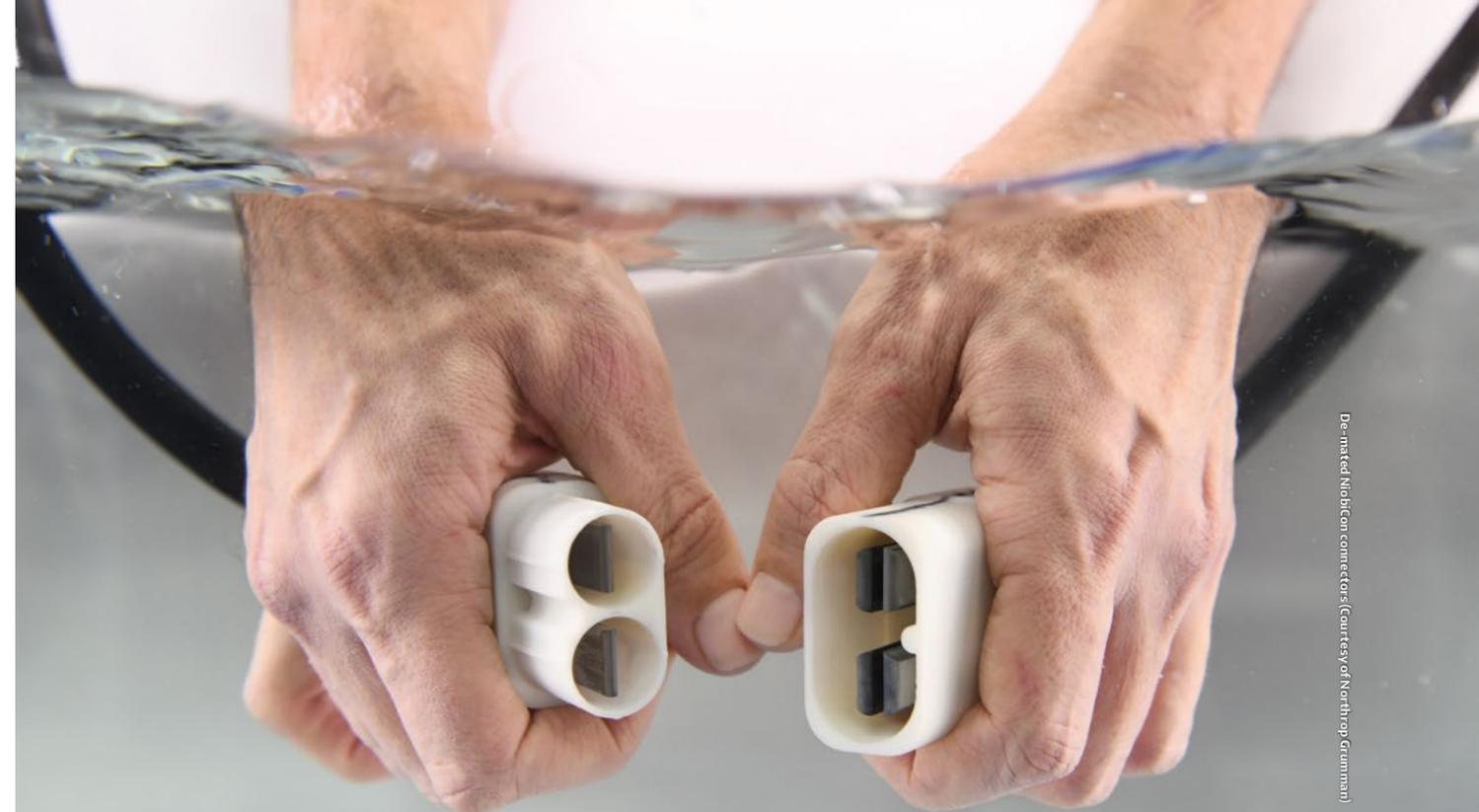
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De-mated Niobicon connectors (courtesy of Northrop Grumman)

## NIOBICON™ CONNECTORS WHEN ELECTRICITY AND WATER DO MIX

By Richie Enzmann – ROV Planet

All underwater connectors on the market are basically trying to make conventional electrical contacts used in air to be used underwater by keeping water away. For this purpose, other manufacturers have been using O-rings, seals, and oil, to keep the water from touching the electrical contacts, by using the same technology underwater that was used above water. Northrop Grumman took a different approach to this and the NiobiCon connectors were invented.

Jim Windgassen is the co-inventor of NiobiCon and an engineer at Northrop Grumman in Annapolis, Maryland. Several years ago, Windgassen worked on a proposal effort that involved recharging autonomous underwater vehicles (AUVs) using inductive charging which was very cumbersome. The inductive charger occupied a lot of space inside the vehicle, and it wasn't that efficient. Windgassen, frustrated by the limitations of inductive charging, started going down a different path and talked to a colleague, friend and co-inventor, Harvey Hack, who had done some work with connectors in the past using niobium, but purely for its corrosion resistance characteristics. When Hack mentioned niobium, this made Windgassen think about how an electrical device called a tantalum capacitor works, and that was the inspiration for NiobiCon.

Hack, Windgassen and a third inventor, Jeff Matejka, also an engineer at Northrop Grumman, fabricated a crude working prototype and tested it. It worked surprisingly well, so they got a small amount of internal funding and made it into a more professional design that they demonstrated. During one of their demonstrations, they met Keith Johanns who had recently been hired to commercialize technologies from Northrop Grumman. Hack and Windgassen had been struggling on their own trying to advance this technology; Johanns was the missing piece of the team and this project has really blossomed since.

### PHYSICAL PRINCIPLES AND CONNECTOR DESIGN

So, what is NiobiCon? It's a novel way of achieving underwater wet-mate connections that leverage the material properties of transition metals, which include metals such as tantalum,

niobium, titanium, etc. You can mate and de-mate this connector underwater while it's powered; in fact, you can reach inside and touch the contacts after you have de-mated it and it won't shock you. The connectors operate in a flooded state all the time; seawater or other liquids surround the contacts while in operation.

How do the connectors work? The contacts were fabricated out of solid niobium metal. After the contacts are incorporated into the connector, it goes through an anodizing process, similarly to the way tantalum capacitors are made to grow an initial layer of oxide. This oxide layer is approximately 150nm thick, which is about the same as one wavelength of ultraviolet-C light. When the connector is mated, you get localized disruption of the oxide and metal to metal contact allowing current to flow. As soon as the connectors are de-mated those very small areas re-grow the oxide within milliseconds and reinsulate themselves. The oxide layer is an extremely good insulator, and keeps leakage currents down to micro amp levels. As with any type of underwater connector, the area where copper wires from the cable transition to the niobium contacts must be insulated from the environment. Northrop Grumman has used polyurethane and epoxy resins for potting this area in our connectors; glass-to-metal seals are also possible with niobium.



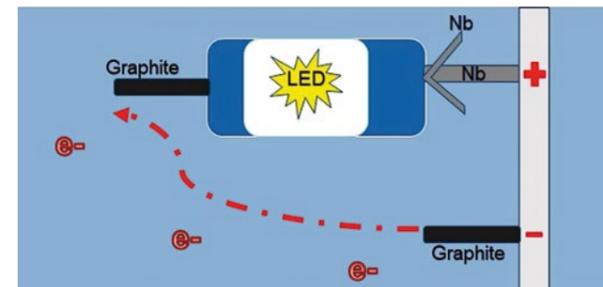
Coaxial High Power AUV Charging & Data Transfer Demonstration Connector (Courtesy of Northrop Grumman)

An advantage of coaxial connectors for an AUV application is that you don't have to axially align the connector, allowing a simple stab operation in order to mate. This connector demonstrates the charging at power levels that you would need for a medium to large size AUV at 2.75 kilowatts. The current of 55 amperes was limited by the 6AWG cable attached to the connector. NiobiCon connectors can operate at any current level by properly designing the contacts.

### SINGLE CONTACT WITH "SEAWATER RETURN"

An application combining NiobiCon technology with a "Seawater Return" has also been demonstrated. A seawater return uses seawater as a conductor to provide a return path for current in lieu of another wire. Seawater returns have been done for many years, but when you combine NiobiCon with it, you can have a single contact connector with a long exposed area such as a rod or wire that you can simply connect to. In this demonstration, the power supply's positive terminal is connected to a niobium rod approximately 200mm long, and then the negative terminal of that power supply is connected to a graphite rod. Both of these rods are immersed in a fish tank filled with artificial seawater. The oxide layer on the niobium rod provides the insulation to prevent current flow in the water between the (+) niobium rod and the (-) graphite rod.

A handheld surrogate vehicle was used for this demonstration. Inside the vehicle there is a 12V LED light bulb as a demonstration load. At the front there is a V shaped yoke made of niobium and at the rear, there is a short graphite rod. The anode of the LED bulb is connected to the niobium yoke, and the cathode of the LED bulb is connected to the graphite rod at the back of the vehicle. As soon as the vehicle's yoke touches the niobium rod, it makes electrical contact after the thin oxide layer of the niobium is displaced during mating. This allows current to flow through the LED bulb inside the vehicle, then out the graphite rod into the seawater, and then finally back to the power supply through the graphite rod connected to the power supply. With this solution you can do single contact connections underwater anywhere.



NiobiCon Combined With Seawater Return Demonstration (Courtesy of Northrop Grumman)

This combination of NiobiCon and seawater return allows for some interesting applications. For example, you could have a niobium wire stretching through the water and just by clipping onto the wire anywhere along its length, power will be accessible. If you had LED lights, you could just clip them onto this wire and have light wherever needed.

NiobiCon technology gives you a lot of design freedom that you wouldn't have doing such things any other way. The same exposed niobium rod or wire in the water can also support seawater exposed dynamic sliding contact applications.

### DIFFERENT CONNECTOR STYLES

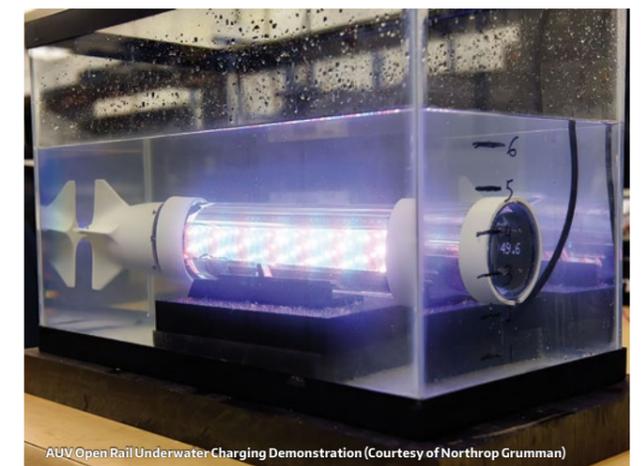
Depicted below is a commercial style connector made two years ago by Northrop Grumman's first manufacturing licensee, iCONN Systems, LLC. This connector is an M12 style connector. This has been used to demonstrate communications with a small remotely operated vehicle (ROV), as the tether cable connector.



M12 Style Connector Manufactured by iCONN Systems, LLC (Courtesy of Northrop Grumman)

Another type of connector is the prototype USB connector. The contacts inside were actually made out of niobium earring wire. Niobium as a material is very safe and has no toxicity, so it's used in biomedical applications because it's hypoallergenic. With this connector, you can plug it in and watch videos underwater.

Another demonstration is an AUV proxy which is demonstrated in a fish tank filled with artificial seawater. This demonstration consists of two parts, a simulated docking station and a model AUV. The docking station consists of a plate with two horizontal niobium rails approximately 18cm long on it which are attached to a 48 volt DC power supply. Our AUV consists of a clear acrylic tube with curved niobium contacts on the underside that follow the curvature of the tube. Inside the tube is a voltage display, and an Arduino connected to some addressable RGB LEDs. When the AUV is set down upon the rails, power transfer begins, the incoming voltage is displayed, and an underwater animated light show begins. You can reach into the fish tank and touch the niobium rails with your fingers and not get shocked, yet the oxide is thin enough that simply setting the AUV onto the rails is sufficient to establish a connection. The purpose of this demonstration is both to show the ease with which an AUV can be charged underwater as well as to demonstrate the design freedom that NiobiCon technology has to offer for making underwater connections.



AUV Open Rail Underwater Charging Demonstration (Courtesy of Northrop Grumman)



### ADVANTAGES AND DISADVANTAGES OF THIS TECHNOLOGY

The advantages of this technology are that it's simpler than inductive charging or conventional underwater connectors with seals. No large, complex electronics are involved as with inductive power transfer, and NiobiCon is much smaller and more efficient than an inductive solution. There are no seals, no O-rings, no oil and nearly an infinite number of mating cycles on these connectors. The very first connector made years ago, has been mated over 1,500 times and still looks the same as the day it was made. NiobiCon connectors have very low mating forces and can be designed for very loose alignment tolerances unlike many conventional wet-mate connectors which require precise alignment and high mating forces. In addition, this technology has a level of intrinsic safety built into it. You can touch the contacts with your fingers underwater and you won't get shocked and it will not deliver current into the water if left open while powered. Connectors based on this technology lower maintenance and enhance reliability immensely as you don't have to worry about replacing seals, or damaged O-rings. If you de-mate this connector while it's powered, you don't have to turn off the power first as with conventional connectors. With conventional underwater connectors if you take them apart while powered, you will short out the connectors and corrode the contacts rapidly. With NiobiCon you can reimagine or reinvent how underwater connectors can be designed. For example, you could swap a removable battery pack underwater just as you would in air. It provides for a very simple design – which can effectively lower costs. As long as your cable can withstand the pressure, there is no intrinsic depth limit to this technology because it's a solid metal.

This technology is a good solution for up to 60-75VDC. The film that is on the niobium breaks down at about 120VDC. At present, these connectors are not directly capable of handling AC power due to the reversing polarity disrupting



In this test the NiobiCon connectors used on a BlueROV2 tether connectors (Courtesy of Northrop Grumman)

the oxide layer formation. Northrop Grumman has received two patents for addressing the AC power and voltage limitation issues and are conducting research into other means of improving this technology. One unusual thing about these connectors when you put them together and want to measure the resistance of that connection, particularly when dry, there is a low voltage varistor-like effect. If you try to use a common digital multi-meter to measure the resistance of the connection, you will get erroneous results. In order to measure the resistance / voltage drop across the connector, a constant current source and a voltmeter must be used.

Finally, the cost of niobium metal is about 10 times the cost of copper but usually the copper is not the driving factor in the overall cost of connectors; particularly underwater connectors. The cost difference of the niobium vs. copper can easily be made up by the simplification of the design of the rest of the connector which is devoid of sealing features.

### LICENSING AND FUTURE PLANS

Northrop Grumman is not a connector company, which is driving its commercialization strategy to non-exclusively license this technology out to connector manufacturers and other interested parties. Currently, Northrop Grumman has granted a non-exclusive manufacturing license to iCONN Systems, LLC, located in Lombard, IL. There are also organizations interested in developing their own connectors. For example, Monterey Bay Aquarium Research Institute (MBARI) is another licensee with a plan to recharge their long range AUVs underwater that are utilized in deep-ocean scientific research. Their primary interest is to develop this technology specifically for their platforms. If your company or organization is interested in licensing the technology directly, please get in touch with the Northrop Grumman NiobiCon team. The team has a website which has several videos, information, and contact information on it. If you are interested in directly purchasing NiobiCon based design solutions, please reach out to iCONN Systems, LLC. iCONN Systems LLC's website devoted to the NiobiCon technology is here:



**Jim Windgassen is a co-inventor of NiobiCon connectors and is a senior staff engineer and technical fellow who has been with Northrop Grumman for 21 years.**

**Harvey Hack is a co-inventor of NiobiCon connectors. He is a Northrop Grumman fellow with a PhD in Metallurgy and Materials Science from the Pennsylvania State University. He has spent 25 years working as a corrosion electro-chemist working for the Naval Surface Warfare Center and then 25 years working in corrosion control at Northrop Grumman. He is also a past president of NACE International (now AMPP), the world's largest organization of corrosion control professionals, and past chairman of the board of ASTM International.**



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# SUBSEA 7 AND THE NATIONAL OCEANOGRAPHY CENTRE LAUNCH RESEARCH ALLIANCE TO IMPROVE SCIENTIFIC UNDERSTANDING OF GLOBAL OCEANS

Global offshore operator Subsea 7 and the National Oceanography Centre (NOC) recently launched BORA Blue Ocean Research Alliance™ an exciting alliance to improve understanding of the world's ocean and seas for a sustainable marine future. The combination of Subsea 7's global deep-water reach, established track record in innovative marine technology and project management together with the NOC's breadth of scientific expertise, will enable BORA Blue Ocean Research Alliance™ to bridge the gap between industry and science to support sustainable research and development. The alliance will provide researchers with access to hard-to-reach areas, as well as the sharing of open access scientific data to gain knowledge at every step of the way.

Huw Gullick, Associate Director Strategic Business Development at the NOC comments: "Subsea 7 is a global leader in the delivery of offshore projects and services in locations over the world. The alliance allows the NOC to work with them to take advantage of their global presence for our scientific research purposes.

"Our launch project will see the development of an innovative sensor box for measuring essential ocean variables which can be deployed on Subsea 7's fleet of Remote Operating Vehicles (ROVs) and vessels. The use of these sensors across Subsea 7's fleet that are used all over the world means that the rate and scale of key data being streamed to the NOC which can be used for research purposes is unprecedented. This gives our scientists access to data rapidly, which normally would take much longer to collect from our own equipment."

Other key projects using ROV technology will involve searching for and obtaining footage of undiscovered sea creatures that inhabit remote locations and unexplored ocean depths. Subsea 7's unique operational access to uncharted waters enables the close monitoring of different ocean characteristics which will then be analysed by scientists at the NOC.

However, BORA Blue Ocean Research Alliance™ isn't just aimed at collecting data. It will be output focussed in order

to accelerate understanding of critical ocean systems and processes that can help tackle the big questions around sustainability and climate change.

Huw explained: "Understanding our oceans is now more important than ever. The ocean is increasingly playing a pivotal role in key political decisions around climate change and this alliance gives us an opportunity to bring industry and research together to focus on providing the best understanding we can so we can make informed decision about how we work with and protect our oceans."

Emma Stephen, Director of Sustainability at Subsea 7 added: "It is the responsibility of all of us to contribute and ensure the preservation of this most valuable natural resource. Our relationship with BORA Blue Ocean Research Alliance™ supports Subsea 7's value of sustainability, where we will use our global reach and technology to collect and share data to understand more about protecting our seas and marine ecosystems for future generations."

Both organisations are committed to ensuring that the data collected is as accessible as possible to enable engagement with the alliance as widespread as possible. "It is important that we share what we do," said Huw. "We are in the privileged

position to be able to collect data about areas of our world that few ever see, and we have the expertise at the NOC to make sense of all of this data. Translating this into something that can be understood and interacted with is key for us and Subsea 7."

Industry and research collaborations have often been talked about and both organisations hope this formal alliance can be seen as a model for how commercial organisations can work with research institutes and pool their resources.

Huw's final comment on this is clear: "putting the output of this alliance aside, I am particularly proud that both organisations have formalised what many have talked about doing; committing long-term to an industry and research partnership focussed on understanding but with action at the heart of it."

BORA Blue Ocean Research Alliance™ was officially launched at the Ocean Business show in October this year and both Subsea 7 and NOC would welcome any direct discussion with those interested in finding out more.

ROV Planet is rebranding as **Ocean Robotics Planet** from 2022 to reflect the ongoing changes in the ocean space.

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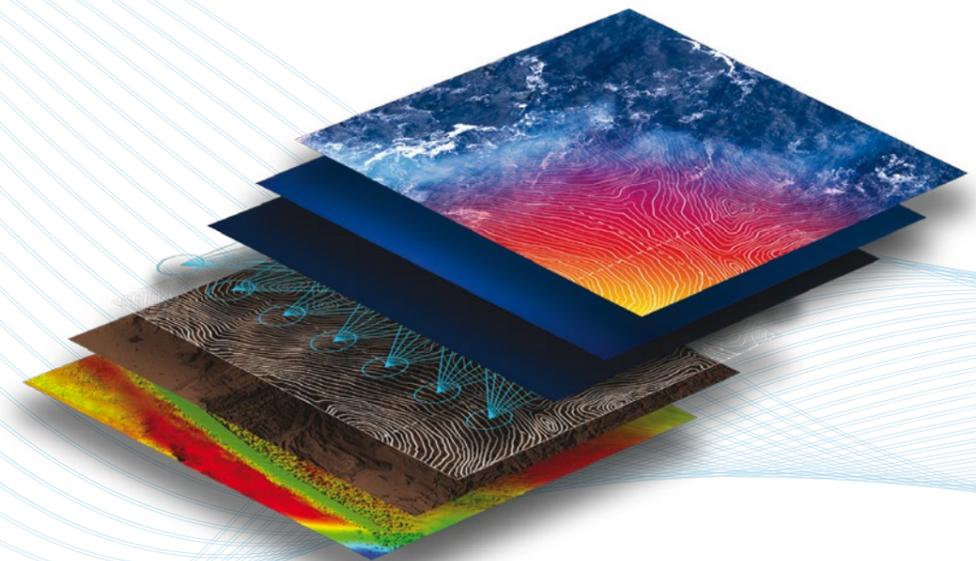
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