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THE FUTURE OF OCEAN TECHNOLOGY

VOLUME 4

TRANSFORM YOUR CAPABILITY

REAL-TIME IMAGING IN ALL CONDITIONS

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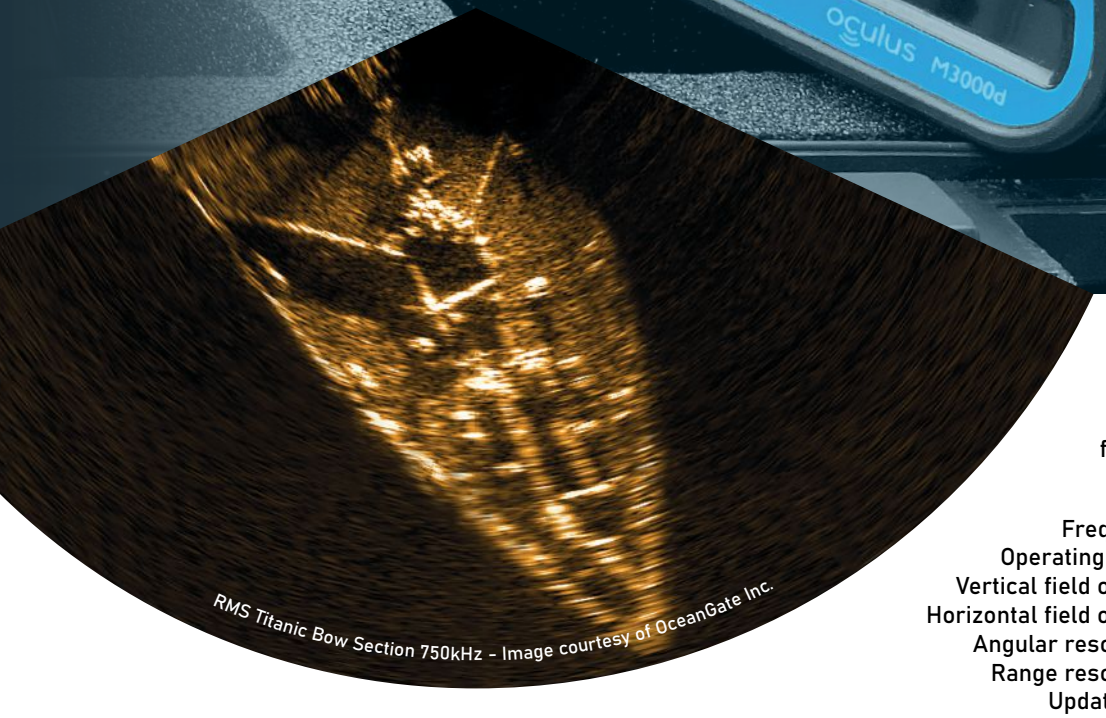

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ON THE COVER:
High resolution image collected by Voyis for the IMAGE Project for glass sponge reef mapping and preservation.
(Image credit: Voyis)

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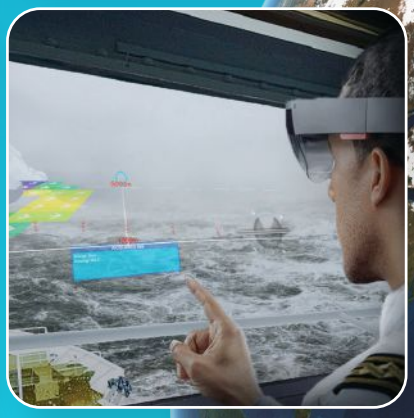
From coast-to-coast-to-coast, Canadian ocean companies are delivering game-changing solutions in energy transition, food security, decarbonization of shipping, and climate solutions.



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THE FUTURE OF...

OCEAN TECHNOLOGY

Past pioneers continue to inspire

» *Trieste bathyscaphe. (Photo courtesy of US Navy/Woods Hole Oceanographic Institution)*

By ED FREEMAN, *Managing Editor, ON&T*

The passing of Retired Navy Captain Don Walsh, on November 12, 2023, closed an important chapter in the story of ocean exploration.

The peerless deep-sea explorer and oceanographer led a storied life, one that changed forever on January 23, 1960, when the then 28-year-old US Navy Lieutenant assumed command of the notorious bathyscaphe *Trieste* and piloted a historic dive to the deepest reaches of the Mariana Trench alongside Swiss oceanographer Jacques Piccard.

Following a 5-hour descent, Walsh and Piccard touched down at a depth of 10,911 m (35,814 ft.) and then spent 20 minutes parked at the bottom of the planet. With world leaders seemingly more motivated to get boots on the moon than seafloor canyons, this pair of aquanauts had conquered a new, most alien frontier: Challenger Deep.

EXPLORATION WITHOUT PRECEDENT

Their fate at these crushing depths—the water column above exerting a pressure of 1,086 bar (15,750 psi)—was entirely reliant on the in-house engineering might of the US Navy. Every aspect of the 15-m *Trieste's* form and factor—from the hull to the many components (lights, cameras, samplers, sensors, etc.)—was purpose-built to make the code name Project *Nekton* an archetype for future ocean exploration.

In 1960, there was no established commercial supply chain of vendors; there was no online catalog of equipment and bolt-on marine instrumentation. In many ways, the US Navy servicemen and women charged with getting Walsh and Piccard safely to the Hadalpelagic Zone and back were drafting the playbook for the scalable commercialization of subsea investigation.

This is what true pioneers do; they pave the path for others to explore.

INSPIRING LEGACY

The landmark dive immediately inspired—and continues to inspire—generations of ocean professionals to invest in the development of safe and cost-effective ways to both retrieve data and imagery from below the surface and transport humans to once unfathomable depths.

True to the proverb, necessity is the mother of invention: We need to explore our ocean, in every sense, to plan and enact sustainable ways to leverage offshore resources, further our scientific understanding of submarine environments, and ultimately futureproof the burgeoning blue economies around the world. This obligation has helped fund and field an expanding range of commercially available technologies geared to advance meaningful ocean enterprise, from human occupied vehicles and remotely operable assets to sensor instrumentation and subsea cameras and lighting capable of real-time data feeds.

I suspect that many of the original crew that worked on the *Trieste* might scratch their heads in disbelief at the rapid intensification of present-day efforts to integrate artificial intelligence and machine learning into commercial-off-the-shelf products and services. Not Walsh, though. He remained active throughout his 92 years, delivering captivating keynote speeches and insightful editorial that many of the readers of this publication, like me, would have enjoyed.

The stellar lineup of editorial features and opinion pieces in this special edition of ON&T serves as a timely reminder of just how profound inspiration can be in setting a new agenda of discovery, as we open the next chapter of *The Future of Ocean Technology*.

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UNCREWED MARINE EXPLORATION

USVs are instrumental to the expansion of the Blue Economy

BRIAN CONNON
VP Ocean Mapping
SAILDRONE

Humanity has been observing Earth's oceans for centuries, but we've barely scratched the surface of all there is to know. This lack of exploration is largely due to the high cost and logistical challenges of accessing the ocean, traditionally undertaken by large ships that are expensive to build and operate. The adoption of uncrewed systems and advanced sensors has opened up unprecedented possibilities for maritime exploration. These technologies offer the potential to conduct more efficient, cost-effective, and environmentally friendly operations.

Saildrone has evolved its autonomous platform, machine learning, sensor integration, and data telemetry to provide high-resolution real-time ocean data and intelligence to customers around the world. Recognizing the importance of the maritime domain to national security, the possibilities of renewable energy, and the value of the Blue Economy providing livelihoods and sustenance to billions of people, Saildrone has pushed technical and endurance boundaries to collect critical ocean data where it has traditionally been out of reach, or prohibitively expensive to collect.

Ten years to the month after Saildrone's first Pacific crossing from San Francisco to Hawaii, its fleet of uncrewed surface vehicles (USVs), now 136 strong and scaling rapidly, has sailed more than 1,000,000 nautical miles and spent over 32,000 days at sea, demonstrating once again the reliability, endurance, and ability of its fleet to operate in diverse and challenging maritime environments.

The recent announcement by the American Bureau of Shipping (ABS) issuing the first-ever class certificate for a commercial USV marks a significant milestone in the acceptance and recognition of autonomous technologies in the maritime industry. One of the world's leading classification organizations at the forefront of marine and offshore innovation, ABS granted classification for the Saildrone Voyager after an extensive review and evaluation process. The Voyager is the first autonomous asset built to ABS Class using the *ABS Requirements for Autonomous and Remote Control Functions*.

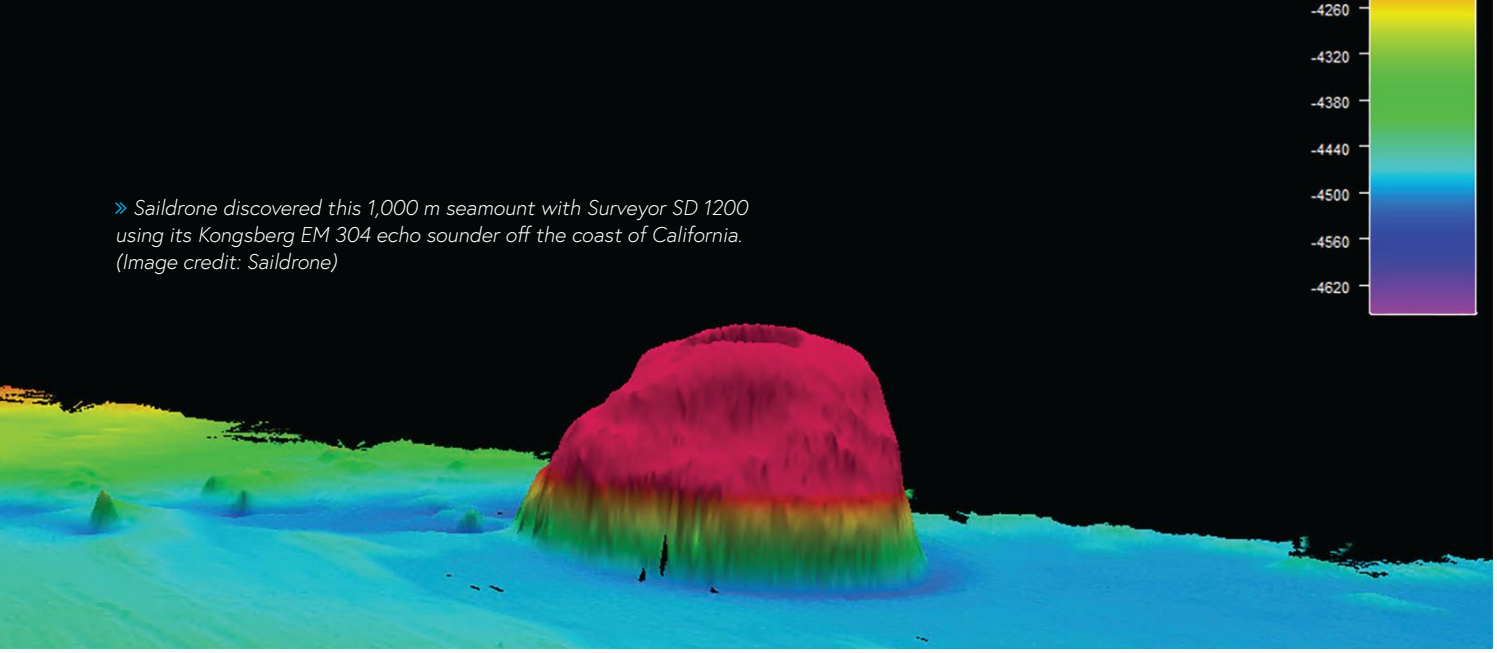
Classification allows the Voyager to operate in the ports and waters of countries that require vessels to be classed by organizations such as ABS and demonstrates Saildrone's commitment to safety, standardization, and reliability in its technology and operations.

> AS THE MARITIME INDUSTRY CONTINUES TO EVOLVE, THE INTEGRATION OF AUTONOMOUS TECHNOLOGIES WILL UNDOUBTEDLY SHAPE THE COURSE OF MARITIME EXPLORATION LIKE NEVER BEFORE.

MISSION AS A SERVICE

Saildrone is known for its eye-catching USV, but the backbone of these vehicles is a robust and mature organization supporting deployment, execution, and data delivery. Unlike other companies that sell their hardware, this "mission-as-a-service" model removes barriers to entry and reduces customer risk. Saildrone assumes the responsibility of owning and maintaining the assets, which allows them to be constantly updated with the most current payloads and software.

With extensive experience deploying and operating data collection missions around the world and an expert team of mission manag-



» *Saildrone discovered this 1,000 m seamount with Surveyor SD 1200 using its Kongsberg EM 304 echo sounder off the coast of California. (Image credit: Saildrone)*

ers, pilots, and surveyors, Saildrone is the overwhelming leader in ocean data collection using autonomous vehicles. Saildrone vehicles can remain on mission for months at a time, and collected data can be accessed 24/7/365 via a proprietary web portal or secure API, which seamlessly integrates into common operating pictures (COPs) and analytical platforms.

All of Saildrone's vehicles are primarily powered by wind and solar energy with a minimal carbon footprint, making them an ideal platform for developing offshore renewable energy sources.

COMMERCIAL APPLICATIONS

From its origins in science and fisheries, testing the integration of various sensors and pushing the platform to its limits in the Arctic and Antarctic with partners like the National Oceanic and Atmospheric Administration (NOAA), Saildrone has expanded its data services to include ocean mapping and defense services for commercial applications.

Maritime infrastructure, including ports, shipping lanes, and undersea cables, forms the backbone of global trade and communication, and offshore energy has the potential to reduce global dependence on fossil fuels, but these activities require massive amounts of data from site identification through construction and operation. There is a global backlog for traditional survey ships. Saildrone USVs are available now.

The Saildrone Voyager and the larger Saildrone Surveyor represent a paradigm shift in how we explore our oceans. They carry the same cutting-edge multibeam sonar and sub-bottom profiling equipment as survey ships but operate at a fraction of the cost and carbon footprint. The bathymetry data that Saildrone can deliver has been found to meet the most stringent industry data requirements.

SENSOR SUITE

The United States Exclusive Economic Zone (EEZ), stretching from the coast to 200 nm (370 km) from shore, is one of the largest in the world, but only about 50% of it has actually been mapped. The Saildrone Voyager is optimized for coastal mapping, in waters to 300 m depth, equipped with the Norbit Winghead i80s, an inductively charged AML-3 sound velocity profiler, and sub-bottom profiler.

The Saildrone Surveyor's advanced sonar system offers deepwater ocean mapping not available from any other autonomous platform. Equipped with the Kongsberg EM 304 MKII and the EM 2040, the Surveyor will help to meet the global backlog for full ocean depth surveys due to the lack of survey ship availability.

Saildrone is dedicated to advancing autonomous technology to meet the toughest maritime challenges. New capabilities include adding Starlink, allowing for high-bandwidth data transfer in near real time, a pan/tilt/zoom infrared camera at the masthead, and a proprietary passive acoustics array on the keel to detect, localize, and classify marine mammals, especially endangered whales, around offshore wind sites. Saildrone USVs have demonstrated their ability to withstand even the most challenging ocean conditions. From Arctic missions to hurricane tracking and Antarctica circumnavigation, Saildrone USVs have consistently proven robust and reliable.

As the maritime industry continues to evolve, the integration of autonomous technologies will undoubtedly shape the course of maritime exploration like never before. By harnessing the power of renewable energy and autonomous technology, Saildrone is revolutionizing the way ocean data is collected and utilized for public and commercial industry applications worldwide.

www.saildrone.com

» *Saildrone Voyager. (Image credit: Saildrone)*

AUTONOMOUS SURVEYS

The integration of cooperative uncrewed systems in marine environments

OLIVIER MOISAN
DriX Operations Manager
exail

It's a world first. With the concerted use of a DriX uncrewed surface vehicle (USV) and a FlipiX remotely operated towed vehicle (ROTV), Exail continues to push the boundaries of marine technology to provide customers with a unique uncrewed solution that will redefine how operators carry out bathymetric and geophysical surveys.

With the ongoing development of ocean-based infrastructure—offshore windfarms, cables, and pipelines, etc.—accurate surveys of the seabed provide critical data needed for pre-installation project planning. The Drix USV is renowned for being able to integrate various payloads in its gondola (2 meters below the surface), however, certain projects require higher resolutions only made possible by sensors operating closer to the actual seabed.

» *DriX (right) alongside a FlipiX ROTV. (Image credit: Exail)*

Leveraging the company's extensive experience in the design and fabrication of next-generation ocean technology, Exail recently engineered a new ROTV—FlipiX—conceived to operate alongside a DriX USV to service the demand from the offshore industry for cost-effective high resolution bathymetric, geophysical, and Unexploded Ordnance (UXO) survey campaigns.

Compact in size—1.8 (L) x 2.7 m (W)—FlipiX is a full composite, agile, and versatile vehicle with active pitch and roll motion control and stabilization. The ROTV can be towed by a USV or a conventional vessel and operated at fixed altitude or fixed depth—up to a 100 m depth and as close at 1 m from the seabed for optimum measurement quality and resolution. FlipiX Control software is directly implemented in DriX's Human Machine Interface, a web-based interface allowing multiple users to easily and efficiently supervise both DriX and FlipiX from the same access point.

When designing FlipiX, Exail teams set about to create an intuitive, user-friendly vehicle that would respond to DriX's behavior. Its positive buoyancy is a significant advantage in operation. During a typical survey mission, if DriX is stopped for some reason, FlipiX will then slowly rise to the surface instead of sinking to the bottom like a conventional towed heavy weight payload. As soon as DriX resumes its mission, FlipiX repositions itself at the requested depth/altitude. DriX was designed with optimal maneuverability in mind, so when the USV makes sharp turns in between survey lines, FlipiX will mirror the pattern and stay at the same depth or altitude. For the end users, this stability and accuracy translates into increased survey control and efficiency.

MULTI-SENSOR PAYLOAD

From a system's perspective, DriX and FlipiX have been designed around an open platform concept. Thanks to their open architecture, they can accommodate best-in-class payloads for a wide

> WHEN DESIGNING FLIPIX, EXAIL TEAMS SET ABOUT TO CREATE AN INTUITIVE, USER-FRIENDLY VEHICLE THAT WOULD RESPOND TO DRIX'S BEHAVIOR.

range of missions. As an example of configuration tested at sea, DriX's payload gondola is fitted with one of Exail's Phins Compact C7 Inertial Navigation System, a multibeam echosounder, an Exail Echoes T1 sub-bottom profiler, and an Exail M5 USBL system GAPS to position the FlipiX underwater.

The FlipiX is currently equipped with an Edgetech 4205 side-scan sonar, the gold standard in the industry, providing first-class data acquisition up to 850Khz frequency. The side-scan sonar provides high quality imagery data of the seafloor. These quality data are ideal for the inspection of underwater structures, identification of potential UXO (unexploded ordnances), and seabed and habitat classification. A G882 Cesium Vapour magnetometer from Geometrics towed 2 m behind FlipiX is also fitted and is ideal for UXO detection projects thanks to its resolution and detection capabilities.

A Valeport MiniSVS fitted with a pressure sensor enables FlipiX to collect sound velocity profiles during the ROTV's dive from the surface to the seabed. FlipiX real-time underwater position is tracked by an Exail MT9 transponder.

Other payload configurations for additional missions are already being studied by Exail engineers.

For the customers, one of the main advantages of using DriX and FlipiX together is that in a single line, sailing between 5 to 6 kts, these two vehicles deliver high-resolution seabed mapping capabilities, combining multibeam, sub bottom, side-scan sonar and magnetometer data. Test campaigns from April to September 2023 have garnered very positive results.

ROUND-THE-CLOCK MISSION CAPABILITIES

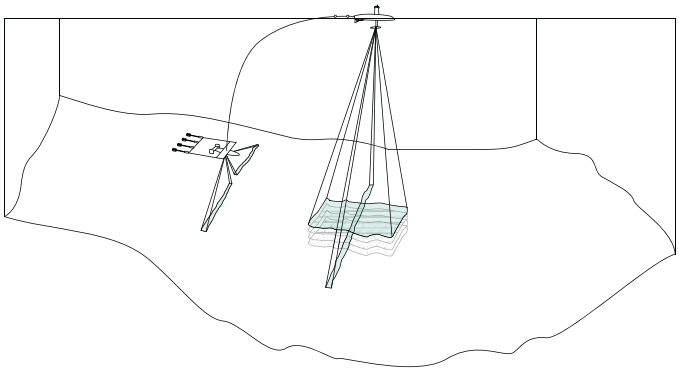
Meanwhile, the success story of Exail's DriX continues for commercial customers worldwide, demonstrating that, with an average fuel consumption of only 2 liters of fuel per hour, a long-endurance USV can perform round-the-clock missions in the most demanding offshore conditions.

DriX can perform a very accurate surface, ocean, and seabed survey for up to 10 days with a minimal environmental footprint compared to a crewed ship. DriX USVs are currently being used on several scientific survey campaigns around the world to assess the impact of windfarm construction on the surrounding marine ecosystem, as well as to monitor the ongoing operation of offshore structures such as turbines, underwater cables, and seafloor pipelines.

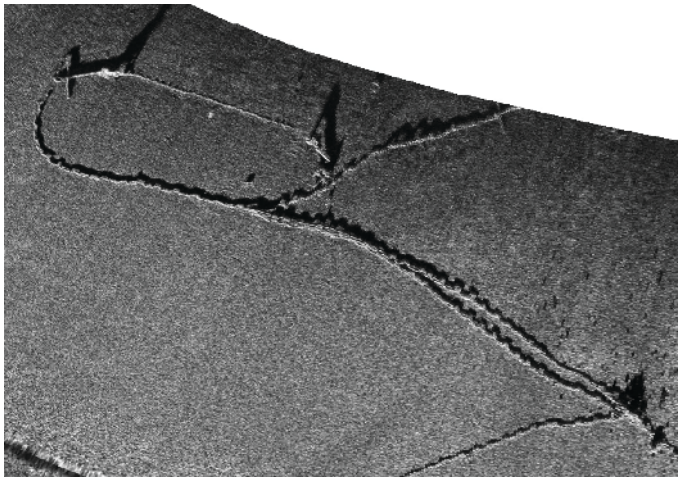
By transmitting data in real time to clients via line of sight and Satcom, DriX's steady integration into the offshore developer's toolkit of autonomous systems represents a game-changing approach to safe, efficient, and increasingly carbon conscious marine survey and seabed monitoring procedures.

www.exail.com

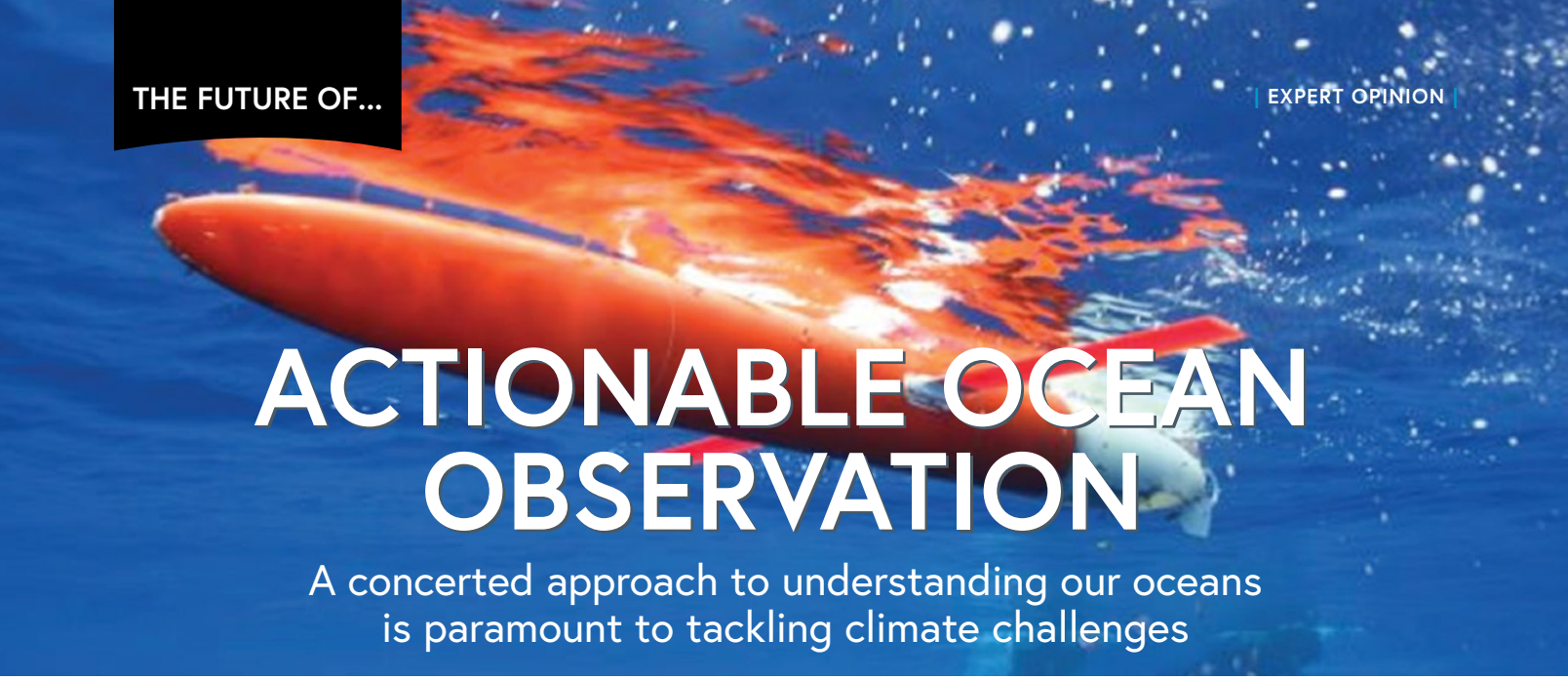
» *FlipiX can be towed by a USV or conventional vessel at a fixed depth. (Image credit: Exail)*



» *Diagram of DriX and FlipiX. (Image credit: Exail)*



» *FlipiX's multi-sensor payload affords best-in-class seabed image data. (Image credit: Exail)*



ACTIONABLE OCEAN OBSERVATION

A concerted approach to understanding our oceans is paramount to tackling climate challenges

» *Spray Gliders. (Image credit: Robert Todd/Woods Hole Oceanographic Institution)*

PETER DE MENOCAL
President & Director
WOODS HOLE OCEANOGRAPHIC INSTITUTION®

> THE OCEAN COULD HELP US RESTORE BALANCE TO OUR CLIMATE, BUT WE NEED MORE 'EYES' IN THE OCEAN TO MEASURE, UNDERSTAND, AND MAKE INFORMED DECISIONS ABOUT OUR FUTURE.

For years, some version of H. James Harrington's process-improvement maxim, "If you can't measure something you can't understand it," has floated around corporate boardrooms. That is equally true in ocean science labs and research ships around the world. But if we are going to stave off the worst that the climate crisis has in store for us and not hand a dangerously overheated world over to our children, that must change.

That's why a group of the world's leading ocean science, philanthropic and advocacy organizations organized the Ocean Pavilion at the UN's annual climate conference. COP28 in Dubai gave us an opportunity to carry this message to global leaders across civil society.

MORE DATA NEEDED

Events of the past year have afforded us a glimpse of a future in which extreme weather events become more commonplace and societal upheaval driven by our inaction more likely. Altering this future rests on civil leaders being able to make informed decisions, and the burden to provide the basis for these decisions rests on the scientific community. There is, however, only so much we can do with the relatively limited data we have, something that is especially true for those of us who work in the ocean.

The ocean can seem almost cruelly designed to thwart efforts to peer into its interior. It is a cold, dark, corrosive environment that would like nothing more than to crush or batter our sensitive instruments into oblivion. Pioneering programs like Argo and the Ocean Observatories Initiative offer ways to measure critical variables at useful time and space scales, but there are still too few of these and they are too sparely distributed to keep track of an immense, constantly changing volume that seems designed to defy regular observation.

Before you think this is another plea for more investment in science, consider the alternative of turning away from this challenge. Climate change and the cost of carrying on with business as usual is stunningly expensive. Extreme weather events in the US over the last four decades have cost Americans an average of $60 billion per year. In the 2020s alone, there were more than $400 billion in US climate-related losses. These events are increasing in cost and frequency, and disproportionately affect the disadvantaged who are on the front lines of risk geographically, economically, and socially.

THE CO2 PROBLEM

Cutting greenhouse gas emissions must be our immediate priority. As we work toward this goal, however, we must now also remove carbon dioxide from the atmosphere to stay below the critical, yet imminent, 2°C warming threshold. In this, the ocean is humanity's ally. Since the Industrial Revolution, the ocean has naturally absorbed about 30% of the atmospheric carbon dioxide we have produced. From phytoplankton on the surface to the seafloor sediments, a host of physical, chemical, and biological processes can lock away additional heat-trapping carbon, sometimes for thousands of years. The deep ocean alone holds 50 times more carbon than Earth's atmosphere.

Independent science must lead as we pursue safe, effective solutions that leverage these processes. The ocean could help us restore balance to our climate, but we need more "eyes" in the ocean to measure, understand, and make informed decisions about our future. Only with better observations will we build knowledge about what is happening below the surface and over the horizon.

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UNCREWED FORCE MULTIPLIERS

Pairing autonomous systems to streamline marine operations

ALEXANDER STEELE
Subsea Robotics Product Manager
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As the offshore energy industry looks for ways to reduce environmental footprints and offer safer, more operationally efficient, and cost-effective services, the industry will look toward uncrewed solutions to light the path forward.

Uncrewed Surface Vessels (USVs) can complement offshore survey work by eliminating or reducing the need for larger multi-service vessels, and crews to staff them, to stay on site while subsea work is carried out with remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs).

FORCE MULTIPLIER

Oceaneering is a leader in remote operations, having established its first dedicated Onshore Remote Operations Center (OROC) in 2015 in Stavanger, Norway, and has achieved over 100,000 hours of piloting from shore. In addition to this, Oceaneering has pioneered Remotely Operated Survey since 2016, helping to transition over 9,000 personnel days from the field through the use of innovative technologies to enable secure data transmission to shore.

At Offshore Europe 2023, Oceaneering announced that it will add a DriX USV from Exail to its fleet. The new vessel will be used to complete offshore survey and inspection work scopes, enabling us to improve operational efficiencies, reduce overall vessel time on site, and significantly reduce carbon emissions for customers.

The DriX USV will work in conjunction with Oceaneering's existing assets and services to expand capabilities, with the first use case detailed to support deepwater geophysical surveys and asset inspection scopes. The USV introduces a force multiplier when performing survey scopes in tandem with Oceaneering's AUVs, such as HUGINs and hybrid Freedom™ ROV/AUV vehicle system.

By operating in conjunction with Freedom, the USV will provide a collaborative robotics solution for our customers that helps reduce the carbon footprint of operations. When using the USV and Freedom together, we can use the USV as a tracking and communication tool, a function traditionally provided by a large, crewed vessel. However, by using the highly capable USV, the mother vessel is released to carry out concurrent work scopes in the local vicinity, such as geophysical, seismic, and geotechnical surveys or ROV-based asset inspection, maintenance, and repair (IMR). By freeing up the project's multi-service vessel, we can drive operational efficiencies, and complete work scopes faster.

FIELD-PROVEN USV

The DriX USV has accumulated several thousand hours in operation since entering service in 2016 and is able to conduct over-the-horizon supervised autonomous operations thanks to its AI-powered CortiX software and state-of-the-art sensors.

The USV's shape and stability allows for continued operations alongside Oceaneering's AUVs in poor sea conditions (up to Sea State 5), without compromising the system's ability to capture high quality data.

The USV's speed and endurance also reduces transit downtime and enables high-speed, nearshore surveys to be conducted while obtaining optimal data quality, harvested in a fraction of the usual time. It offers a lower environmental footprint at only two liters of fuel usage per hour, a massive carbon emissions savings when compared with the output of a crewed vessel.

DUAL REDUNDANCY

Our service will offer the industry's first USV equipped with true, dual positional redundancy for guaranteed continuity of service. Oceaneering's USV service offering will utilize dual independent positioning correction services from Oceaneering's C-NAV® group for uninterrupted operations, thereby improving reliability.

Launched earlier in 2023, C-NAV LEO, a Satellite-based Correction Service, is delivered exclusively through the Iridium® Short Burst Data® service. Iridium offers truly global coverage, with 66 satellites in six polar orbits, nine in-orbit spares, and six ground spares. Iridium satellites work even in adverse weather conditions, moving quickly so any blockage in coverage is temporary and leaving correction accuracy unaffected.

FUTURE PLANS

Adding a USV to Oceaneering's fleet is a natural progression of our remote operations expertise and will drive significant opportunities to scale operations and drive greater efficiencies while supporting our IMR growth strategies.

The DriX USV allows us to remotely gather high-quality data at a lower operational impact, without the need for dedicated offshore crew, thereby reducing health and safety risks to personnel and the environment.

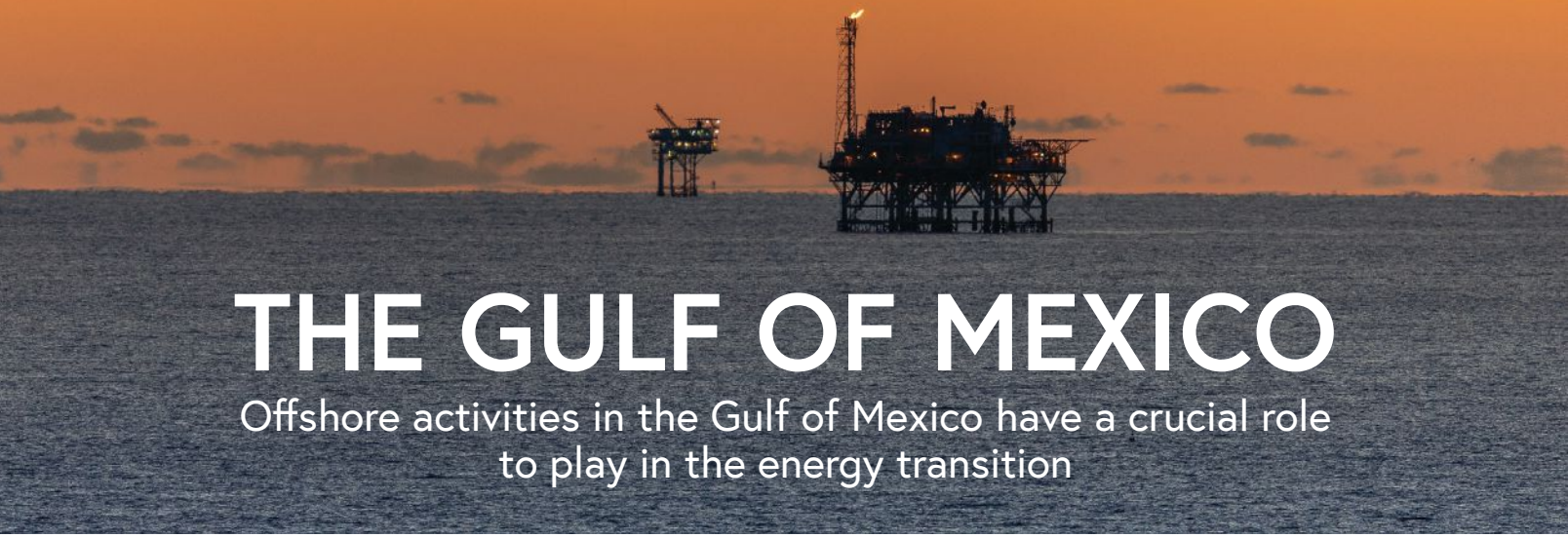
We see the USV service expanding over time to support cost-effective growth in the offshore renewables market, enabling the towing of sensors from larger USVs while providing a platform for deploying ROVs remotely.

> WHEN USING THE USV AND FREEDOM TOGETHER, WE CAN USE THE USV AS A TRACKING AND COMMUNICATION TOOL, A FUNCTION TRADITIONALLY PROVIDED BY A LARGE, CREWED VESSEL.

Overall, our USV services aim to reduce the risk of downtime associated with weather conditions and make it more efficient for our customers to complete AUV inspection and survey scopes alongside asset inspection, remediation, and conventional surveys.

www.oceaneering.com

» *Executing operations from the OROC. (Image credit: Oceaneering)*



THE GULF OF MEXICO

Offshore activities in the Gulf of Mexico have a crucial role to play in the energy transition

ERIK MILITO
President
NOIA
America's Offshore Energy Industry

> THE GULF OF MEXICO IS A CRITICAL ECONOMIC HUB, PROVIDING HUNDREDS OF THOUSANDS OF JOBS, DRAWING BILLIONS IN INVESTMENTS, AND GENERATING SIGNIFICANT GOVERNMENT REVENUE.

The upcoming year has the potential to be monumental for offshore energy, provided our policymakers seize the opportunity.

After years of anticipation, the first wave of offshore wind projects is on the brink of realization. The Vineyard Wind 1 project is set to commence power generation off Martha's Vineyard by the end of 2023. Soon after, South Fork wind will begin producing electricity off the coast of New York.

Construction is slated to start on several other noteworthy projects, including projects offshore Maryland, Rhode Island, and Virginia. All these ventures are expected to make significant progress in the coming year.

DEVELOPMENT OPPORTUNITIES

With over 2.8 terawatts of untapped offshore wind energy potential in waters too deep for traditional fixed foundations, floating wind technology is essential to unlock this massive resource. The US awarded five leases in the deep waters offshore California, opening the door to floating wind leadership.

Offshore carbon capture and storage (CCS) is closer than ever. The Department of the Interior was tasked with developing the first offshore CCS regulations. While the release of the rules has been delayed, there is optimism they will provide a strong regulatory foundation for rapid CCS growth in the US offshore.

The US is well-positioned for global leadership in both offshore wind and CCS thanks to the skill and expertise of its offshore oil and gas industry. Operating in the marine environment presents unique challenges. The world-class companies that have cultivated the Gulf of Mexico into a premier, lower-carbon energy region can leverage their experience to drive emerging energy segments.

POLITICAL LANDSCAPE

However, substantial political challenges persist. The new federal offshore oil and gas leasing plan offers the fewest lease opportunities in the history of the program. It schedules only three offshore oil and gas lease sales in the Gulf of Mexico, to be held in 2025, 2027, and 2029.

The Gulf of Mexico is a critical economic hub, providing hundreds of thousands of jobs, drawing billions in investments, and generating significant government revenue. It's a notable source of low-carbon oil on a global scale. Increasing domestic offshore oil production is vital for national security, bolstering global stability, and reducing the risk of oil supply weaponization by nations like Russia and Iran.

From 2022 to 2023, nine new offshore oil and gas projects started, with some expected to produce over 100,000 barrels per day. However, they won't fully offset declining Gulf of Mexico production through the decade. Washington's policies are crucial for Gulf oil production. As global energy demand rises, the Gulf can remain an environmentally advantageous resource.

The Inflation Reduction Act sets offshore oil and gas lease sales as a condition of the issuance of offshore wind leases. With the two tied together, the Biden Administration should follow the smart path of lease sales throughout each calendar year for both offshore oil and gas and wind.

The advantages of the Gulf of Mexico extend beyond party lines and regional boundaries, its imperative policymakers chart a course correction to ensure that our offshore energy resources remain a source of strength for our nation.

www.noia.org

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OCEAN ROBOTICS

Autonomous systems to deliver next-level safety and efficiency

ROB HOWARD
Chief Growth Officer
Greensea IQ
Intelligent Ocean Solutions

The future of ocean robotics necessitates a fundamental transformation. In the pursuit of expanding human exploration and operation in the Earth's oceans, it is imperative to not merely incorporate automation and robotics but to introduce autonomous systems that fundamentally alter our established operational paradigms. The current practice of deploying human crews to operate remotely operated vehicles (ROVs) aboard ships is fiscally unsustainable due to its exorbitant cost, extreme risk, and limited scalability.

Greensea IQ has embarked on an initiative to reshape the way we interact with ocean robotics. Taking advantage of 17 years of development, our comprehensive open architecture operating system, OPENSEA®, is ready to deliver advanced autonomy and over-the-horizon supervision technologies to platforms facing big challenges.

These efforts have been met with success: we have effectively deployed OPENSEA-enabled products in various industry segments, including maritime and EOD (Explosive Ordnance Disposal), creating immediate impact through the application of OPENSEA in these markets.

DEFENSE MARKETS

Greensea IQ's mission has always been to make our world safer, especially when it comes to MCM and EOD. For years, our EOD Workspace has been the preferred ROV operating system for EOD units around the world; it has enhanced the way we send out advanced robots and autonomous systems to survey areas for mines, but clearance divers have still been required to dive into the water to retrieve them. However, thanks to our OPENSEA Edge computing system, we are taking our EOD Workspace, along with our command-and-control solution, Safe C2, directly onto the platform.

We're on the cusp of a breakthrough. Very soon, untethered robots will be able to search, identify, and safely manage explosive ordnance, all while being supervised by a technician who is completely out of harm's way. This exciting development promises to bring safer and more efficient solutions to action in the field.

Greensea IQ is also delivering new robotic solutions for littoral MCM, EOD, and ISR through the power of OPENSEA with the new Bayonet autonomous underwater ground vehicle (AUGV). By providing the ability to move unmanned systems into the surf, we are able to close the intelligence gap in the surf zone with real-time actionable data and give operators a new level of situational awareness near shore.

RENEWABLE ENERGY

As we continue to increase our attention to harnessing safe and sustainable energy from the ocean, we realize that we need a fresh approach to maintenance, construction, and servicing. The traditional methods we have relied on for offshore oil and gas no longer fit the bill for renewable energy

sources. The costs just don't add up. For instance, sending offshore supply vessels to wind farms ranging from tens to hundreds of thousands of dollars per day simply isn't feasible for effectively servicing these installations.

Our oceans, beaches, and coastal regions are unfortunately marred by remnants of past conflicts, the aftermath of battles, and wartime preparations. The removal of unexploded ordnance is a daunting challenge in the development of these resources offshore. However, the solution lies in autonomy, which we currently provide in the versatile Bayonet AUGV platforms (pictured left, the Bayonet 250); they are capable of autonomous cable lane survey and pre-construction UXO clearance for Offshore Wind developers.

By minimizing the human component and employing autonomous vessels and resident subsea vehicles, we can truly unlock the potential of offshore renewable energy. Greensea IQ is at the forefront of this transformation.

COLLECTING DATA

The scientific community has embraced OPENSEA, Greensea IQ's open architecture platform. For years, we have collaborated with prestigious organizations like the Schmidt Ocean Institute and Monterey Bay Aquarium Research Institute (MBARI), providing software and technology expertise to various scientific institutions and deep-sea research vehicles worldwide.

In the near future, our aim is to expand OPENSEA's accessibility to the entire scientific community by establishing an open platform that science groups worldwide can utilize to enhance their efficiency and economy of scale. This initiative will enable them to share technologies and leverage our autonomy and communications innovations developed for the defense industry, thus facilitating a deeper understanding of oceanic climate change and its impact.

> BY MINIMIZING THE HUMAN COMPONENT AND EMPLOYING AUTONOMOUS VESSELS AND RESIDENT SUBSEA VEHICLES, WE CAN TRULY UNLOCK THE POTENTIAL OF OFFSHORE RENEWABLE ENERGY.

Climate change is hitting our coastlines and surf zone areas the hardest. To handle rising sea levels, changing wave patterns, increasing erosion, and stronger storms, we must gain a deeper grasp of these nearshore environments. Greensea IQ offers a practical solution: our Bayonet AUGV can work autonomously in surf zones, coastal areas, and even amphibious regions, creating exciting possibilities for ocean research and discovery and providing us the tools required to understand the effects of climate change on our shorelines.

MARITIME INDUSTRY

Global shipping, which includes cargo ships, container vessels, and other maritime transport, contributes to a significant portion of carbon emissions. Reducing the carbon emissions from worldwide shipping is essential to mitigating the impact of climate change and achieving the global sustainability goal of net-zero shipping by 2050.

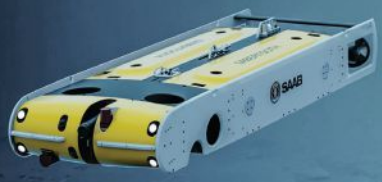
Greensea IQ introduced EverClean™ to literally clean up shipping by providing a economical, safe, and repeatable solution to hull fouling and the performance and fuel penalties it causes. EverClean commercializes a technology that leverages our proprietary navigation technology. This technology empowers robots to navigate and traverse a ship's hull accurately and efficiently while collecting data for EverClean IQ, the hull monitoring portal that allows EverClean customers to monitor change detection, coating condition, and more.

Greensea IQ's EverClean concept is nothing short of transformative; it provides immediate ROI through proactive cleaning and redefines the landscape of ship husbandry by maintaining an EverClean, or always clean, hull.

The future of ocean robotics holds immense promise and potential. Innovative developments and advancements in the field are poised to reshape the way we interact with the world's oceans. From the transformative capabilities of Greensea IQ's EverClean solution, which is revolutionizing hull maintenance, to the broader trends in autonomous underwater vehicles and their applications in marine research, offshore energy, and environmental conservation, the path forward is both exciting and challenging.

www.greenseaiq.com

» *EverClean robot shown during cleaning. (Image credit: Greensea IQ)*



CRITICAL UNDERSEA INFRASTRUCTURE

The crucial role of collaboration in safeguarding the seas

CHRIS LADE
Head of Sales and Marketing (Naval)
SAAB

The realm of Critical Undersea Infrastructure (CUI) unfolds as a complex network, spanning pipelines, communication cables, and power channels beneath the ocean. By bridging the physical gap between countries, this infrastructure is crucial to the growth and prosperity of nations all over the world, even more so for the socioeconomic progress of developing nations.

The importance of CUI has now put a target on its back. This has been made abundantly clear over the last year, with the Nord Stream pipeline damage in late 2022, and further damage to a gas pipeline and a telecom cable connecting Estonia to Finland and Sweden in October 2023. The prioritization of protection strategies sees government and defense agencies, asking themselves how they deal with this new threat as it arises, who owns the problem, what is its nature and how can it be prevented. Yet, it is the commercial industry that has the technological advancements required for effective safeguarding, already in play.

SECURING CUI

If we examine one particular subset of CUI, undersea communication cables offer a suite of key advantages crucial to the modern interconnected world. In fact, The UK's Ministry of Defence suggests 99% of global internet traffic goes through these undersea cables. Their high-speed transmission, ensures not only rapid but consistently reliable connectivity, facilitating seamless data transfer. By bridging continents, these cables foster global interconnectivity, facilitating real-time communication and colossal collaboration, vital for international trade, research partnerships, and cultural exchange. There are more than 500 active and planned cables laid around the world, and over 1.4 million kilometers in overall length.

> THE FUSION OF COMMERCIAL INNOVATION WITH DEFENSE STRATEGIES ENHANCES ADAPTABILITY AND AGILITY, ENABLING FASTER RESPONSE TIMES AND THE IMPLEMENTATION OF PROACTIVE MEASURES AGAINST EMERGING THREATS.

A vulnerability to the cables comes in the form of how deep they are laid. Some can go as deep as 8,000 meters, the deepest point in the Japan Trench—a depth that is almost equivalent to the height of Mount Everest. This makes monitoring and defending these cables a challenge, not only because of their depth, but their length—with some spanning multiple jurisdictions. We must solve how to protect these vital data routes, but also answer who protects them—the government of the country, the CUI owner, the respective defense agency?

The problem comes when we consider the importance these cables have on society, and the potential outcome if one of them was to be interfered with, as seen with the Nord-stream pipeline damage. Whilst the world debates who is responsible for the safeguarding of CUI, these vast webs of infrastructure go often unguarded. Seeing recent leaps in technological advancements, diving down into subsea terrain to damage and disrupt these cables is not only achievable, but has already been realized. It has opened the world up to a new strategic battleground: CUI warfare. Defense agencies are racing to equip their fleets with the same technology; one example is the UK welcoming RFA *Proteus* to its fleet, a ship designed to function as the base for remotely operated vehicles (ROVs) dedicated to underwater surveillance.

There is a clear opportunity here for defense agencies to tap into the commercial industry expertise that has been driving the recent technological advancements that the defense systems are founded on.

THE COMMERCIAL INDUSTRY'S ROLE

The commercial industry has spearheaded remarkable technological strides aimed at maintaining and safeguarding CUI. Advanced surveying techniques, like multibeam sonar systems and LiDAR, enable precise mapping and monitoring of the seafloor, ensuring accurate identification of potential hazards. Underwater robotics, including autonomous underwater vehicles (AUVs) and ROVs, play a pivotal role in inspection, maintenance, and repair tasks, allowing for the efficient, real-time assessment of underwater structures.

These innovations not only enhance the efficiency of infrastructure protection but also minimize risks to human divers, significantly advancing the reliability and resilience of critical undersea assets in the commercial sector. These advancements have inspired the defense sector, showing that the key of ensuring effective protection will be in international collaboration and forward-thinking initiatives between the two industries.

COMBATING THREATS TOGETHER

A collaborative approach between the commercial and defense industries stands as an imperative pillar in safeguarding CUI, offering multifaceted advantages crucial to fortifying this vital network.

» *A Seaeye Falcon taking part in REPMUS, an operational exercise in September 2023. (Image credit: Saab UK)*

Firstly, the commercial sector's technological prowess, rooted in innovation and agile development, synergizes with the defense industry's strategic acumen and security expertise, fostering a holistic defense framework. This collaboration harnesses advanced tools and solutions from the commercial realm, such as cutting-edge surveying methods, and underwater robotics, fortifying defense strategies with state-of-the-art capabilities to monitor, respond, and protect CUI.

NATO has already showcased its focus on collaborative approaches to solving CUI safeguarding tactics, through the NATO Maritime Unmanned Systems Initiative (MUSI), launched in October 2018. The initiative aims to promote interoperability in the development of Maritime Unmanned Systems. It has inspired the annual 'Operational Experimentation Exercises' REPMUS and DYNAMIC MESSENGER, with Saab's underwater systems, AUV62-AT anti-submarine warfare training target and Seaeye Falcon underwater electric robot, supporting elements of the most recent exercises in September 2023. The exercises involved over 2,000 civilian and military personnel from 15 NATO nations, Ireland and Sweden.

The fusion of commercial innovation with defense strategies enhances adaptability and agility, enabling faster response times and the implementation of proactive measures against emerging threats. Beyond technological synergies, the collaborative approach fosters knowledge exchange, offering a fertile ground for cross-sectoral expertise sharing, thereby enhancing understanding, preparation, and resilience against evolving risks to undersea infrastructure. Ultimately, this alliance not only bolsters the immediate defense of CUI but also cultivates a continuous cycle of innovation and readiness, essential for the ever-evolving challenges posed to critical undersea networks.

In a world in which CUI warfare's strategic importance grows, governments, defense agencies, and those that have an invested interested in CUI need to start advocating for proactive international collaboration and commercial initiatives in navigating the evolving CUI landscape.

www.saab.com

» *Underwater robots, like Saab's eWROV, are pivotal in IMR work. (Image credit: Saab UK)*

HABITAT MONITORING

Advanced underwater optical imaging to transform subsea modeling and streamline complex data analysis

CHRIS GILSON
CEO
VOYIS

> THESE HIGH-RESOLUTION AND COLOR-CORRECTED DIGITAL TWINS ENABLE PRECISE CHANGE DETECTION BETWEEN PERIODIC SURVEYS, AND THE ABILITY TO METICULOUSLY INSPECT THE FLORA AND FAUNA.

Beneath our oceans' surfaces lies a complex tapestry of marine habitats which are increasingly impacted by human exploitation and climate change. Many countries have ambitious targets for the management of marine protected environments (MPAs), but effectiveness has been limited by conventional monitoring methods.

Historical observations have been conducted by divers navigating predefined transects to collect downward video recordings for manual review. The future of marine habitat monitoring will be driven by advancements in underwater optical imaging with data that is automatically analyzed and correlated with biological sensing data.

UNDERWATER OPTICAL SENSORS

Optical sensors can be deployed on autonomous underwater vehicles (AUVs) which excel in wide-area transect-based surveys and complemented with remotely operated vehicles (ROVs) for localized inspection in regions of limited water clarity. This combined approach can adapt to regional ocean conditions and scale to cover wider areas than conventional methods.

Two revolutionary technologies will make the concept of remote MPA monitoring a reality. First, the ability to rapidly generate accurate 3D models of localized habitats using calibrated cameras and powerful lighting systems. These high-resolution and color-corrected digital twins enable precise change detection between periodic surveys, and the ability to meticulously inspect the flora and fauna. These captivating reconstructions empower conservation efforts by better illuminating the fascinating ecosystems we need to protect.

The second transformation is using unsupervised machine learning for the automated statistical analysis of image datasets. Each MPA is unique, as are the scientific questions, a variability not well suited to conventional machine learning approaches that thrive on consistency. A powerful new approach, developed by Voyis in partnership with the University of Southampton, efficiently clusters and indexes immense image datasets to streamline data interpretation and dissemination, supporting automated tasks such as measuring species abundance and live versus dead coral ratios.

THE IMAGE PROJECT

The IMAGE project (Image Mapping and Analysis for Governance and Education), funded by the Canadian Department of Fisheries and Oceans (DFO), showcased the commitment of Voyis and Shift Environmental to advancing ocean science. A novel monitoring methodology was demonstrated using a small ROV with optical sensors to map, model, and analyze the Glass Sponge Reef MPAs in Howe Sound, Canada. Voyis deployed a downward 3D laser and color camera to capture transect data for machine learning analysis, as well as the Discovery Camera for vehicle piloting and 3D modeling. In the future, biological sensors will be added to correlate ocean health measurements with features in the images.

APPLICATIONS BEYOND REEFS

Automated data clustering can be used in Mine Countermeasures (MCM) operations to search for artificial objects in large datasets to swiftly localize possible threats. For offshore infrastructure, thousands of pipeline images can be automatically indexed to separate anomalies for closer inspection, and in offshore wind site surveys, images with debris can be rapidly isolated from typical seabed images, increasing data review efficiency.

The adoption of underwater optical sensors with advancements in machine vision and machine learning will revolutionize the future of ocean habitat monitoring, helping steer us toward a more informed and sustainable ocean sector.

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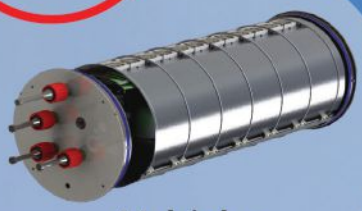

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OUR BLUE PLANET

Canada is leading the way in bringing scalable ocean technology to market

KENDRA MACDONALD
CEO
CANADA'S OCEAN SUPERCLUSTER

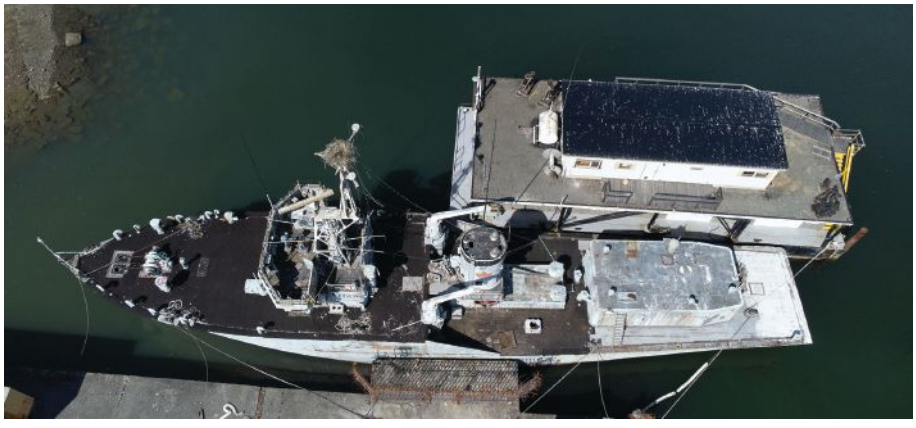
Ocean technology has important applications for ocean sectors, whether traditional or emerging, as we seek to move faster, with greater safety and sustainability, better understanding our ocean and how climate change is impacting it, and the ability to efficiently leverage the power of data in making the best decisions.

This is where ocean tech companies—from nimble startups to larger, more mature firms—are delivering important solutions to the market and unlocking significant growth in the blue economy. It's not just the rise of the blue economy, however, that is driving demand and opportunity in ocean technology. It's the future of our planet.

On the path to energy transition, more mouths to feed worldwide, more goods to move, and making the changes necessary to meet our global commitments to net zero, none of this can be achieved without the ocean—and ocean technology as an enabler. The United Nation's Sustainable Development Goal 14 focuses on the sustainable use of oceans, sea and marine resources for sustainable development, as a part of a broader global agenda to help address global challenges.

An updated report by the High Level Panel for a Sustainable Ocean Economy shows that up to 35 to 50 percent of emissions reductions required by 2050, on the journey to 1.5°C, can be achieved through the ocean. And in doing so, there is significant economic opportunity, increased attention on purpose driven ocean innovation, and the need for more investment in the ideas, the projects and the companies that can deliver on the potential of our ocean.

» The Coastal Incident Management System Project provides coastal stakeholders with a cost-effective rapid response package. (Image credit: Canada's OSC)



REACHING GLOBAL MARKETS

In the race against time in emissions reduction, Canadian ocean technology is enabling solutions that reduce emissions today, and on the path to more carbon-neutral solutions in the future. These solutions generate new revenues, scale more companies, and increase competitiveness for Canada as a leader in ocean enterprise. For example, Graphene Innovation Technology, along with its project partners, just four years ago launched its Smart Protective Coatings Project through Canada's Ocean Supercluster (OSC), and today has not only demonstrated significant emissions reductions for vessel operators with the application of their hull coatings, but has built a customer base in 50 different countries.

SMART SEAFOOD

With a growing global demand for protein combined with the expectation for sustainability and transparency from consumers, the seafood industry is adopting advanced technologies including artificial intelligence (AI) to inform decision-making, smarter fishing technologies, and remote operation capabilities. This includes the wild and farmed seafood that we tradition-

ally associate with our ocean but also seaweed and other emerging seafood alternatives. Announced in Montreal in September, Kitchener, Ontario's Coastal Carbon ocean monitoring company and seaweed farming company, Holdfast of St. John's, Newfoundland, have partnered up to develop a project as a part of Canada's Ocean Supercluster's new AI Ocean program that will deliver a small, non-intrusive, AI-enabled sensor for online remote biomass monitoring of seaweed growth for operators, and of particular benefit to rural and Indigenous communities.

EMPOWERING COMMUNITIES

In building innovative ocean solutions that contribute to the health of our planet, Indigenous communities not only bring a close cultural connection to the ocean but also bring valuable knowledge, experience, and insight. That is particularly critical to coastal resiliency, where it is a win-win when Indigenous partners are active participants in developing and delivering solutions that empower communities.

A great example is Canada's Ocean Supercluster's Coastal Incident Management System (CIMS) Project. Led by Shift Environmental, the British Columbia-led project provides coastal, Indigenous, and remote communities a cost-effective rapid response package, including a mobile command, control and communications system, data analysis tool and mobile incident platform for marine emergencies.

Through CIMS, Indigenous knowledge is combined with communications software and hardware; novel response equipment, procedures and training; and uncrewed surface vessels and aerial vehicle designs for spill detection, immediate response, and persistent monitoring.

BUILDING PARTNERSHIPS

The more emerging ocean tech companies we help get started, and the more we bring together startups with mature companies to develop commercial solutions, the more economic value and growth will be generated. On Deck Fisheries out of Vancouver, British Columbia is just one example of an early stage SME that participated in the OSC's Ocean Startup Project programming, and now leading a project. They won the Ocean Idea Challenge for early stage startups just 18 months ago, and now more established, the SME has undergone rapid growth and leads Canada's Ocean Supercluster's recently announced AI for Scaleable Fisheries Monitoring Project.

With strong innovation ecosystems across the country, Canada continues to focus on becoming the best place to start and grow an ocean company, and a partner of choice in global partnerships and collaborative opportunities.

> WITH STRONG INNOVATION ECOSYSTEMS ACROSS THE COUNTRY, CANADA CONTINUES TO FOCUS ON BECOMING THE BEST PLACE TO START AND GROW AN OCEAN COMPANY.

Canadian ocean technology is playing a leading role in addressing some of the biggest challenges of our generation, where SMEs are starting, scaling and competing for global contracts (and winning) in a way we have never seen before. This is the future of ocean technology working at break-neck speed for the future of our planet. And that future is now.

www.oceansupercluster.ca

» *The Smart Protective Coatings Project promotes emission-reducing hull coatings. (Image credit: Graphene Innovation Technology)*

MINI UNDERWATER DRONES

The rise of micro-AUVs for remote seabed inspection missions

XAVIER ORR
CEO

ADVANCED NAVIGATION

Advanced Navigation, a world leader in AI robotics and navigation technologies, recently collaborated with the Australian Institute of Marine Science (AIMS) to conduct a simulation at the institute's tropical marine test range, known as ReefWorks, located near Townsville, a city on the north eastern coast of Australia within proximity to the Great Barrier Reef. The test range, which opened its doors to industry in 2022, is one of the first marine technology test ranges in the world located in tropical waters.

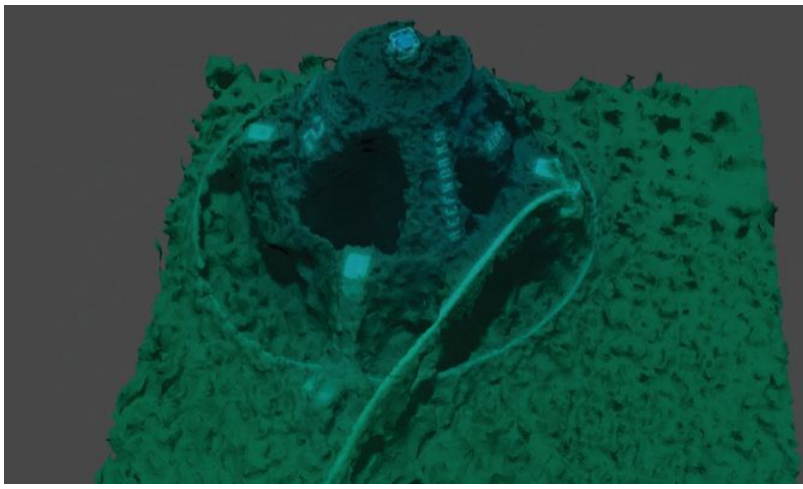
For the exercise, Advanced Navigation's underwater drone, or micro-autonomous underwater vehicle (micro-AUV), Hydrus, was tasked with autonomously mapping a predefined area of the seabed in search of specific points of interest—which, in this scenario, were hidden objects intended to represent underwater mines.

NAVIGATING TROUBLED WATERS

Numerous challenges accompany a scenario of this nature. To begin, exercises of this kind typically entail significant costs and logistical complexities. Enlisting boats and highly trained specialists is not only expensive but also time-consuming. Moreover, deploying and recovering traditional AUVs necessitates the use of large equipment, such as cranes, which consumes valuable time that could otherwise be devoted to data collection.

Secondly, the operation required Hydrus to function in tropical waters, which are notoriously difficult for autonomous marine systems. Foremost, higher temperatures in tropical waters have the potential to cause robotic systems to overheat. Additionally, complex water flow and bottom topography in these regions can result in higher turbidity, causing water to become clouded with suspended sediment, reducing visibil-

» *Deploying Hydrus in tropical waters. (Image credit: Advanced Navigation)*



» *3D reconstruction from data captured by Hydrus, showing the mine-like object. (Image credits: Advanced Navigation)*

ity and potentially causing thrusters to clog and seize operation.

Lastly, the simulation centered around a scenario where ensuring the safety of personnel was paramount. It focused on a situation in which a customer would deploy a drone to detect potential hazards, such as underwater mines, before advancing their vessel. Furthermore, the exercise introduced an element of unpredictability, as Hydrus had no prior knowledge of the placement of mine-like objects. This mirrored a real-world search in a hazardous and unfamiliar environment.

PURPOSE-BUILT PACKAGE

Fortunately, Hydrus was purpose-built to address these very concerns. Thanks to its compact size and autonomous capabilities, the mission could be executed with cost-efficiency and minimal logistical complexities.

To illustrate this, all the necessary equipment for this exercise could be conveniently transported in just three transit cases, each weighing less than 21 kg. Hydrus itself, weighing a mere 7 kg, can be deployed and recovered by a single individual. This obviates the need for heavy transportation, on-site storage, large vessels, cranes, or a team of specialists.

What truly distinguishes Hydrus is its ability to operate effectively within the challenging tropical waters environment, setting it apart from comparable products in the market. Being developed in Australia provided a local advantage, as Hydrus underwent extensive testing in warm tropical waters during its design phase. Additionally, its thrusters were thoughtfully designed with the challenges of suspended sediment in mind. The drone's impellers offer a higher level of control authority than any comparable product on the market, rendering them resilient to suspended sediment and complex water flow.

USV COMPATIBILITY

Regarding safety, this simulation presented an opportunity for the Advanced Navigation team to showcase a unique solution aimed at minimising risk to personnel. Typically, USBL and GNSS systems are affixed to crewed boats. However, in this exercise, Advanced Navigation's Subsonus and GNSS Compass were integrated onto Surfbee, an autonomous uncrewed surface vessel (USV). Leveraging the autonomous capabilities of Surfbee, this setup allowed the crew to maintain a safer distance from the scouting area (see top image on p. 30).

> WHAT TRULY DISTINGUISHES HYDRUS IS ITS ABILITY TO OPERATE EFFECTIVELY WITHIN THE CHALLENGING TROPICAL WATERS ENVIRONMENT, SETTING IT APART FROM COMPARABLE PRODUCTS IN THE MARKET.

The end-to-end operation, from deploying to recovering Hydrus, took less than 30 minutes. Hydrus performed flawlessly right out of the box, requiring minimal mobilisation time and experiencing no delays. Coupled with the use of a small vessel, this efficiency allowed the team to swiftly gather the necessary data to complete the mission. In fact, due to the rapid turnaround time, the team ran the simulation two more times with each operation completed in under 30 minutes.

Notably, by repeating the simulation, the team observed that the mine-like objects had shifted positions on the seabed between each operation. This not only highlights the complex currents in tropical waters but also underscores the potential safety risks had the operation been conducted only once, as typically expected with traditional systems.

To locate the objects, Hydrus autonomously followed a predefined search pattern within a set perimeter in the water, in a path akin to mowing a lawn. While executing the search pattern, Hydrus' camera successfully identified points of interest and captured high-accuracy imagery of the target objects.

As is customary with all simulations involving Hydrus, the data collected during this exercise will be used to train Hydrus' AI model, enhancing its capability to pinpoint and inspect points of interest on the seabed with even greater precision and detail. Conducting more simulations will continue to enrich Hydrus' onboard AI, improving its overall capabilities.

The successful completion of this simulation at ReefWorks validates Hydrus' ability to provide a data collection solution that not only minimises logistical effort but also allows for rapid deployment compared to other systems. Moreover, it does not require trained specialists, keeping the overall costs minimal. This enables users to deploy Hydrus quickly, safely and cost-effectively wherever it is needed.

www.advancednavigation.com

OCEAN MONITORING

Advances in autonomous vehicle capabilities signal a new era of smart ocean survey

LAYTON QUINTON
Head of Marine Information Products and Services

National Oceanography Centre

> CARBON CAPTURE AND STORAGE (CCS) IS ONE OF THE FIRST OBVIOUS SECTORS THAT COULD BENEFIT FROM A NOC COMMERCIAL ALR SERVICE.

Autonomous vehicles with high endurance and advanced sensor capabilities are becoming game changers in monitoring and understanding the ocean.

Here at the National Oceanography Centre (NOC) we have developed a leading position in new autonomous technology to increase scientific understanding of the ocean. We operate Europe's largest fleet of underwater gliders, but in addition to enhancing existing glider technology, we have developed our own autonomous underwater vehicles to provide the capabilities required by our science to operate in some of the deepest and most remote parts of the ocean.

This technology provides new commercial possibilities for work traditionally completed by crewed vessels. The NOC's commercial team, who operate under the 'NOC Innovations' banner, are taking NOC's Autosub Long Range Vehicle (ALR), known affectionately as *Boaty McBoatface*, to offer its capabilities in new commercial applications.

LONG ENDURANCE SURVEY

ALR is an electrically powered underwater vehicle which operates at depths of up to 1,500 m or 6,000 m (dependent on variant) and can carry a sensor package including ground and side scan sonar, camera system and a package of chemical sensors in addition to its own navigation equipment. Mission duration is ultimately dependent on the power requirements of the sensor package; however, 2 to 3 weeks is typical. ALR operates at a fairly low speed of around 0.5 m/s, but can often be shore launched and recovered without the need of a vessel, which usually means it can provide both a more cost effective and environmentally friendly solution than the traditional alternative of a crewed vessel with remotely operated underwater or survey equipment.

Carbon Capture and Storage (CCS) is one of the first obvious sectors that could benefit from a NOC commercial ALR service. CCS has become an extremely important tool in helping businesses decarbonize their operations. Carbon Dioxide (CO2) is captured and liquified for storage in disused oil and gas fields which are being repurposed world-wide. This activity is governed by legislation requiring the provision of effective monitoring of the fields to ensure that if any leakage of CO2 occurs, operators are informed and can take necessary action.

CO2 MONITORING

Over the last decade NOC has taken part in several ground-breaking scientific trials combining seabed landers and ALRs with NOC's unique lab on chip, as well as commercially available, sensors with sonar technology to understand the best way to monitor CO2 escaping from the seabed. This has enabled the design of a service to provide regular CO2 monitoring of fields using ALRs to patrol the entire area and landers to monitor areas of specific interest, such as well heads, continuously. Our sensor package differentiates between organic and inorganic sources of CO2 and automatically checks in daily to update a customizable dashboard with alerts designed to the end-user's requirements.

As well as CCS, ALRs are being used by NOC to monitor marine protected areas, offer potential for patrolling oil and gas fields during decommissioning, and provide an alternative to conventional surveys.

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ENGINEERED INFLATABLES

The utility of subsea buoyancy continues to expand

RICHARD FRYBURG
President
SUBSALVE

The premise that underpins the science of buoyancy is quite simple; when a lighter medium is placed and contained in a heavier medium, an upward buoyant force is generated. This was first discovered and documented by, the Ancient Greek mathematician, physicist, engineer, astronomer, and inventor Archimedes in or around 250 BC.

The Archimedes' Principle states that a body wholly or partially submerged in a fluid (gas or liquid) is buoyed up by the weight of the fluid displaced. In this case, air, the lighter medium, when placed and contained in water, the heavier medium, generated an upward positive buoyant force of 63 lbs. per cubic foot of air. On a larger scale, when 1 cubic meter of air is placed and contained underwater, it generates an upward positive buoyant force of 1 metric ton!

The technology of buoyancy refers to how the buoyant forces created are harnessed and used. Early examples include using goatskin bags and canvas bags coated with tar to hold air and support the buoyant force created. Neither of these were very reliable, nor highly scalable. Later came steel drums and steel pontoons, which proved too difficult to transport and maneuver underwater due to their weight, and ultimately would rust and deteriorate.

MATERIAL INNOVATION

Today, advances in modern fabrication processes have made the production of high strength woven fabrics such as nylon, polyester, and Kevlar relatively widespread, all of which are surprisingly lightweight given their resistance and strength. Breakthroughs in manufacturing technology have also given us Polyurethane, which has high adhesion properties, is UV resistant, has high resistance to Petro-chemicals, and very abrasion resistant. When Polyurethane is used to coat other fabrics, like nylon, polyester or Kevlar, we end up with a material that is lightweight but surprisingly strong, capable of air retention and superior performance.

The technical development of these coated fabrics allows us to create a wide range of shapes and sizes, generating buoyant forces from 50 lbs. to 50 metric tons. Additional technological advancements in valves for inflation, deflating, pressure relief, and actuation along with specialty woven webbings, all contribute to today's highly advanced underwater engineered inflatables.

PROVEN APPLICATIONS

Real-world examples of how this advanced buoyancy technology is being applied across the ocean sectors vary but stem the commercial maritime, defense, and scientific industries.

In shipyards inflatable pontoons are used to reduce the draft of vessels and ships while launching are retrieving them. For example, as pictured, the use of 20–50-ton salvage pontoons can generate approximately 1,000 tons of upward buoyant force to significantly reduce the draft of a vessel to enable it to avoid any known obstacles or shallows.

Specially manufactured buoyancy aids are also used regularly to install critical seabed infrastructure, including seafloor pipelines as well as heavy submarine power cables carrying electricity from offshore wind farms.

» *Shipyards use inflatable pontoons to reduce vessel draft. (Image credit: Subsalve)*

> TODAY, ADVANCES IN MODERN FABRICATION PROCESSES HAVE MADE THE PRODUCTION OF HIGH STRENGTH WOVEN FABRICS SUCH AS NYLON, POLYESTER, AND KEVLAR RELATIVELY WIDESPREAD, ALL OF WHICH ARE SURPRISINGLY LIGHTWEIGHT GIVEN THEIR RESISTANCE AND STRENGTH.

Specialized buoyancy payloads are integrated into space capsules to ensure a speedy recovery following splashdown.

Salvage is a growing application for buoyancy engineered inflatables. Large salvage pontoons and parachute lift bags are regularly deployed to carefully raise and recover sunken yachts, ships, and even military submarines.

Buoyancy is widely used by military forces across the globe to raise, tow, and render safe, explosive ordnance that has been planted by enemy forces under ships, in harbors, and other strategic locations. Expert explosive ordinance disposal (EOD) is reliant on having the precise tools as well as the knowhow. EOD is accomplished by using a highly technical underwater ordnance disposal kit that includes a 1-ton cylindrical pontoon and a self-contained air supply that can be remotely actuated in water up to 100 meters from 1 mile away.

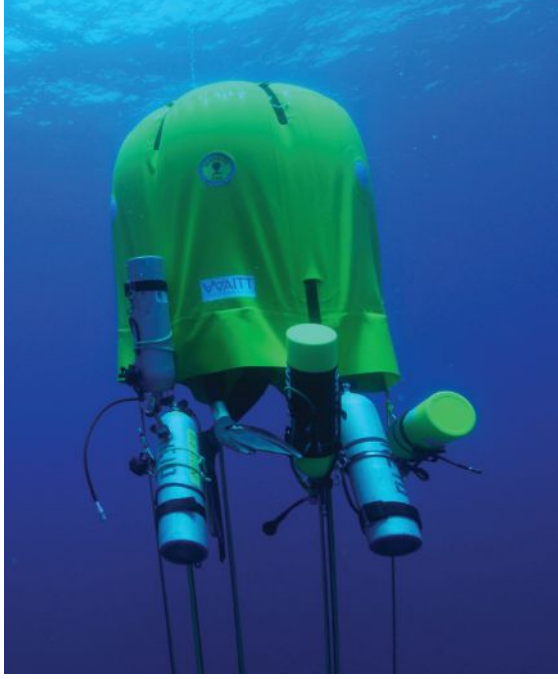
Custom buoyancy systems are also instrumental for certain manned subsea craft. For example, Producer Director James Cameron's *Deepsea Challenger* submarine was equipped with engineered inflatables for his solo dive to the bottom of the Mariana Trench as a redundant rescue system to bring the craft back to the surface should power be lost or the primary drop weight rescue system failed.

Some of the more innovative uses of buoyancy technology have inspired the development and manufacture of inflatable underwater habitats used by divers as a means of entering a dry environment to rest, decompress, or get medical treatment, while remaining underwater.

A BUOYANT FUTURE

The future technology of buoyancy which is being developed includes having live buoyancy control to raise, lower, and even hover objects underwater. Maybe at some point in the future there will be engineered inflatable underwater vehicles, underwater housing, or even underwater colonies.

While some of this may at first sound somewhat far-fetched, the truth is that we've only 'scratched the surface' in terms of developing and applying buoyancy technology in marine environments. Subsalve was formed in 1977 with a clear mission to rethink the use of buoyancy systems across the ocean industries and offshore



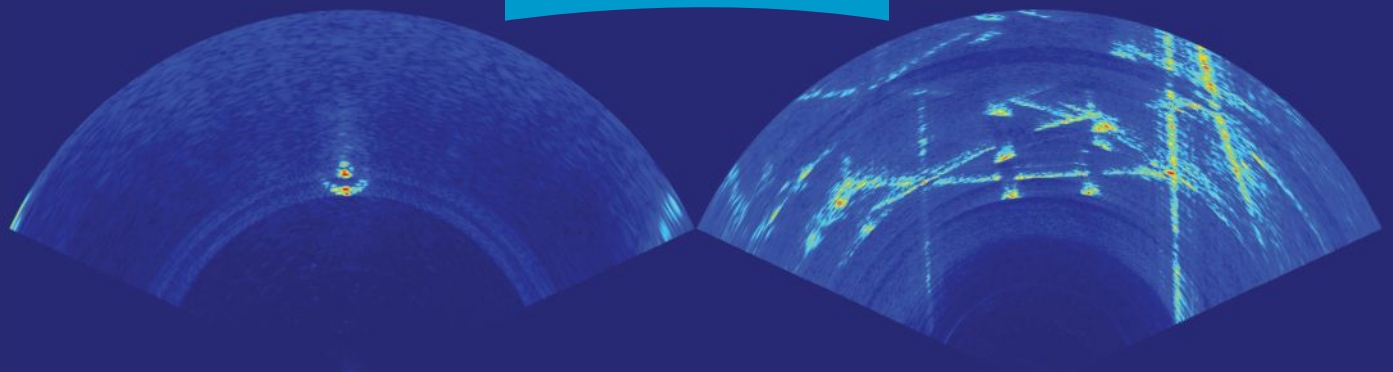
» *An inflatable underwater habitat. (Image credit: Subsalve)*

industries and today, after decades of innovation, we are the worldwide leader in this space. Our underwater lift bags are specified to meet the toughest challenges and conditions faced by recreational, commercial, scientific, and military operators.

Central to our success has been our ongoing investment into the introduction of high-strength synthetic fabrics—including nylon, polyester, and coated Kevlar—to deliver puncture-, abrasion-, and chemical-resistant lift bags and systems. We are the only major lift bag manufacturer that offers polyurethane-coated materials, which not only guarantees an extended service life (with less maintenance) over other lift bags, but also promises best-in-class performance and reliability.

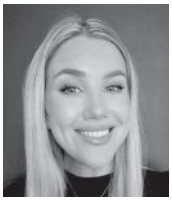
www.subsalve.com

» *Recovery of the Orion space capsule after splashdown. (Image credit: Subsalve)*



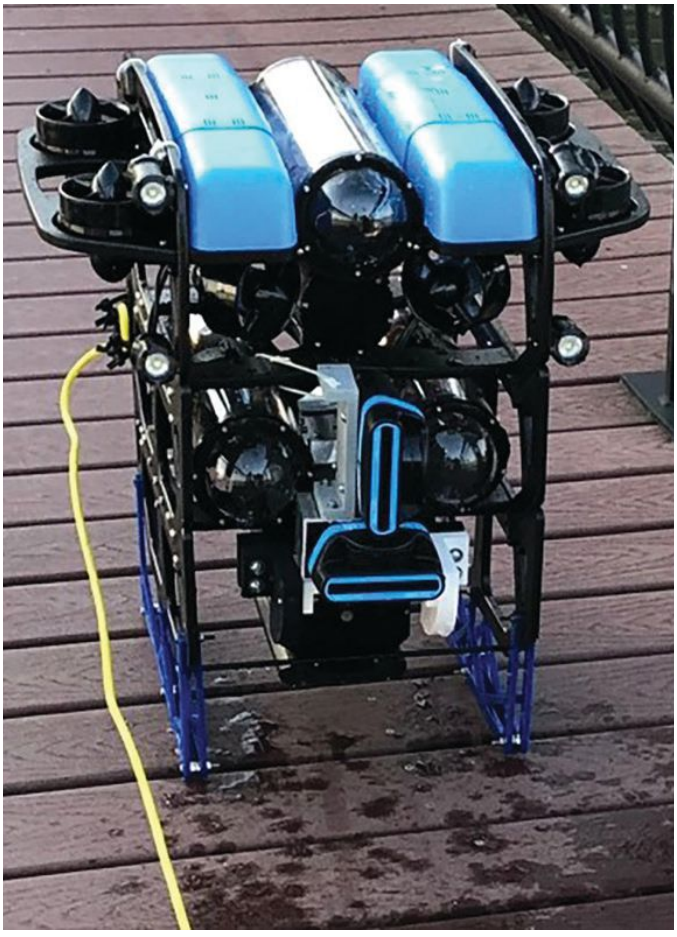
SUBSEA MAPPING

Pairing a multibeam sonar with advanced perceptual algorithms



RACHAEL READER
Sales & Marketing Assistant

blueprint subsea



» *A pair of Blueprint Subsea Oculus sonars integrated onto a Blue Robotics BlueROV2 platform. (Image credit: Blueprint Subsea)*

The subsea environment presents multiple challenges when it comes to the surveillance and maintenance of offshore assets. Among these, one prominent issue is poor visibility caused by choppy, turbid water. Consequently, the utilization of underwater vehicles for subsea inspection has seen a rapid increase in recent years, as they have been developed to carry out numerous functions and can operate effectively in extreme conditions.

This has introduced significant benefits in terms of efficiency and safety by mitigating the risks associated with deploying human divers into challenging subsea environments. However, underwater vehicles reliant solely on cameras for navigation and inspection frequently prove ineffective in providing adequate situational awareness to their operator, as they fail to capture imagery beyond a few inches in such dark, murky conditions.

SONAR TECHNOLOGY

Sonar technology offers a viable solution to this problem, with its ability to build a picture of underwater environments even when optical visibility is limited. There are three leading options for sonar imaging available on today's market, the first being side-scan sonar which is employed to detect features on the seabed. Side-scan proves to be a valuable tool for seafloor mapping, making it a popular choice for search and rescue operations and survey applications. Another option is profiling sonar, typically considered the most highly detailed but also the most expensive sonar solution. Profiling sonar employs a narrow beam to create high-definition imagery of the underwater environment.

While this technology can be used to generate excellent 3D reconstructions, it is extremely time-consuming as it takes multiple samples over a small section of the seafloor to build an image. Finally, multibeam imaging sonar uses a wide beam angle to cover a large

area, generating results in a fraction of the time a profiling system would and generally retailing at a much lower cost. Multibeam imaging sonars operate by analysing echoes in a 3D volume of water and compressing the data into a single plane to produce real-time 2D imagery.

EFFICIENT 3D RECONSTRUCTIONS

Professor Brendan Englot and Ph.D. student John McConnell of Stevens Institute of Technology have designed a unique way of improving underwater situational awareness by building 3D reconstructions with multibeam imaging sonar. Their approach involved mounting two Blueprint Subsea Oculus sonars orthogonally on a Blue Robotics BlueROV2 platform, creating a system that offers an efficient, cost-effective alternative to profiling sonar for generating 3D imagery.

One of the Oculus sonars was dedicated to collecting data on the horizontal plane to measure range and bearing, while the other focused on the vertical plane to assess elevation. The team then fused together the stereo pair of images to build a dense 3D point cloud, enabling them to successfully map a cluttered underwater environment. Professor Englot expressed that the Oculus' compact form factor was highly beneficial as it meant the pair of sonars could be successfully integrated onto the small inspection-class ROV.

PROVEN IN THE FIELD

The researchers initially used the Stevens Institute Davidson Laboratory high speed towing tank as a proving ground, submerging a custom-made object designed to resemble a blow-out preventer as a target for inspection. Each sonar collected data points from different planar slices and these observations were combined to form a real-time reconstruction of the object in the tank. Following these successful lab tests, the team proceeded to conduct experiments in the field, demonstrating the operational capabilities of their underwater robot in the complex and dynamic setting of a real-world subsea environment.

The ultimate goal was to develop an underwater vehicle with fully autonomous mapping capability and advanced situational awareness. This was achieved by combining the data obtained from the pair of Oculus sonars along with the perceptual algorithms developed by John McConnell during his Ph.D. studies at Stevens Institute. This breakthrough has the potential to revolutionise subsea industries such as offshore wind and fish farming. The development of an affordable, advanced autonomous underwater vehicle (AUV) with the capability to execute complex underwater inspection and maintenance tasks could significantly improve efficiency, safety, and cost-effectiveness across the ocean industries.

In conclusion, sonar technology, particularly multibeam imaging sonar, has emerged as a crucial solution for enhancing situational awareness and underwater imaging. The innovative work carried out by the scientists at Stevens Institute in utilizing multibeam imaging sonar in conjunction with advanced perceptual algorithms is a remarkable development. It has the potential to transform the way subsea inspections are conducted through offering a cost-effective, efficient, and safe approach for various industries operating in the underwater environment.

www.blueprintsubsea.com

THE DEVELOPMENT OF AN AFFORDABLE, ADVANCED AUTONOMOUS UNDERWATER VEHICLE (AUV) WITH THE CAPABILITY TO EXECUTE COMPLEX UNDERWATER INSPECTION AND MAINTENANCE TASKS COULD SIGNIFICANTLY IMPROVE EFFICIENCY, SAFETY, AND COST-EFFECTIVENESS ACROSS THE OCEAN INDUSTRIES.

» *Brendan Englot and John McConnell during a field test in New York. (Image credit: Blueprint Subsea)*

THE BLUE ECONOMY

Harnessing the power of our oceans with breakthrough technologies is key to supporting the world economy

NEIL GORDON
CEO
Global Underwater Hub

> FRESH THINKING AND NEW TECHNOLOGIES THAT EMANATE FROM ACADEMIA AND THE UNDERWATER SUPPLY CHAIN TODAY CAN BE USED TO ADDRESS FUTURE GLOBAL NEEDS.

For centuries, our oceans and seas have helped power the global economy. Central to this has been innovation and a pioneering spirit. From clippers shipping goods around the globe, to divers and submariners exploring deep below the waves and communicators installing inter-continental submarine cables, each evoked fresh thinking to achieve ambitions.

Today, that courage to push boundaries remains alive and well in our underwater industry. We have developed technologies and equipment that has enabled industry and academia to explore, conduct research, and work in the harsh and unforgiving environment of our seas and oceans. Yet, there is huge potential for growth in the blue economy, harnessing the oceans' resources in a sustainable, environmental manner.

MANAGING NET-ZERO AMBITIONS

By 2050, countries around the world have outlined ambitions to reach net-zero, at a time when the global population is estimated to reach nine billion. To fulfil the needs of a growing population in terms of energy, communications and food supply, whilst reducing global emissions and reaching net-zero, harnessing the promise of our oceans and new technologies is key.

Security and surety of supply, affordability, and decarbonization will remain at the forefront of the future energy industry. Floating offshore wind equipment and knowledge pioneered in Scottish waters will be applied in seas worldwide, offering an efficient means to capture the wind's power. Challenges remain around increasing the size and scale of turbines and siting them in deeper waters.

The energy generated by the ebb and flow of waves and tides can be utilized as a source of electrical power. Research continues into the most efficient methods, but the opportunity is clear.

The world's waterways are used by many sectors. Respecting those competing needs for seabed space in a sustainable and manageable way is critical. Maximizing how we use that space, potentially for different purposes, is central to responsible marine stewardship.

Should offshore wind farms accommodate wave and tidal arrays or house floating solar developments, for instance. While aquaculture trials co-located within offshore wind farms are underway to identify what conditions are suitable for kelp and mussel aquaculture to thrive.

ACTIONING COLLABORATIVE EFFORTS

Co-location of different underwater sectors in the same sea space needs greater discussion now to meet impending global pressures.

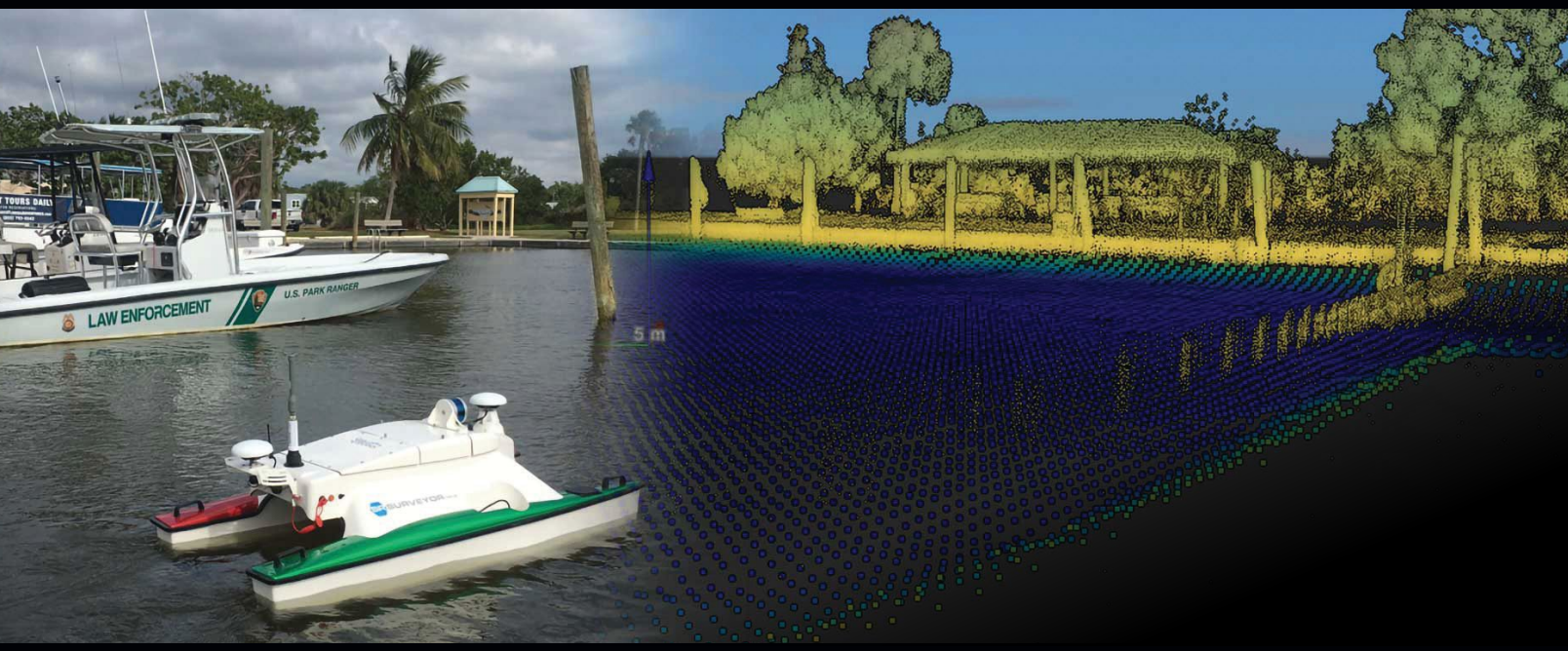
Thousands of kilometers of undersea cables for offshore wind and data communications, along with subsea oil and gas pipelines, are part of our critical global seabed infrastructure. Inspecting and protecting them from new threats is imperative.

Remotely operated vehicle (ROV) technologies developed in the defense sector and honed by the oil and gas industry, which improved safety and cost-efficiency, can be applied across the underwater sectors to undertake inspection, repair and maintenance operations. Developments in automated underwater vehicles (AUVs) and uncrewed surface vessels (USVs) offer additional inspection options, particularly when coupled with subsea battery storage systems.

Necessity is the mother of invention. The underwater industry has clearly evidenced this. Fresh thinking and new technologies that emanate from academia and the underwater supply chain today can be used to address future global needs.

The blue economy can help power and feed the world, and charting the right, sustainable course is key to delivering this.

www.globalunderwaterhub.com



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REMOTE OCEAN POWER

Scalable subsea Li-Ion batteries to fuel offshore energy expansion

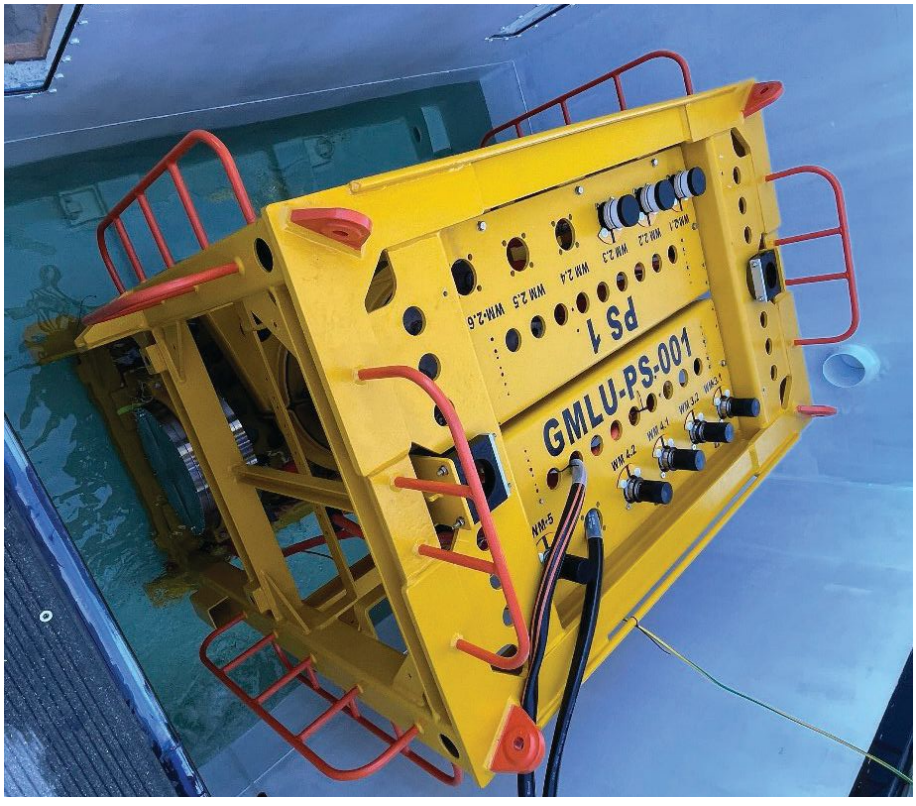
STEFAN MARX
CEO

In the realm of offshore exploration, these are unprecedented times. Never has there been such a pronounced need to systematically leverage ocean-based resources to sustainably meet global energy demands. For many who work in the ocean technology sector, this propels us to challenge operational conventions and, as appropriate, apply fresh thinking and practical solutions to solving the associated complexities of the so-called energy transition.

In recent years, breakthroughs in subsea technologies have triggered a new outlook for the offshore energy industry, essentially enabling us to prospect further offshore and into deeper waters. Charting these relatively unknown regions has spotlighted what's possible in a new era of safer, more efficient, and yes, less carbon-intensive exploration.

Ambition on this scale, however, walks hand in hand with the need to plan, build, and implement the most suitable offshore energy infrastructure and resources—hardware, software, and, of course, a skilled pool of labor. And while we, as a sector, have a fairly aligned sense of what is possible in the long-term by incorporating offshore renewables into the energy mix and steadily decarbonizing existing E&P practices, settling on short-term priorities based on immediate feasibility requires more than speculation—it calls for true innovation.

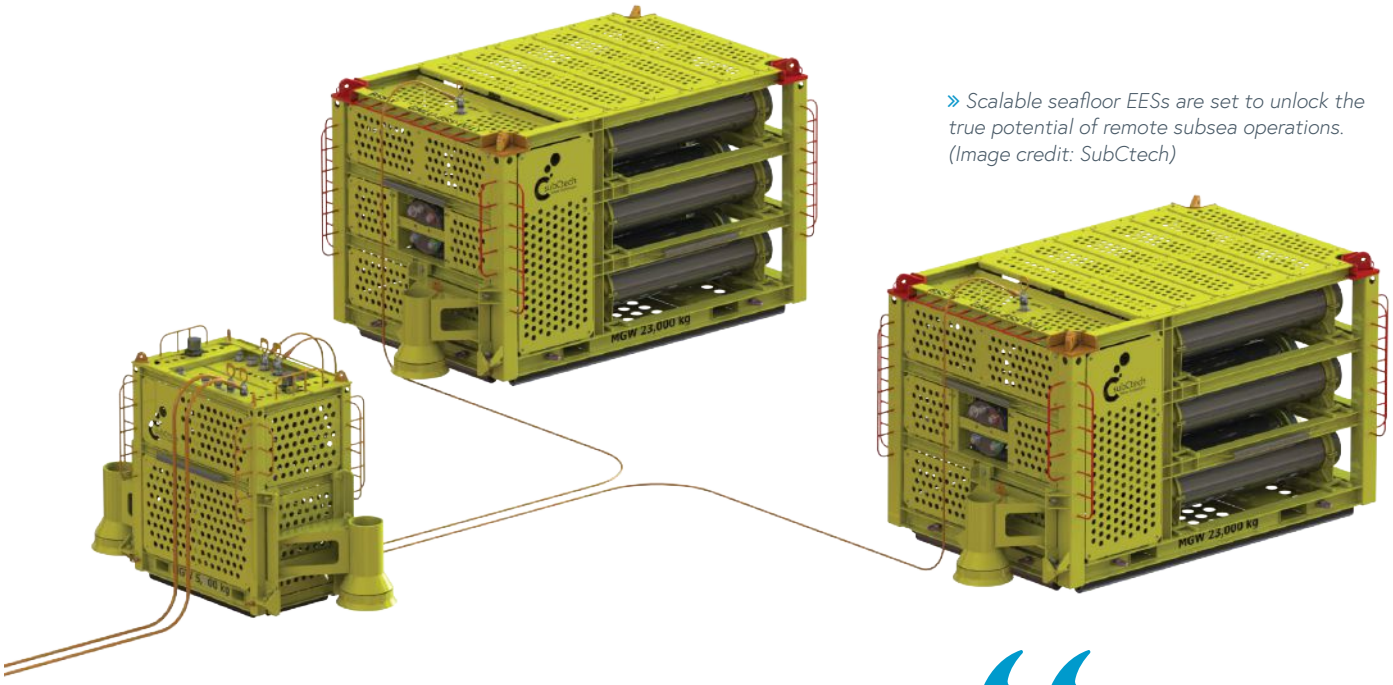
What we can say with no degree of uncertainty, though, is that progress will hinge on the buildout of two fundamental technical points: 1. Harnessing energy from deeper, more remote regions will rely on unprecedented investment in the next generation of offshore energy infrastructure—a cooperative network of anchored platforms, turbines, seabed cabling, etc. supported by the latest information and communication technology (ICT); and 2. The reliable operation of these assets will increasingly depend on localized energy storage systems.



» *A 1 MW battery system undergoing underwater testing at SubCtech's HQ. (Image credit: SubCtech)*

CUSTOM SUBSEA ENGINEERING

Proposing novel solutions to address part two of this conundrum has been a consistent theme at SubCtech throughout 2023, a very busy year that began with a strategic move to significantly increase our manufacturing capacity by doubling the production area of our Kiel, Germany-based headquarters. This expansion was not only to better accommodate our growing team of expert engineers and support staff—a present-day headcount of 80 up from 20



» *Scalable seafloor EESs are set to unlock the true potential of remote subsea operations. (Image credit: SubCtech)*

when the company was founded in 2010—but also in preparation for a highly custom remote ocean power project.

SubCtech has never shied away from a challenge; our company-wide belief is that by partnering with our customers to solve subsea dilemmas, we are able to bring innovation to life, in the form of cost-effective, flexible, and customized solutions. And that characterizes everything that we do as a team; while perhaps most immediately recognized as a supplier of subsea batteries, what SubCtech really specializes in is the design and delivery of energy storage solutions.

One of 2023's missions was to design, test, and deliver what is, at the time of writing, the first subsea Energy Storage System (ESS) of its kind—a "Portable Offshore Unit"—fully certified by DNV. This made-to-order system serves as a bellwether for the way in which offshore developers are introducing subsea solutions designed to support remote operations.

SUBSEA INDUSTRY FIRST

The unique EES has a total energy storage capacity of 2 MW—comprising two 1 MW battery systems—but this configuration is easily scalable by stacking our SmartPowerBlock battery modules. The Battery Control Module is based on our NetDI® Control technology, and Power Distribution Units (PDU), voltage conversions, and data interfaces can be integrated into titanium or duplex steel housings as required. The fact that SubCtech is a specialist in titanium and manufactures housings means that battery systems can be easily scaled up to meet any special water depth and form-factor requirements.

The EES features SubCtech's standardized, safe, and reliable Li-Ion batteries, which have a typical service life of 15–25 years, depending on the cell chemistry. The titanium housing eliminates the need for any coating and corrosion protection (CP) and so reduces the risk of any associated pollutants contaminating the surrounding water. The reliability of the system and the quality of the build and components not only optimize the life cycle but also limit the need for monitoring and inspection.

Beyond supporting offshore energy structures, modular EESs of this nature signal a new approach to the use of uncrewed vehicles for certain subsea inspection, monitoring, and repair (IMR) operations, as well as other intervention tasks.

POWERING SUBSEA RESIDENCY

The concept of subsea residency is well accepted. Increasingly remote operations require remotely operatable assets with high endurance capabilities. The premise is simple: rather than deploy and recover remotely operable subsea vehicles equipped with the latest sensors and intervention tooling, have them permanently reside on the seafloor, supported by rechargeable subsea batteries and docking stations—no need for topside support, massively reducing operational costs, CO2 emissions, and time. The goal, ultimately, is to provide carbon-zero survey and IMR solutions with faultless over-the-horizon control and supervision from a shore-based command center.

THE UNIQUE EES HAS A TOTAL ENERGY STORAGE CAPACITY OF 2 MW—COMPRISING TWO 1 MW BATTERY SYSTEMS—BUT THIS CONFIGURATION IS EASILY SCALABLE BY STACKING OUR SMARTPOWERBLOCK BATTERY MODULES.

Across the ocean industries, we have already seen a clear upturn in capital funding to develop a growing range of uncrewed subsea vehicles to perform these campaigns, such as hybrid ROV/AUVs capable of hovering over fixed structures to run inspection reports and perform simple intervention tasks.

Again, scalability is the key here. We know that developers are seeking to explore remote waters, so their need is twofold: they need innovative approaches to offshore installations as well as increasingly intelligent robotics—uncrewed vehicles equipped with the latest subsea inspection equipment—to service them. The expansion of both is entirely dependent on having access to a steady and reliable power source and so development plans can only accelerate at a pace that scalable battery solutions will allow.

www.subctech.com

USV MULTIBEAM INTEGRATION

Rigorous test and evaluation program delivers industry-leading results

MARIA PLESKACH
Technical Writer
EvoLogics®

EvoLogics, a high-tech provider of robotic solutions, sensor systems, and underwater data networks, is perhaps most immediately recognized among industry peers for designing and manufacturing the Sonobot 5 uncrewed surface vehicle (USV). The Sonobot is a well-established product with a remarkable track record in performing bathymetry, underwater object search, and subsea reconnaissance missions.

To further enhance the USV's utility, reach, and accuracy, EvoLogics has made further steps to upgrade the system's hardware, including, in April 2023, the unveiling of a new multibeam echosounder (MBES) option for the Sonobot 5—the EvoLogics Multibeam—at the Ocean Business conference in Southampton, UK.

During the summer of 2023, a team from EvoLogics' Berlin-based HQ embarked on a demonstration tour to showcase the new multibeam platform to existing partners and clients. The MBES "roadtrip" garnered valuable feedback which in turn informed further upgrades to the integration of the sonar into the USV.

> THE EVOLOGICS MULTIBEAM FOR THE SONOBOT 5 INCORPORATES A NORBIT OEM SOLUTION, AN ENTRY-CLASS MBES DESIGNED FOR SURVEY PROFESSIONALS.

MIGHTY MULTIBEAM

Unlike single-beam echosounders, the multibeam echosounders offer superior coverage and 3D mapping. Releasing multiple sound waves concurrently, it efficiently maps extensive underwater areas, helping operators drastically reduce the required survey time.

The key strength of multibeam sonar technology lies in its capacity to generate higher-resolution imagery. Emitting a fan-shaped array of sound waves, it captures echoes from various angles, facilitating the creation of detailed 3D representations of underwater features.

Multibeam sonars deliver enhanced depth accuracy compared to their single-beam counterparts. Leveraging advanced algorithms, a MBES compensates for seabed complexities, mitigating the impact of factors like slope, refraction, and interference.

The EvoLogics Multibeam for the Sonobot 5 incorporates a Norbit OEM solution, an entry-class MBES designed for survey professionals. Featuring high-grade dual GNSS and INS positioning and motion control, standard across all Norbit echosounders, this system boasts 256 beams at 1.45° x 1°, a range exceeding 200 m, and a 50 Hz ping rate. These specifications enable professional surveying in accordance with the IHO's S-44 standard.

The compact Norbit sonar interface unit (SIU) is fully embedded in the submergible pod of the Sonobot vehicle. Connected by a single cable for power and data link, the sonar head is easily detachable with a "slide-and-lock" mechanism for convenient transportation and storage.

In the pursuit of optimal performance, EvoLogics engineers created a custom-molded cover for the sonar head before the production of the first serial orders. This sleek cover not only enhances the hydrodynamic form of the USV but also adds to the unit's robustness,

providing crucial protection to the sonar-pod assembly.

The cover has also proven advantageous when performing multibeam sonar surveys in strong currents, as it minimizes drag and ensures efficient navigation through challenging conditions. It enables better utilization of the Sonobot's powerful thrusters and aids in maintaining the steady survey speed during data collection.

The mechanical connection between the submergible pod and the sonar—the "slide-and-lock" mechanism—also underwent a rigorous test and evaluation process during the demonstration tour, resulting in some final design tweaks to optimize overall handling of the unit before and after field operations.

Weighing less than 32 kg, the Sonobot 5 with EvoLogics Multimeam measures 1.29 m (L) x 0.96 m (W) x 1.04 m (H, with antennas) making it the most compact and easy-to-handle USV equipped with a professional multibeam sonar on the market.

IN THE WATER

In November 2023, EvoLogics completed a survey of the Plessow Lake in Brandenburg, Germany (a regular testing site for the company's latest innovations) with the upgraded Sonobot 5 USV. Notably, early trials at this site revealed an unexpected feature: a cairn-like mound formation on the lake floor, initially thought to be an ancient burial mound. EvoLogics shared the bathymetric data with the Association for Underwater Archaeology Berlin-Brandenburg for further evaluation. After a period of underwater archaeological scrutiny among experts, the feature was determined to be a geological phenomenon, likely a remnant of the last glacial period.

The mound subsequently became a focal point for testing bathymetric equipment. EvoLogics often returns to Plessow Lake with a Sonobot USV, taking advantage of the cairn's unusual underwater features to help test and evaluate the MBES' capabilities in detecting and mapping underwater structures. The mound's elevation and shape create variations in the lake's bathymetry, providing a unique opportunity to evaluate the echosounder performance in measuring depths and generating detailed bathymetric data.

The survey plan chosen for the multibeam swath survey at the Plessow Lake was a crosshatch pattern, a series of intersecting parallel lines. This pattern ensured comprehensive data collection, eliminating any gaps in area coverage. During the survey, the complete sonar dataset was stored onboard the vehicle, with a live preview displayed to the operator at a shore-based command.

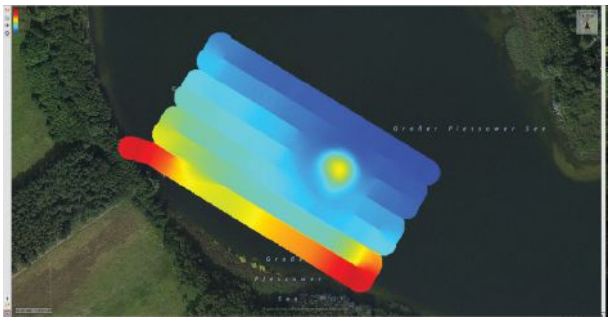
SYSTEM COMPATABILITY

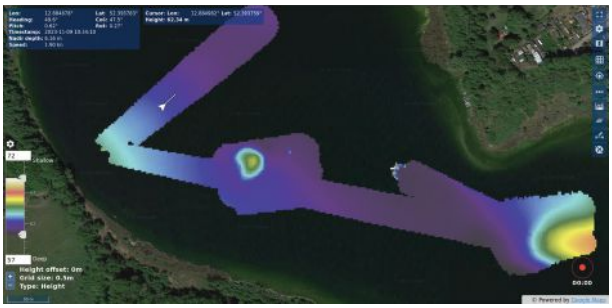
EvoLogics Multibeam is compatible with the Norbit data collection tools DCT and NORdredge, web-based solutions for real-time monitoring of multibeam sonar operations. Norbit DCT was used for the live multibeam data preview at Plessow Lake, and even without post-processing of the full set of data points, the multibeam sonar data preview is more detailed than the single-beam bathymetry of the area.

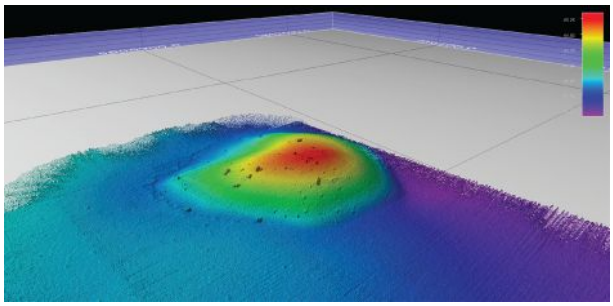
EvoLogics Multibeam is also compatible with various third-party software packages supported by the Norbit WBMS sonar family. The data from the Plessow Lake survey was processed with QPS Qimera, revealing intricate details of the "cairn" feature on the lakebed.

www.evologics.de

» *Sonobot 5 with the updated EvoLogics Multibeam. (Image credit: EvoLogics)*







» *Plessow Lake in Brandenburg: (Top) Bathymetry at the mound site taken in 2017 with the Sonobot's standard 200 Hz single-beam echosounder with the "cairn" clearly visible; (Middle) Multibeam sonar survey of the underwater mound, DCT data preview during the mission, November 2023; (Bottom) MBES data processed with QPS Qimera, November 2023. (Image credits: EvoLogics)*

OCEANOLOGY INTERNATIONAL 2024

Oi24 gears up to accelerate innovation across blue-tech, energy, and offshore sectors

DAVID INCE
Oceanology International Portfolio Director

> OI'S FOCUS IN 2024 WILL REFLECT TODAY'S GLOBAL CHALLENGES CONFRONTING THE INDUSTRY AND INFLUENCING THE TRAJECTORY OF TECHNOLOGY DEVELOPMENT ACROSS NUMEROUS OCEAN-BASED SECTORS.

Innovation, sustainability and new applications for technology will be at the heart of Oceanology International 2024 (Oi24), with anticipation building for the opening of the next Oi event at London's ExCeL from March 12–14, 2024.

Oi's focus in 2024 will reflect today's global challenges confronting the industry and influencing the trajectory of technology development across numerous ocean-based sectors. Key themes such as the energy transition, climate change and ocean health, offshore energy, geotechnics, hydrography and ocean science, improved sustainability in offshore operations and the development of ocean-tech investment and finance opportunities, plus new applications of autonomous systems and AI, and ocean connectivity, will feature throughout the exhibition and the varied conference programmes.

Dan Hook, Oi24 committee member, CEO at RAD and Consultant Marine Technologist, said: "Oi has always been a solid date in the calendar for getting updates on information, meeting customers, potential suppliers, hearing what's happening in the industry—whether you are there for one day or the whole event. As a new committee member, I look forward to hearing about the latest innovations, the latest companies, the latest user cases, and the latest industry success stories."

EXCLUSIVE AGENDA

With exhibitor product development and R&D cycles aligned with Oi's return to London every two years, more than 100 companies are expected to conduct product or service launch activity in 2024. Oi24 is introducing new solutions, with scheduled launches, promotion, PR and demonstration activities, delivering an enhanced launch platform and greater reach for exhibitors.

Oi's global connections will also be showcased with 10+ International and Regional Pavilions, promoting more than 100+ SME's, start-ups, accelerators and innovation clusters.

Unique feature areas on the show floor in 2024 include the Future Tech Hub, highlighting the start-up and tech-accelerators who are building transformative new technological eco systems.

OceanICT, powered by ON&T in 2024, is a co-located event within the main exhibition hall and will be a focal meeting point for visitors to engage with information and communication technology (ICT) experts and discover how recent breakthroughs are facilitating a smarter, more sustainable ocean through greater connectivity.

The popular Dockside Demonstrations return on the Royal Victoria Dock giving Oi24 visitors the opportunity to experience different vehicle, imaging, sonar and instrumentation technologies live, in- and on- the water.

The final day of Oi24 sees the return of the Catch the Next Wave conference, examining how emerging scientific understanding and disruptive technologies will contribute to information and enable the continued transition of the Ocean Economy.

As always, there will be three days of Technical and Ocean Futures-focused content across five different conference locations.

LONDON CALLING

Oi is an unmissable date in the calendar for returning exhibitors, while a range of new companies to the event are looking forward to making their debut in 2024.

Rob Smets, Head of Business Development at uWare Robotics, said: "There is no better place to be if you work around underwater robotics. So, when we were contacted by Oi to be part of future technology, we didn't have to think about it. It fits our roadmap perfectly. Next year will really be about production and increasing our sales network. So, Oi is just the perfect place to be for us."

Visitor registration is now open.

www.oceanologyinternational.com

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UNDERWATER ROBOTICS

Enhanced underwater imaging technology will accelerate autonomous subsea vehicle applications

CHRIS GIBSON
CEO
VideoRay

VideoRay recently acquired Blue Ring Imaging, a St. Petersburg, Florida-based innovator known for its 3D visualization, multi-view perception and simulation technologies for unmanned systems.

With Blue Ring products, like the OctoView™ cutting-edge mixed reality software and the OctoCAM™ multi-view 360-degree underwater camera, we are now focused on improving the situational awareness of our vehicles, helping them to navigate more autonomously.

This fundamentally shifts the way that operators will interact with their unmanned vehicles in the future. These technologies align perfectly with VideoRay's commitment to pushing the boundaries of underwater operations with man-portable robots and fostering effective collaboration between humans and machines.

Today, not only does VideoRay have the chance to provide a best-in-class operator experience for our existing ocean robotics customers, but we can also expand our offerings to benefit other unmanned systems.

> THERE'S AN OVERLAP BETWEEN VIDEORAY AND BLUE RING'S CUSTOMER BASES, WHICH MAKES THE ACQUISITION A GREAT FIT.

BLUE RING BACKSTORY

Blue Ring Imaging was the brainchild of Casey Sapp, who today serves as Vice President of Strategy and Emerging Technologies at VideoRay. Casey helped invent some of the first 360-degree underwater camera systems—some of which were used in Hollywood—and became an expert in underwater perception. Casey came from a growth software background but, in transitioning into the 360/Virtual Reality industry, quickly recognized that there were more pressing hardware issues to solve before tackling any software requirements.

It was the lack of any underwater 360 camera systems that drove Casey to explore the commercial viability of Virtual Reality solutions. In 2019, Blue Ring Imaging moved from entertainment to military applications and started focusing on problems associ-

» *Enhanced underwater imaging is fundamentally shifting the way that operators interact with their unmanned vehicles. (Image credit: VideoRay)*

ated with situational awareness and human-machine teaming for unmanned systems and fleets.

In particular, there was a huge opportunity to improve the efficiency of the handoff process between unmanned systems and humans.

Blue Ring Imaging's initial business premise was that, like the autonomous driving industry, unmanned systems need more sensors and perception capabilities than what was available to become fully autonomous. Display preferences were changing from mobile and tablet displays to mixed and augmented reality headsets. These headsets are the future of visualization and control for unmanned systems.

The challenges that concern human-machine teaming relate to sensor latency from the machine to the human and getting large quantities of data—such as 3D video, point clouds, and augmented reality markers—to human eyes as quickly as possible. That was the challenge Blue Ring Imaging set out to overcome by developing a prototype with the Monterey Bay Aquarium Research Institute, an oceanographic research center in Moss Landing, California.

This prototype had a multi-view 3D camera that was streamed through a headset. The goal was to determine if this display could help ROV operators to complete tasks more efficiently. The answer was a resounding yes, on average halving the time needed to execute the tasks at hand.

» *Pairing Blue Ring's multi-view camera technology with VideoRay ROVs gives user enhanced situational awareness. (Image credit: VideoRay)*

JOINING FORCES

Working under existing Navy contracts, it wasn't long until we crossed paths with Blue Ring Imaging. It was immediately clear to our team that Blue Ring's technology was cutting-edge and pairing it with our products would provide our clients with a distinct underwater advantage as it allows users to experience what the robot senses.

The camera technology is also being optimized for close-range manipulator work, allowing operators to see 3D depths at close ranges where manipulators do most of their work. As this technology develops, it will simplify complex underwater tasks and help users understand the environments in which they work. This will help them perform their jobs with more efficiency, safety, and at a lower cost.

There's an overlap between VideoRay and Blue Ring's customer bases, which makes the acquisition a great fit.

Bringing Blue Ring into the VideoRay family has also expanded our physical footprint, incorporating Blue Ring's Florida location alongside our Pennsylvania-based locations and our San Diego office. Our new St. Petersburg office is close to MacDill Air Force Base, where the special forces run their Middle Eastern and South American operations, so there's immense military acumen in the area and access to defense events and conferences.

BRAND INTEGRATION

We're already integrating Blue Ring technology into our research and development projects with the US Navy and other customers. We expect the first product from the merger to be a smart camera for our Mission Specialist systems, which we plan to release early next year.

Aspects of Blue Ring technology will be part of every system that VideoRay sells. As we move forward you will hear more about VideoRay Emerging technologies through VideoRay Labs. Under the leadership of Casey Sapp, VideoRay Labs will serve both new and existing VideoRay customers through applied research and the utilization of the Blue Ring technology suite. Together, we're ready to pioneer next-generation man-machine teaming and autonomy.

www.videoray.com

» *The premise of the headset is that you feel more attune to the robot in terms of depth perception and other situation awareness parameters. (Image credit: VideoRay)*

| FEATURE |

THE FUTURE OF...

ACTIONABLE DATA FOR COASTAL PLANNING

Coastal resilience starts with resilient data

ROB COLLARO
Director of Hydrographic & Land Survey
Morgan & Eklund Inc.

Coastal regions are diverse ecosystems that support a myriad of economic and societal services. Various industry stakeholders, such as port authorities, shipping firms, tourism operators, and fisheries, to name but a few, rely on coastal habitats and their resources. These environments, unlike inland ones, face unique challenges in terms of coastal resilience and vulnerability, factors that are acerbated by their ongoing exposure to extreme weather and erosion.

Just this past year, the National Oceanic and Atmospheric Administration (NOAA) announced Hurricane Ian, a deadly and extremely destructive Category 5 Atlantic hurricane that produced catastrophic storm surge, winds, and unprecedented flooding across much of central and northern Florida as the costliest hurricane in the state's history and the third costliest on record in the United States. Having made landfall initially in Cuba, then Florida, and finally North Carolina, the storm tallied up a bill of $112.9 billion. As extreme weather events of this magnitude continue to impact coastal regions with increased frequency, the need to establish enduring and cost-effective protections and response practices remain paramount for coastline communities.

Planning authorities have begun to research and enact solutions for coastal flooding and erosion. Resilience structures—whether artificially engineered or restored natural environments—have proven successful in reducing storm damage. Overtime, proactive measures to mitigate destructive forces have included the use of manmade structures like artificial reefs, erosional deposition pits, groins, and jetties—all come with pros and cons.

Additionally, the restoration of natural marine environments, such as coral reefs, seagrass meadows, and mangrove forests, has also helped abate the cumulative cost of constant wave action and the increased sediment deposition associated with it. While these interventions may seem straightforward, coastal managers and practitioners must assess risk, cost, and effectiveness before implementation, as well as monitor the success of such projects ongoing.

ENABLING TECH-LED PROGRESS

Hydrographic survey provides much of the data needed to support coastal resilience engineering and decision-making. For 37 years, Morgan & Eklund, Inc. (M&E) has been providing accurate and robust hydrographic and geophysical data to engineering firms, marine construction contractors, and federal, state, and local governments to help them make sound, defensible decisions. Whether running survey campaigns for beach restoration or marine and coastal infrastructure projects, M&E has built a team of experienced and talented subject matter experts (SMEs), supported by an expanding toolkit of the latest technologies, to deliver best-in-class marine data.

When in the field, M&E surveyors rely on several well-established technologies—including side-scan sonar, LiDAR, RTK GPS, and multibeam echo sounders. In recent years, however, we have also invested significantly in the growing utility of autonomous survey vehicles (ASVs). Our current ASV of choice is a SeaRobotics SR-Surveyor M1.8. With its catamaran hull design, the SR-Surveyor M1.8 is a highly portable autonomous platform equipped with a multi-sensor package that includes an EdgeTech 2205 multibeam echosounder, a 1,600 kHz and 540 kHz dual-beam side-scan sonar, an AML Oceanographic SV sound velocity sensor, and a Velodyne LIDAR for mapping features above the water surface.

The ASV's capacity to capture such a diverse range of data sets alongside its portability and ease of deployment deliver a series of game-changing benefits to M&E operators, and so subsequently,

our customers. Over the last 36 months, we have tracked a significant reduction to in-field operating costs, gains that we consistently share with our clients.

The use of ASVs, including the deployment of multiple units at one time in swarm format, is slowly bringing about a new streamlined approach to gather better data, quicker, without putting people in harm's way. We tend to use compact, quick-to-deploy ASVs as we also need to navigate coastal waters that can be trick to navigate for a conventional research vessel, but the growing range of commercial ASVs on the market is a sure sign that the future of marine survey will lean in heavily on our industry's capacity to thread autonomy into our day-to-day operations.

THE USE OF ASVs, INCLUDING THE DEPLOYMENT OF MULTIPLE UNITS AT ONE TIME IN SWARM FORMAT, IS SLOWLY BRINGING ABOUT A NEW STREAMLINED APPROACH TO GATHER BETTER DATA, QUICKER, WITHOUT PUTTING PEOPLE IN HARM'S WAY.

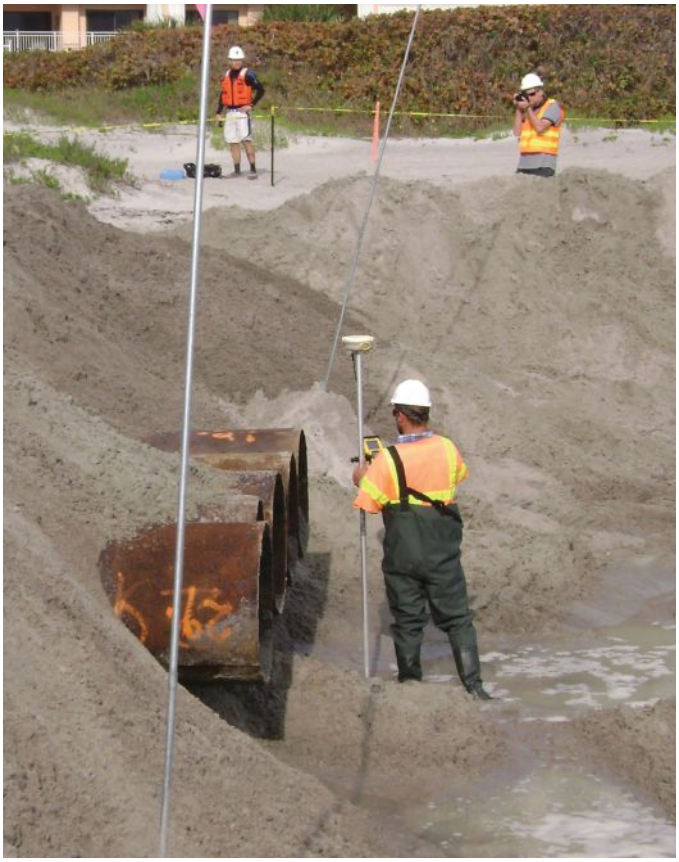
FORGING LONG-LASTING PARTNERSHIPS

M&E's local and regional relationships with key clients—the Army Corps of Engineers, the Florida Department of Environmental Protection (FDEP), Olsen Associates Inc., Stantec Consulting, and various Florida counties—have enabled novel collaborative methodologies for completing coastal projects on time and on (a more manageable) budget.

Just recently, M&E was a recognized player in an innovative beach restoration project performed by three coastal municipalities and three engineering consulting entities. Through a subcontract by both the construction company and coastal engineer, M&E collected essential data required by FDEP that was instrumental in ensuring the successful completion of the beach nourishment project.

Due to the project's successful partnership between multiple municipalities and consulting agencies that exemplified the use of shared permits and provided a unified workforce to meet the needs of a cost-effective renourishment project, it earned the American Shore & Beach Preservation Association (ASBPA) Award of 2023 Best Restored Beach. Collaborative projects like these, aided by the expanding capacity of some of the specialized marine survey equipment readily available on the market—especially those, like ASVs, that are bringing real-world efficiencies to the field—are setting new standards in using defensible ocean data for coastal restoration and reliance projects in the future.

www.morganeklund.com



» *Surveying dredge discharge pipe elevations during beach renourishment project. (Image credit: M&E)*

» *Launching SeaRobotics M1.8 ASV from work boat to perform oyster mapping survey. (Image credit: M&E)*

OFFSHORE WIND IN THE US

Public policy developments means the industry is primed for investment

LIZ BURDOCK
CEO
OCEANTIC NETWORK

> THE INDUSTRY IS EVOLVING TO INCORPORATE OCEAN RENEWABLES THAT ARE COMPLEMENTARY TO OFFSHORE WIND, SUCH AS GREEN HYDROGEN, AND THE NETWORK IS EVOLVING ALONGSIDE IT.

The US offshore wind industry is at a critical juncture. In the past year it has seen new opportunities and made remarkable progress, but also faces serious challenges. It needs new business partners in a variety of sectors including port infrastructure, shipbuilding, and maritime operations. And US market troubles related to inflation and supply chain crunches have often overshadowed the strong groundwork being laid, the real achievements coming to fruition, and the true benefits of offshore wind.

Despite these challenges, states and the federal government continue to reaffirm their commitments to offshore wind through new leasing rounds and supply chain initiatives, including announcements made for new vessels, ports, and manufacturing facilities. Our industry is ripe with opportunities for global companies, particularly those in maritime industries.

INFLATION REDUCTION ACT

At the start of 2023, the federal government concentrated activity on the offshore wind sector and other renewable energy industries with new opportunities like the Inflation Reduction Act (IRA) and other initiatives from the Biden-Harris Administration. The IRA has provided and continues to provide major production and investment tax credits for offshore wind projects. The IRA—along with the Biden-Harris Administration's Hydrogen Shot and the 2021 Bipartisan Infrastructure Law—has helped the federal government strengthen the market and open new possibilities for offshore wind in green hydrogen production.

As we approach the end of 2023, state demand for offshore wind projects has reached 86.9 GW. The first turbines were completed at the Vineyard Wind and South Fork Wind projects, our first commercial-scale offshore wind farms. In addition to this historic milestone, several more projects were approved for construction, states made new efforts to coordinate on offshore wind development, and the supply chain saw new investments and strong performance among participants. The industry is evolving to incorporate ocean renewables that are complementary to offshore wind, such as green hydrogen, and the Network is evolving alongside it.

WINDS OF CHANGE

Amid this monumental progress, the US offshore wind industry's supply chain is yet to be fully formed. For the past decade, Oceantic Network (formerly known as the Business Network for Offshore Wind) has worked tirelessly at bringing new companies into the industry by educating them on the latest information, making connections, and sharing how they can identify and capitalize on new opportunities. This work is critical to the success of the industry, and at Oceantic we are driven by the understanding that we need new partners to achieve the manufacturing capacity necessary for a full US buildout of offshore wind.

The offshore wind market isn't perfect, but we're just getting started and our foundation is strong. There's never been a better time to make an entrance. We invite you to join us in building a network that will usher in a global offshore wind future and support the development of other ocean renewables technology.

www.oceantic.org

Whatever the mission...

Okeanus designs and manufactures mission-critical ocean equipment for commercial and government agencies throughout the world. We harness breakthrough Science and Technology to equip clients with the tools and trusted support they need for the rigors of ocean exploration.

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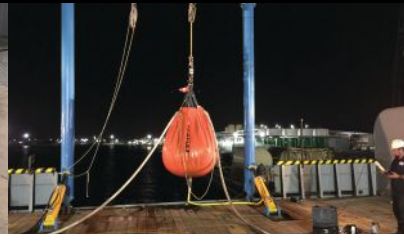


OKEANUS

AN ADVANCED OCEAN SYSTEMS COMPANY

THE ENERGY TRANSITION

Challenges facing developers must be used as a catalyst for action

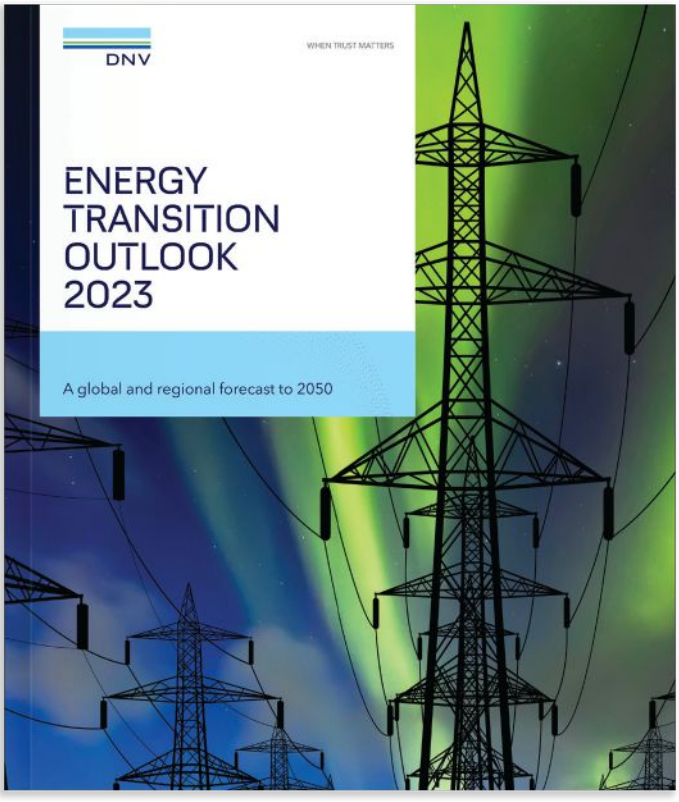
SVERRE ALVIK
Energy Transition Outlook Director
DNV

This year's edition of DNV's flagship Energy Transition Outlook was abundantly clear in its conclusion that the transition is still in the starting gates. Green energy still isn't absorbing all of the world's new energy demand and fossil fuels still aren't being replaced in absolute terms.

What is more, emissions from conventional energy sources are tipped to move even higher in 2024, a detail not aided by the recent revival in oil and gas exploration and the cost increases that are hampering the rollout of renewables.

So, if the current conclusion is that the energy transition is still in stall mode, the obvious question is: when will it begin in earnest? DNV expects emissions from oil use to reach their peak in 2025, followed by natural gas in 2027. Moreover, our forecasts put non-fossil sources at 52% of the energy mix in 2050, a huge and welcome spike from the 20% they represent today.

» *Energy Transition Outlook 2023 is available for download at www.dnv.com. (Image credit: DNV)*



GEOPOLITICAL FACTORS

An important driver in that predicted expansion is the recent roll-out of mammoth decarbonization policy packages. In the United States, the Inflation Reduction Act (IRA) has caught the eye of private equity and $240 billion of clean investments have already been committed in response to the generous incentives. Meanwhile similar moves from the European Union have given the continent's net zero ambitions a fighting chance.

It is also worth noting that the benefits of such big policy plays won't be constrained to their specific geographies. This 'race to the top' in clean technology will boost global learnings around technologies like green hydrogen and carbon capture and storage, aiding regions that aren't quite as far along on their transition journey. Such advances will only partly benefit medium and low-income regions, where de-risked financing will need to do much of the heavy lifting.

Geopolitics has had a major role in shaping these policy changes. Russia's invasion of Ukraine put energy security at the forefront of the minds of governments around the world and much of what has happened since has been in direct response to the soaring commodity prices we saw in 2022. Increased global preference for domestically produced energy rather than imports, is a trend that, by and large, benefits renewables and nuclear.

FALLING SHORT

All of this concerted effort and cash is—as the ETO clearly asserts—still falling short though and most of the world is still nowhere near where it needs to be. 'Reshoring' policies are adding extra complications to an already strained energy supply chain. Meanwhile increases in the costs of raw materials worsens the situation for the very companies producing the offshore turbines that are going to get us to net zero.

In the face of such pressures, it is testament to the strength of developers that solar installations reached a record 250 GW in 2022, while wind power contributed 7% of global grid-connected electricity. If you combine transmission and distribution, DNV

expects the global grid to double in length from 100 million circuit-km (c-km) in 2022 to 205 million c-km in 2050 as the demand for electricity swells.

But, in the nearer term, looming 'gridlocks' could put the brakes on the green energy expansion as many companies are forced to wait years for their chance to hook up projects. Without a rapid expansion in grid capacity and accessibility, it is likely that many of these renewables projects, particularly those offshore, will stumble and fall, something the energy transition cannot afford.

This goes hand in hand with delays to permitting as governments ready themselves for a mountain of project paperwork. Addressing these red tape related delays relies on top-down changes and both the US and the EU are pushing through policies designed to streamline this cumbersome process. The jury is out though on whether these measures prove effective and further action may well be needed to solve the problem.

FUTURE CLIMATE TARGETS

It is unsurprising therefore that the ETO for 2023 settled on this prediction: limiting global warming to 1.5°C is less likely than ever. By the end of the decade global energy-related CO2 emissions will only be 4% lower than they are today, and 46% reduced by 2050, translating to 2.2°C of global warming above pre-industrial levels by the end of this century. But in the face of such figures, we mustn't allow despondency to creep in.

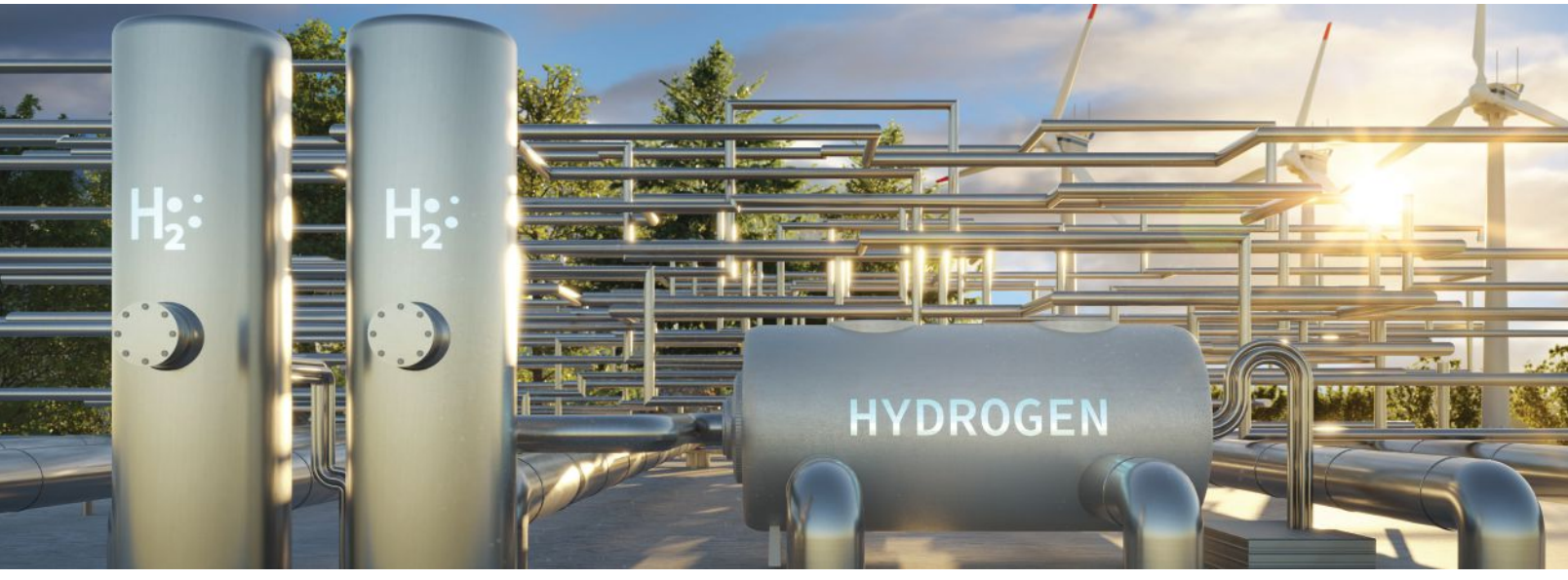
> INCREASED GLOBAL PREFERENCE FOR DOMESTICALLY PRODUCED ENERGY RATHER THAN IMPORTS, IS A TREND THAT, BY AND LARGE, BENEFITS RENEWABLES AND NUCLEAR.

We know that the transition in its current guise is nowhere near fast enough for net zero by 2050 and this awareness is vital because there is still time to act. Countries and companies should still be aiming to hit their ambitious targets and with swift action to supercharge renewables deployment across the globe and simultaneously drastically cut consumption of fossil fuels, there is still a chance of hitting net zero by mid-century.

Ahead of COP28, this year DNV will release its long-awaited update to our 'Pathway to Net Zero' blueprint. It will include steps that must be taken by 2050 to swing the pendulum back towards 1.5°C from our current prediction of 2.2°C. To say that closing the 0.7°C gap will be no mean feat would be an understatement, but as an industry, let us step up to the plate.

www.dnv.com

» *Technologies like green hydrogen and CCS are set to aid regions that aren't quite as far along on their transition journey. (Image credit: DNV)*



BLUE TECH CONFERENCES

Interactive programming and networking events remain high on the agenda

DR. TOBY STAPLETON
Director
blue venture FORUM

The Blue Innovation Symposium (BIS), New England's largest blue tech conference, will be celebrating its 9th anniversary on February 26-29, 2024, in Newport, Rhode Island. Our motto has always been "By the industry, for the industry" and the board of the Blue Venture Forum, which now organizes the BIS, has over 100 years of combined experience working within it. So, in preparation for what will likely be the largest BIS ever, we reflected on the attributes that we think have helped to make our conference a success.

Like most conference organizers, we think that great programming must be at the center of all we do. To attract the right audience of leaders—from industry, defense, government, research, and beyond—you need to have the right mix of speakers and topics. The markets that are of interest to our attendees include defense, marine energy, offshore wind, commercial fisheries, aquaculture, and research, among others. We're fortunate to have a diverse and unmatched network that we can tap to recruit outstanding keynotes and panelists. It is important to also look for ways to partner with like-minded organizations to attract speakers, deliver programming, and reach the right audience.

This year, for example, the Blue Innovation Symposium (BIS) is partnering with the Southern New England Defense Industry Association (SENEDIA) to deliver a "Maritime Communications in GPS-Contested Environments" panel discussion, with representatives from the US Navy, which will be followed by "Flashtalk" presentations from select companies who are developing potential solutions to this challenge. The US Navy and company representatives will then have the opportunity to meet one-on-one in dedicated satellite rooms while the BIS agenda moves on to its next panel discussion.

> NETWORKING IS STILL AT THE HEART OF WHAT WE DO. WE MAKE SURE THAT WE DEVELOP, AND ADHERE TO, AN AGENDA THAT AFFORDS PLENTY OF TIME FOR NETWORKING AND FOR ATTENDEES TO MEET WITH EXHIBITORS.

NEW ENGLAND ADVANTAGE

In addition to our industry and organizational partnerships, we have a special, long-standing relationship, with the Consulate General of Canada in Boston. Since 2015, each year, this partnership ensures that at least two dozen Canadian companies and organizations are represented at the Blue Innovation Symposium. Over the years this has led to Canadian companies making sales, forming partnerships, connecting with US research organizations, and to establishing offices in New England.

The event is attractive to international participants because it is held in Newport, RI, at the geographic center of New England's Blue Economy ecosystem. Within a one-hour drive, you have key assets like Woods Hole Oceanographic Institution (WHOI), the Naval Undersea Warfare Center (NUWC), UMass Dartmouth, the University of Rhode Island, MITRE Corp, Mass. Maritime Academy, L3 Harris Ocean Server, SAAB, Inc., Boston Engineering Corporation, and more.

INTERACTIVE PROGRAMMING

When appropriate, a conference also needs to introduce new programming to keep the format fresh and the areas of discussion conducive to genuine thought leadership and pertinent debate. BIS organizers noticed that, in addition to industry attendees scouting for new technology companies to partner with or acquire, investors started to attend, and even sponsor, our events. We spoke with these attendees and learned that they weren't just interested in hearing from the Flashtalk panels—exclusive opportunities for up to 16 start-ups to deliver a 5-minute pitch to the BIS congregation—but they were also interested in gaining a more comprehensive understanding of the markets for these technologies and what other developments were shaping the industry as a whole.

So, at the Blue Innovation Symposium 2023, we successfully introduced the Blue Venture Investment Summit (BVIS). The BVIS is a half-day program, during the BIS, that attracted over 130 participants.

» *Over the course of the three-day event, BIS 2023 hosted more than 54 speakers, 30 sponsors, and 320 attendees. (Image credit: BIS)*

During the event, we heard from panels of investors, including angels, venture capital firms, family offices, and philanthropic organizations, as they discussed the recent trends that were impacting investment in the sector. We also heard from founders, who have successfully raised funding, as they shared advice about identifying investors, pitching investors, and about building their business.

CREATING LEGACY

We also believe that a conference should take the time to recognize those that are making professional, personal, and organizational contributions to the industry. Each year we give out three "Rising Tide" awards to recognize a company, an organization, and an individual for their work. Over the last 8 years we have given awards to individuals who donate hundreds of hours of their time to mentor industry start-ups, to companies who support scholarships and internship programs, and to nonprofit organizations that provide the key resources that a growing industry like blue tech needs.

Networking is still at the heart of what we do. We make sure that we develop, and adhere to, an agenda that affords plenty of time for networking and for attendees to meet with exhibitors. Networking is important for developing and retaining relationships, creating opportunities, and ultimately facilitating new ideas.

We continue to look for ways to be innovative and deliver a symposium that the industry sees value in. This requires consistently assessing industry and market trends to develop the programming and facilitate the networking that will lead to strengthening and growing the industry.

We wish the industry a successful 2024 and look forward to seeing you at the Blue Innovation Symposium 2024.

https://blueventureforum.org

» *BIS blends an engaging agenda of panel discussions and presentations with a series of networking opportunities. (Image credit: BIS)*

THE USV MARKET

Marine survey and defense markets continue to propel growth

LOU DENNIS
VP of Programs
SEA ROBOTICS
AN ADVANCED OCEAN SYSTEMS COMPANY

> TODAY, CLIENTS CAN PARTNER WITH SPECIALIST USV MANUFACTURERS, LIKE SEAROBOTICS, TO PICK AND CHOOSE THEIR EXACTING SENSOR SUITE AND PAYLOAD OPTIONS.

The market for uncrewed surface vehicles (USVs) is booming. A recent report published by Allied Market Research suggests that the global market for USVs in 2022 generated $0.92 billion and is anticipated to generate $2.7 billion by 2032—that is a staggering CAGR of 11.5% over the next decade.

There are several convergent factors driving this growth, but most demand can be attributed to the steady trial and adoption of USVs for 1. marine survey (ocean mapping, environmental monitoring, subsea inspection, etc.) and 2. defense and security operations (at-sea surveillance, tactical ops, disaster response, etc.).

A RECIPE FOR SUCCESS

In its crudest sense, a USV is a "recipe" of highly integrated technologies—a system of systems. Therefore, the capacity of uncrewed vehicles is entirely contingent on a matrix of tech-inspired supply chains. That means *hardware*—hull materials and dynamics, battery and propulsion systems, sensors, cameras, and collision avoidance systems, etc.—and *software*—information and communication technologies designed to enhance the remote control and telemetry of remotely operable assets.

Today, clients can partner with specialist USV manufacturers, like SeaRobotics, to pick and choose their exacting sensor suite and payload options. This element of customization ensures that the resulting vehicle specifications are a true fit for purpose—the balance of "ingredients" is optimized, if you will. It is no surprise, then, that USV models currently available in the international market come in a range of shapes and sizes, with form and factor tweaked for specific mission requirements.

SWARM TECHNOLOGY

Across the most recent projects at SeaRobotics, both for commercial and defense clients, we see two prevalent trends shaping the future of the USV market. First is the application of swarm formation deployments—that is, the synchronized use of multiple USVs to extend coverage with great efficiency.

This has led us to commercialize a uniquely equipped USV swarm unit, with the SR-Surveyor M1.8, our most compact and fully integrated person-portable model, as its chief protagonist. Equipped with a multibeam sonar and LiDAR as standard, the SR-Surveyor M1.8's shallow draft makes it ideal for accessing hazardous and hard-to-access waters to collect geophysical data to characterize underlying terrain or pinpoint submerged threats, such as underwater mines. Either way, the ability to operate multiple units remotely (we have successfully run exercises with USVs and operators in different hemispheres) keeps people out of harm's way.

EXTENDED OPERATIONS

The other likely development we see is the sustained interest and investment in longer-range, high-endurance USVs engineered for operation in remote offshore environments. The development of our SR-Endurance 8.0 is a direct response to this demand.

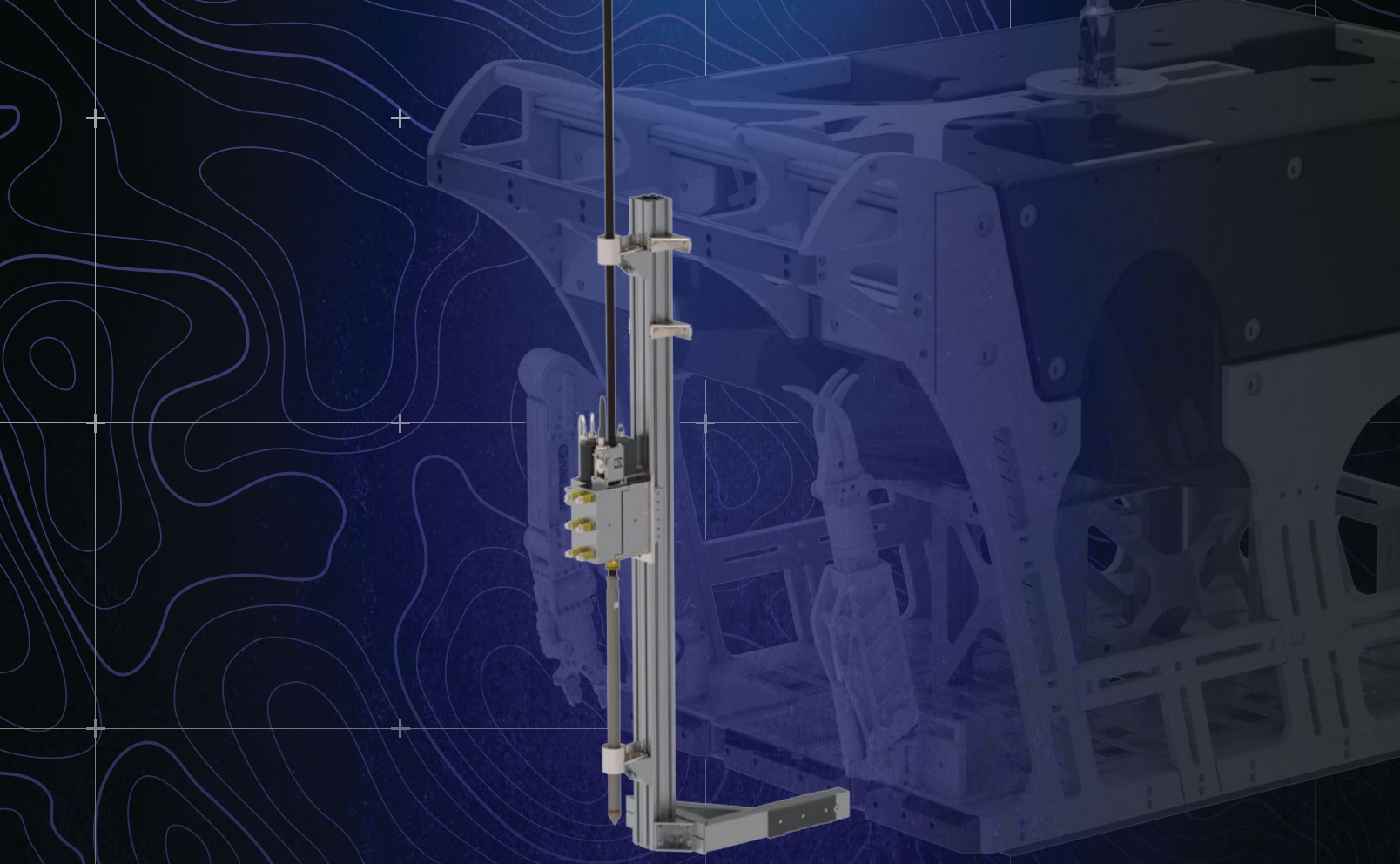
The 8-meter, self-righting hybrid diesel-electric propulsion USV is equipped with collision avoidance technology, GPS navigation, and customizable levels of autonomy—with an operator in the loop and out.

Capable of running 14-day continued missions from a shore-based command, in four-meter-high swells and Beaufort Wind Scale 7 conditions, USVs of this blueprint offer greater versatility due to their capacity to support operations in deeper waters but also access relative shallows. They are also large enough to carry and deploy ancillary assets—smaller USVs, ROVs, AUVs, and other towed bodies—as well as the remotely operable handling systems needed to safely launch and recover them.

The value of uncrewed vehicles in the ocean space is undisputed. Autonomous platforms allow us to work safely, reliably, and with a fraction of the carbon footprint associated with conventional topside operations.

Now is the time to focus on their cross-sector integration to bring about a cooperative ecosystem of cooperative remote sensing technologies.

www.searobotics.com



Pushing Core Data to New Depths

Bluefield's custom penetrometer system wirelessly pairs with any work class ROV to perform CPT and T-Bar testing for seabed site investigation surveys to 6,000 meters

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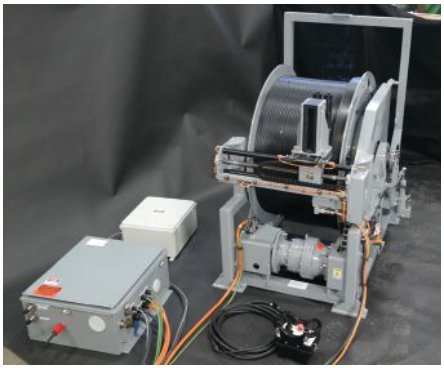
INTELLIGENT DEPLOYMENT SYSTEMS

Uncrewed vessels call for new class of handling hardware

DON BROCKETT
COO
OKEANUS
AN ADVANCED OCEAN SYSTEMS COMPANY

Recent advances in ocean technology have elevated the role and potential of uncrewed systems across a range of marine industries, with artificial intelligence (AI) as the great enabler. In an increasingly connected world, in which information and communication technologies (ICT) are bolstered by an expanding Internet of Things (IoT), the ocean sector is fast approaching the realm of autonomy. However, any suggestion that, before long, conventional at-sea operations will be fully governed by an ecosystem of self-governing robots is somewhat misguided.



» *An Okeanus MCM-015 winch with AQS-24 mine hunting unit aboard Textron MCM-USV. (Image credit: Northrup Grumman and Textron)*

FROM DECK TO DOCK

More accurately, we have set a sure path to a systematic integration of synchronized uncrewed assets, operating on and below the waterline with varying degrees of automation. The need to safely launch and recover these systems will not, initially at least, remove the need for some form of conventional topside support. But as we begin to scale up the endurance and utility of uncrewed vehicles, operators will be able to significantly reduce the headcount needed at sea to execute operations.

Today, rather than mobilize fully crewed vessels for the full duration of a predetermined mission, the tech exists to remotely control uncrewed assets from a shore-based command. With ease of deployment being one of the foremost considerations in an uncrewed vehicle's form, fit and function, ocean technologists are developing uncrewed surface vehicles (USV) and autonomous underwater vehicles (AUV) that favor a "deploy and leave" approach to longer assignments. The vehicle can then be supervised remotely, as appropriate.

The objective of such an approach, below the water at least, is subsea residency, whereby inspection, monitoring, and repair (IMR) assets are primed to "reside" at a target site for months—perhaps even years—before needing to be recovered for servicing. Powered by rechargeable subsea batteries and housed in seafloor docking stations, vehicle tasks are programmed and monitored by skilled remote operators.

HANDLING AUTONOMY

The seamless synchronization and expanding service of these robotic systems, like most pioneering technologies, will hinge on interdependent breakthroughs in both software and hardware. Among other technical areas, the growing application of uncrewed assets in offshore environments will be tempered by the evolution of robust, reliable, and increasingly intelligent deployment equipment—both on-deck and subsea. These hardware systems—winches, LARS, A-Frames, cranes, etc.—are instrumental both to deploy/recover the vehicles safely and to enhance the vehicles'

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capabilities in the field, e.g., by incorporating a remotely operable winch into a USV's payload.

Our collective drive to explore new frontiers remotely is challenging leading manufacturers of deck handling equipment like Okeanus to focus on novel designs and creative fabrication methods, as well as to expand access to specialized materials, advanced control systems, and innovative designs to offer fully customized turnkey solutions. Specific in-field requirements, environmental conditions, mounting location, and length of deployment have made material selection—and its anticorrosive properties—a key design parameter.

Take seabed winch systems, for example. These may be anchored in shallow water, mid-ocean water column, or to the seabed at depths of 6,000 meters. These are very distinct marine environments, so naturally, specifications vary. These winches can perform their tasks either autonomously (pre-programmed profiling schedule) or remotely from a comms cable. They can be designed to support long- or short-term deployments. In other words, one size seldom fits all.

ENHANCING UNCREWED ASSETS

At Okeanus, not only are we seeing a surge in demand for specialist deck handling equipment to launch and recover USVs and AUVs, but also to directly enhance the capacity of a USV by incorporating an automated LARS/winch to deploy additional intervention tools and survey payloads—in short, to make the USV more autonomous. In this case, a USV's weight must determine the right balance between mission resources (power source, sensor suite, tooling) and vessel requirements in higher sea states, and so places heightened scrutiny on any mechanical components used for this additional launch and recovery hardware.

The use of autonomous winches on USVs places increasing scrutiny on failproof communication networks for both executing tasks and real-time data transfer. The product architecture of any USV-supported winch should always prioritize single-point failure and failsafe modes—if a system fails, which can never be ruled out when working in unpredictable marine conditions, it is essential that it fails safely.

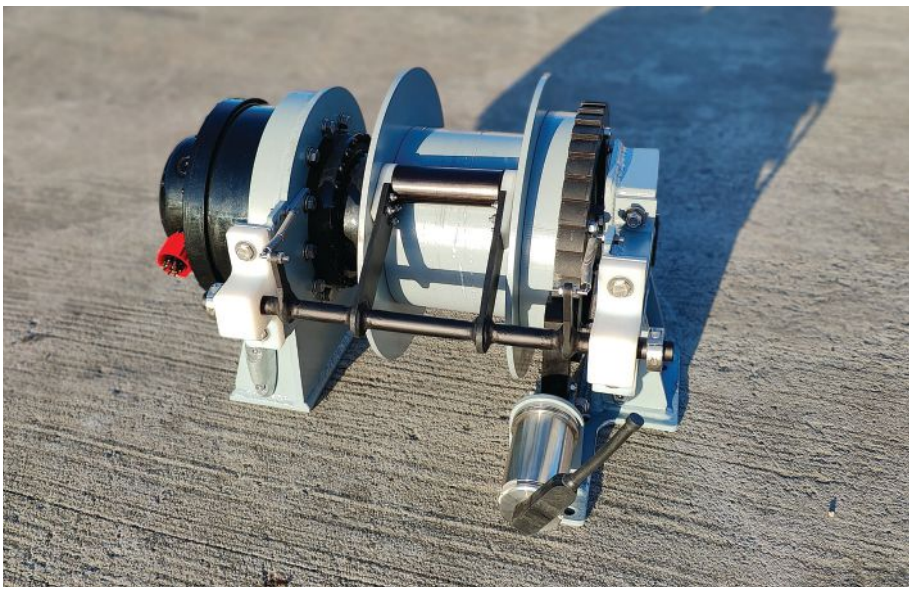
HANDLING THE DESIGN PROCESS

This highly custom design process—from concept through to delivery—can only be effective by partnering with clients early and ongoing to identify their emerging needs in the field and, following extensive testing and evaluation, introducing incremental changes to either our existing winch portfolio or a customer's blueprints. This is what we do in our cutting-edge engineering facility in Houston, TX, and our approach to custom subsea engineering solutions has proven to be a differentiator when working with developers of unmanned vehicles and systems.

One such client, a multinational aerospace and defense technology company, we partnered with to further develop the Okeanus MCM-015 winch for their latest mine hunting unit. Naval forces across the world are directing increasing resources and funding into developing autonomous programs, especially for mine hunting and mine neutralization operations. Therefore, it was essential that this particular winch incorporated a number of bespoke features designed for very specific asset deployment and recovery. It is this level of collaboration and trust that has enabled us to foster long-standing relationships with defense innovators to deliver truly fit-for-purpose solutions.

www.okeanus.com

» *Okeanus standard SMA-40 LARS. (Image credit: Okeanus)*



» *An Okeanus 1,500 m depth rated, 500 kg safe working load, underwater mooring winch custom designed for integration within a large displacement UUV. (Image credit: Okeanus)*

OCEAN TECH & TALENT

Investments in people and pioneering tech platforms to unlock the next chapter in sector advancement

CHRIS OSTRANDER
CEO

MTS marine technology society
Opportunity runs deep™

The marine technology sector has reached an inflection point, with a critical mass of companies, consumers, and innovators advancing automation, autonomy, miniaturization, and digitalization. This community of practitioners has found a professional home within the Marine Technology Society (MTS) for the past 60 years.

Serving as a convenor, thought leader, and common forum for the exchange of information and ideas, MTS enables our members to succeed at the leading-edge of technology design, development, and application. Their efforts have allowed us to gain a deeper collective understanding of our oceans than ever before in human history. As we look to the next few decades of ocean science, technology, and stewardship, several applications of marine technology are shaping our path forward.

1. OCEAN EXPLORATION

While our knowledge is vast, there is still much we do not know. More than 80% of the ocean floor is unmapped, 90% of ocean species have yet to be classified, and an untold number of discoveries are waiting to be made. Ocean exploration, despite being part of the human social narrative for thousands of years, is still in its infancy. Today, technologies like AUVs, ROVs, USVs, and profiling floats—equipped with advanced mapping, biogeochemical, and imaging sensors—allow us relatively quick and affordable access to the depths of the ocean with unprecedented precision and efficiency. Whether mapping the seafloor, identifying and characterizing new mineral and energy resource capacities, or providing non-extractive mechanisms to monitor marine biodiversity and measure species abundance; these technologies are opening a new era of ocean exploration and human knowledge.

2. SUSTAINABLE ENERGY FROM THE DEEP

Our global energy landscape is evolving. Social and market forces are driving a transition from non-renewable fossilized sources towards non-carbon and renewable sources of power. The ocean can potentially serve as the largest power reservoir on Earth—if only we can economically and responsibly tap into it. The cost of production is rapidly falling while advances in grid integration are reducing barriers to consumers buying ocean-derived electricity. Floating solar, OTEC, offshore wind, tidal turbines, and wave energy systems present viable options to meet, and exceed, the current global demand for power. Adjacent innovation could leverage these technologies to deliver sustainable and affordable desalination, marine debris removal, and seafood production.

3. CLIMATE CHANGE MITIGATION

Rising global temperatures and increasing ocean acidity have spurred a global push for carbon capture and removal technologies. The ocean serves as the largest carbon store on Earth and has the potential to sequester and store more carbon than terrestrial solutions. The ocean already acts as a buffer against rising atmospheric carbon. New approaches seek to expand that buffering capacity through biological (iron fertilization, kelp forests, and micro-algae cultivation), physical (pumped storage), and chemical means (alkalinity enhancement, electrochemical processes).

4. CONSERVING BIODIVERSITY

Biodiversity is a cornerstone of ocean productivity. Billions of people rely on productive fisheries, abundant coral reefs, and healthy estuaries for food, economic stability, and cultural reinforcement. As a growing global population strains the capacity of our ocean to sustain that economic impact, marine technology offers insights into sustainable management. AUVs and satellite-based tracking systems are being employed to monitor and safeguard marine species and ecosystems against illegal fishing. Environmental DNA (eDNA) techniques are being used to understand population dynamics and biodiversity of critical ecosystems. Additionally, new technologies and methods are reducing bycatch, enhancing aquaculture, and supporting species resilience and recovery.

INVESTING IN THE FUTURE

To fully realize the potential of marine technology, governments, research institutions, and the private sector must sustain investments in R&D while supporting rapid technology transition across the bench-to-market spectrum. Traditional programs like the UK Small Business Research Initiative (SBRI) and the US Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are being complemented by a rapidly growing

> THE POWER OF PEOPLE AND TECHNOLOGY, DEPLOYED TOGETHER, ALLOW US TO GATHER DATA AND INFORMATION THAT INCREASES OUR KNOWLEDGE AND INFORMS SOLUTIONS.

spectrum of privately financed venture funds, ocean incubators, and accelerators.

Defense-oriented investments in autonomy at scale, such as the US Replicator Initiative, and in dual-use technology innovation like NATO's DIANA Initiative, have the potential to catalyze rapid market opportunity for our industry.

Providing inclusive training and alternative credentialing pathways for the next generation of oceanographers, engineers, and marine technicians is equally crucial. MTS and partners are building a stackable microcredential framework to support this new approach to competency-based experiential learning. This expansion of a new learning paradigm, alongside traditional higher education and vocational training will enable a broader pool of talent to support the growing workforce needs of our ocean economy.

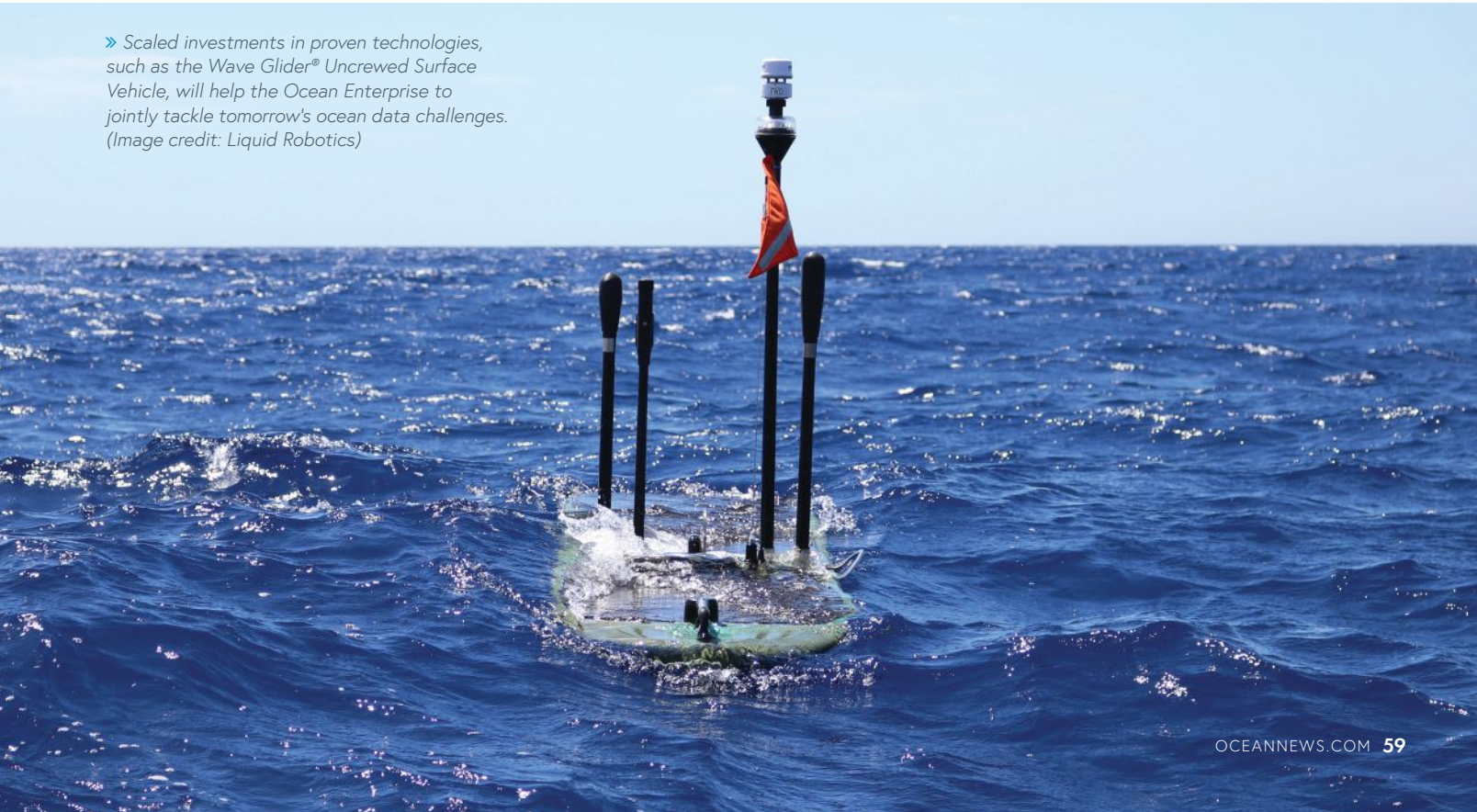
Technology and talent are necessary, but alone insufficient, to support the future of our marine technology sector. The power of people and technology, deployed together, allow us to gather data and information that increases our knowledge and informs solutions. Yet data capture is often done in a vacuum—disconnected from priorities and potential synergies across industry, academia, and government. While the ocean is recognized as critical to life on Earth, ocean data and the Ocean Enterprise that generates it

» *Deep-ocean profiling floats, like the energy harvesting infiniTE™ float developed by Seatrec, enable data capture below the surface persistently and in real time. (Image credit: Seatrec, Inc.)*

are not yet seen as essential to managing our global economic system, geopolitical engagement, and social welfare. Through our Ocean Enterprise Initiative, MTS and partners are working to close this gap.

The ocean offers vast potential to deliver solutions to humanity's pressing problems—the future of marine technology as a sector will center on a talented workforce that leverages innovative marine technologies to unlock the data and information that informs those solutions.

www.mtsociety.org



» *Scaled investments in proven technologies, such as the Wave Glider® Uncrewed Surface Vehicle, will help the Ocean Enterprise to jointly tackle tomorrow's ocean data challenges. (Image credit: Liquid Robotics)*

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2024 ON&T EDITORIAL CALENDAR

MONTH	DEADLINES	EDITORIAL FOCUS AND SHOW DISTRIBUTION	THEME FOCUS
JANUARY/ FEBRUARY	**Editorial:** January 17 **Ad:** February 2	**OCEAN SENSORS & DATA MANAGEMENT** •Oceanology International | March 12–14 •Canadian Underwater Conference & Exhibition (CUCE) March 24–26	Ocean observation, multidisciplinary survey, telemetry, communications
MARCH	**Editorial:** February 12 **Ad:** March 1	**NAVAL DEFENSE & SECURITY**	Uncrewed systems, cyber security, marine surveillance systems
APRIL	**Editorial:** March 11 **Ad:** March 29	**REMOTELY OPERATED VEHICLES (ROVs) IN FOCUS** •International Partnering Forum | April 22–25	ROV development, subsea residency, deployment technologies
MAY	**Editorial:** April 8 **Ad:** April 26	**OFFSHORE ENERGY DEVELOPMENT**	Infrastructure development for oil and gas, renewables, subsea power
JUNE	**Editorial:** May 13 **Ad:** May 31	**UNDERWATER IMAGING**	Advances in geophysical survey and subsea imaging capabilities
JULY (DIGITAL ISSUE)	**Editorial:** June 18 **Ad:** June 28	**UNCREWED VEHICLE BUYERS' GUIDE**	***Special Edition***
AUGUST	**Editorial:** July 15 **Ad:** August 2	**SUBMERSIBLES & THE DEEP SEA**	Subsea vehicles, naval archaeology, bathymetric studies, geotechnics
SEPTEMBER	**Editorial:** August 12 **Ad:** August 30	**REMOTE MARINE OPERATIONS**	Marine autonomy, digital twins, remote monitoring and intervention
OCTOBER/ NOVEMBER	**Editorial:** September 9 **Ad:** September 27	**UNCREWED VEHICLES & MARINE ROBOTICS**	USV R&D, emerging applications, breakthroughs in remote ops
DECEMBER	**Editorial:** October 17 **Ad:** October 28	**THE FUTURE OF OCEAN TECHNOLOGY**	***Special Edition***

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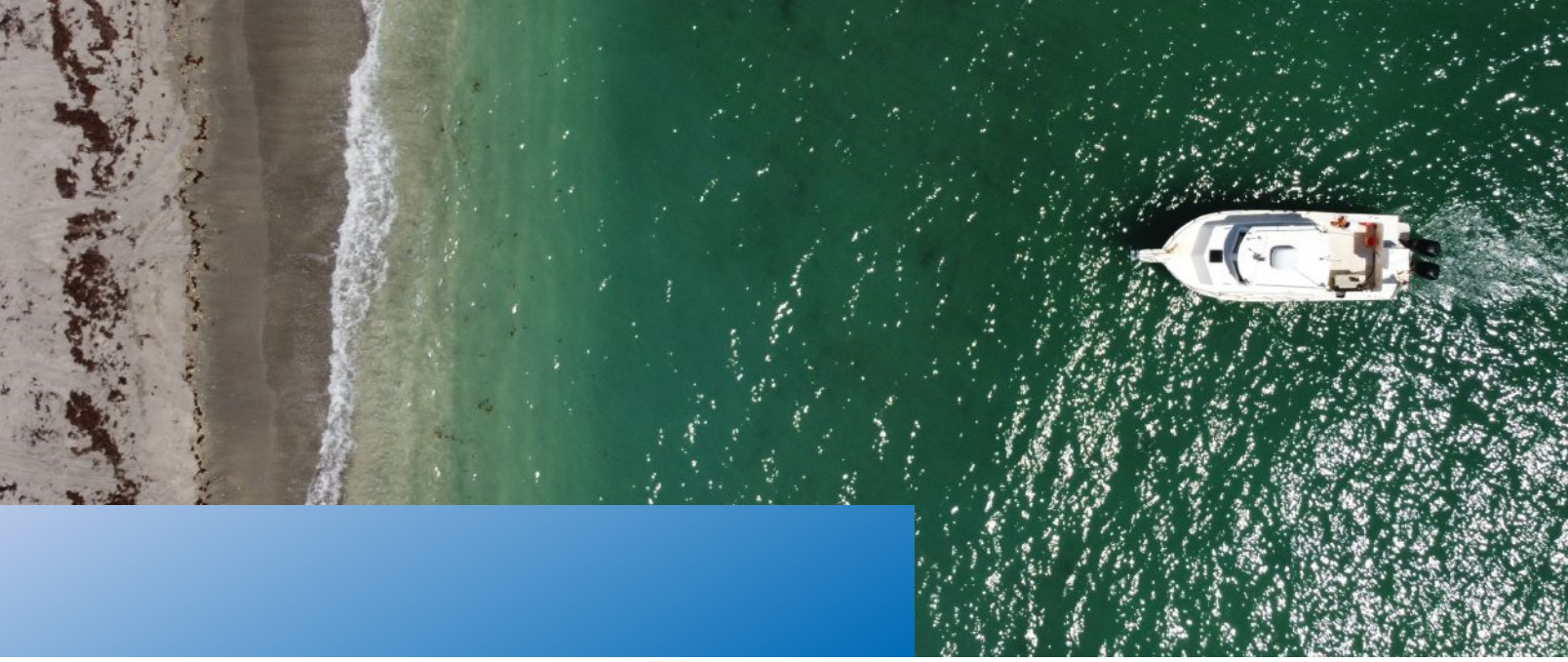

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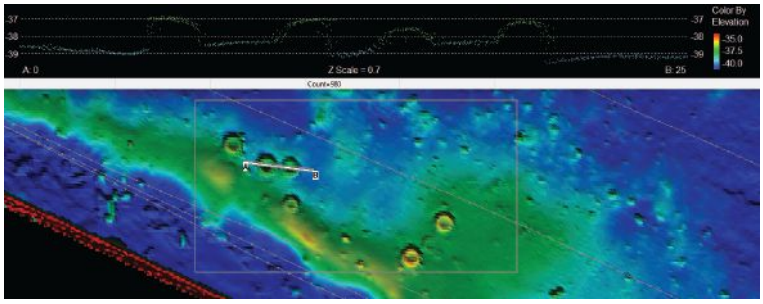

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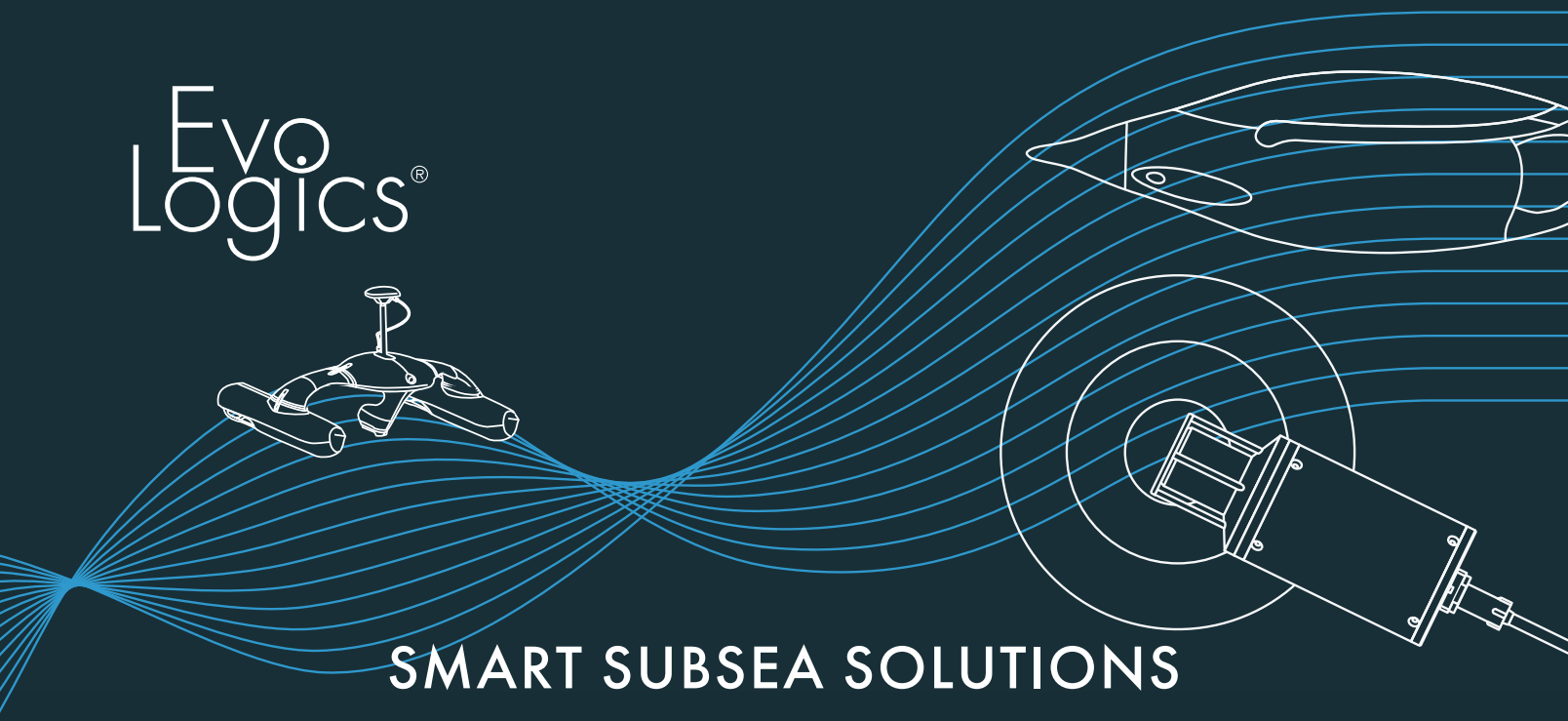

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