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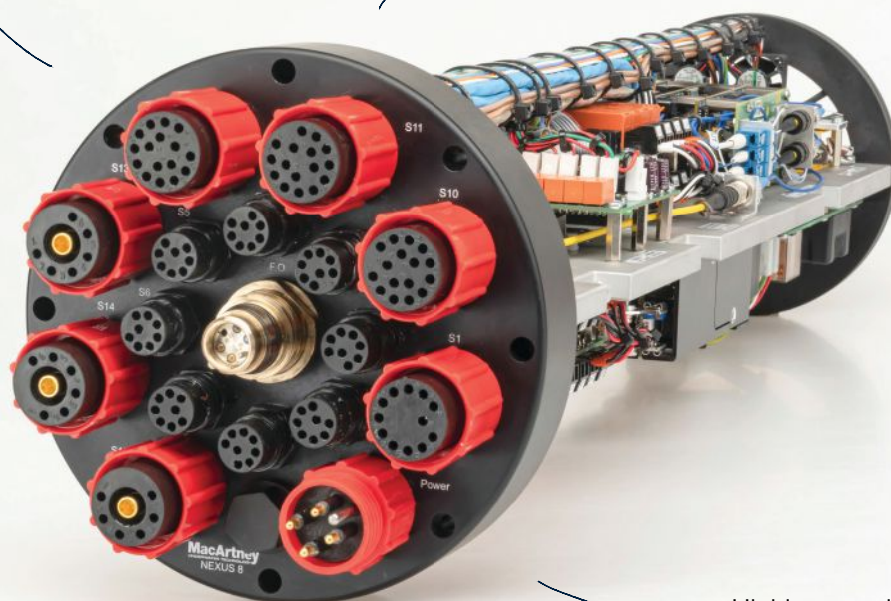
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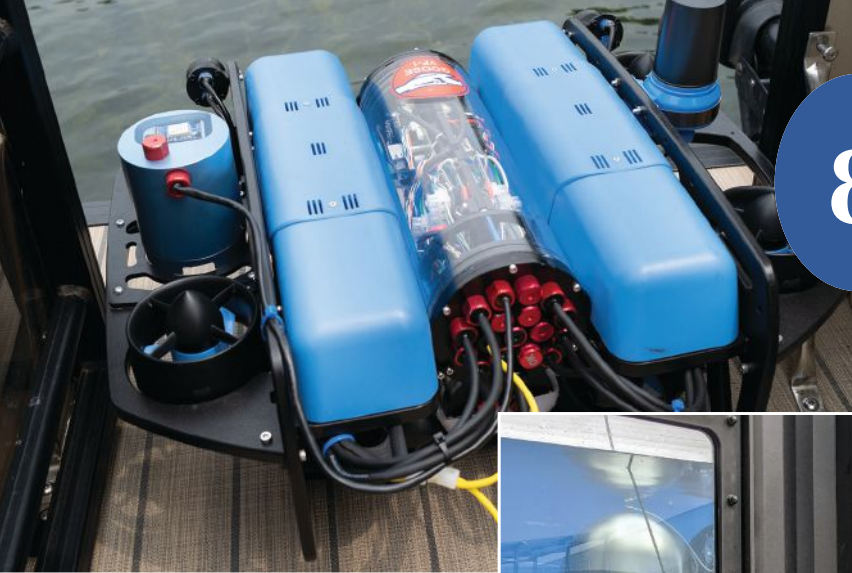
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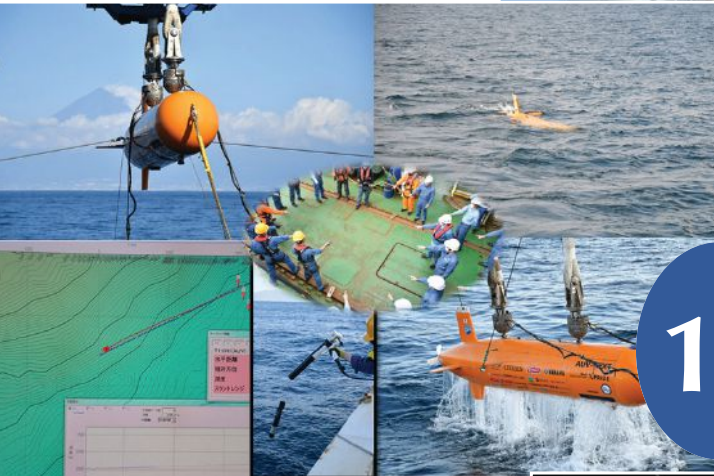




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The Delaware Police Dive Team system during an after-purchase training course for Triton's Diver Mounted Display in March 2021. (Credit: Delaware Police)

NEXT MONTH

Annual Review and Forecast.

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)) Pioneering Bioplastics in the Ocean. Today, plastics are a \$4 trillion industry, but less than 1 percent are bioplastics. The U.S. National Science Foundation has awarded funding to UC Santa Barbara marine microbiologist Alyson Santoro and colleagues—Anne Meyer and Melissa Omand at the University of Rhode Island, Ryan Freedman at the Channel Islands National Marine Sanctuary, and partners from sustainable polymers designer Mango Materials—to pioneer the embedding of live biopolymer polyhydroxyalkanoate (PHA)-degrading marine bacteria directly into plastic materials by developing strategies for extending the viability of living cells in printed materials. The field-deployable respiration chamber developed as part of this project is expected to set a new industry standard for testing materials used in the marine environment. Materials that facilitate rapid degradation of marine instrumentation under realistic environmental conditions would transform society's ability to deploy swarm sensors at scale. The research team will innovate, test and integrate biomaterials designed to rapidly degrade at end of life in oceanic conditions. The project will 3D print living bacteria into the biopolymer PHA, optimized with additives to supplement microbial metabolism. It will modify existing marine instrumentation to produce a chamber for directly measuring the respiration of plastic materials in deep-ocean environments. The research team will work with end-users to prototype products designed to be deployed in the marine environment. The overarching objective of the project is to integrate sustainable materials into oceanographic instrument applications.

)) NOAA Releases 2021 State of High-Tide Flooding and Annual Outlook. Coastal communities across the U.S. continued to see record-setting high-tide flooding (HTF) in 2020, forcing their residents and visitors to deal with flooded shorelines, streets and basements—a trend that is expected to continue into 2022. A new NOAA report shows that between May 2020 and April 2021, coastal communities saw twice as many HTF days than they did 20 years ago—and the trend of near-record-high tides is expected to continue through April 2022. From May 2020 to April 2021, 14 locations tied or broke their records for the number of HTF days along the U.S. Southeast Atlantic and Gulf coastlines, a 400 to 1,100 percent increase over what was experienced in 2000. The number of HTF events is accelerating at 80 percent of NOAA water level stations along the East and Gulf Coasts. By 2030, HTF is likely to be in the range of seven to 15 days, and by 2050, between 25 to 75 days. These long-term outlooks are based on the range of relative sea level rise “more likely” to occur by 2030 and 2050 using projections of the Fourth National Climate Assessment. Coastal flood warnings for significant risks to life and property will become much more commonplace toward mid-century. Learn more at: https://tidesandcurrents.noaa.gov/HighTideFlooding_AnnualOutlook.html.

)) Setting Priorities for Global Seabed Mapping. A new survey has given a major boost to efforts to map the entire seafloor by the end of the decade. Nearly 800 professionals representing 90 countries shared views on the value of seabed mapping and where activities to map using modern digital methods should be focused, as well as identifying some key challenges that need to be addressed to achieve the ambitious goal. The findings were released as the UN Ocean Decade endorsed a range of new global actions covering activities across the world's ocean basins. A new Call for Decade Actions was also launched; the second of a series that will be launched every six months as part of the Ocean Decade. The survey, commissioned by The Nippon Foundation-GEBCO-Seabed 2030 Project and managed by blue economy company NLA International, drew responses from across the scientific, academic, philanthropic and business communities, as well as from government and defense officials. Forty percent of online respondents considered the main benefit of mapping the ocean floor to be “to advance scientific understanding of seabed characteristics,” with 11 percent highlighting the need “to monitor environmental challenges over time.” Bathymetric data were the most desired geospatial information (81.67 percent of respondents), followed by environmental data (69 percent), oceanographic data (65.33 percent) and classification of seabed features (63.33 percent). Respondents were interested mostly in water depths less than 200 m (33.57 percent) and greater than 5,750 m (31.12 percent). A majority of respondents (58.31 percent) would want access to any data sets via an online marine data portal. The survey findings will be converted into a draft global priority list for seabed mapping activities that reflects all maritime sectors and users of seabed bathymetric data.

)) First Movers Coalition Launches New 2030 Commitments to Zero-Emission Maritime Shipping. The First Movers Coalition is a new platform for companies to make purchasing commitments that create new market demand for low- and zero-carbon fuels and technologies. These commitments were made in partnership with the World Economic Forum and U.S. Special Presidential Envoy for Climate John Kerry. Among the eight “harder-to-abate” sectors addressed by the coalition, an ambitious commitment was established for use of scalable zero-emission fuels in maritime shipping; specifically, at least 5 percent of deep-sea shipping will be powered by zero-emission fuels by 2030. An S-curve-based analysis suggests that zero-emission fuels need to make up 5 percent of the international shipping fuel mix by 2030 to enable Paris-aligned decarbonization of shipping by 2050. For cargo owners, at least 10 percent of the volume of goods shipped internationally will be on ships using zero-emission fuels by 2030; on the way to 100 percent by 2040, a target that is in line with the Cargo Owners for Zero Emission Vessels initiative. **ST**

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Introducing: Wisconsin Shipwreck Coast

On the Wisconsin shores of Lake Michigan, maritime heritage runs deep. From the 1800s to the early 20th century, wooden schooners and innovative steel steamships moved raw materials, agricultural products, and passengers over the icy cold waters of Lake Michigan and drove the prosperity and expansion of our nation. Wisconsin communities played critical roles in evolving the Great Lakes from a maritime frontier into the nation's busiest waterway. Wisconsin boasts more individually listed shipwrecks on the National Register of Historic Places than any other state.

In honor of Wisconsin's maritime legacy and following an extensive, community-led nomination and designation process, NOAA announced the Wisconsin Shipwreck Coast as the 15th national marine sanctuary in June 2021.

National marine sanctuaries are our network of protected U.S. waters that sustain spectacular species and seascapes, coastal communities, and our shared heritage. Sanctuaries not only preserve the treasures contained within, but they are also a critical bulwark in the fight against climate change and serve as a model for marine protected area management. Communities across the U.S. look to sanctuaries to protect nationally significant areas of our ocean, coasts and Great Lakes.

In 2014, the mayors of four lakeshore cities—Two Rivers, Manitowoc, Sheboygan and Port Washington—and three counties joined with the Wisconsin governor's office to submit a nomination proposal for an area of Lake Michigan to NOAA's Office of National Marine Sanctuaries. They cited the area's extensive, nationally significant archaeological and natural resources and the desire to build a sustainable economy based on recreation and tourism, new educational opportunities, and an embrace of the local cultural heritage. The nomination was supported by community partners, including the Wisconsin Maritime Museum and the National Marine Sanctuary Foundation.

Along Wisconsin Shipwreck Coast's 962 sq. mi. of Lake Michigan lie 36 known shipwrecks and 59 suspected shipwrecks, yet to be discovered. The icy cold freshwater has preserved many shipwrecks in near pristine condition.

The sanctuary includes Wisconsin's two oldest known wrecks: the schooners *Gallinipper* (built 1833, sank 1851) and *Home* (built 1843, sank 1858). *Gallinipper* was discovered in 1994 by a commercial fisherman who snagged nets on the wreck. *Home* carried grain, lumber, and general merchandise between Lake Erie and the upper Lakes. The *Home's* captain, James Nugent, was an abolitionist and collaborator on the Underground Railroad.

One of the sanctuary's best-known wrecks is the three-masted schooner *Rouse Simmons*, well known in its day as the "Christmas Tree Ship." It was built in 1868 and sank during a winter squall along with the captain and crew in 1912 as it carried Christmas trees destined for port in Chicago.

The designation will afford new protections for the shipwrecks by establishing new rules on anchoring around them. The eventual addition of mooring buoys will prevent damage to these underwater museums.

These protections and the preservative nature of the cold water combine to make the sanctuary's wrecks an irresistible destination for divers. Dive charter businesses operate all along the Lake Michigan coast, and the variation in depths of the shipwrecks means they are accessible to divers of all skill levels.

Wisconsin Shipwreck Coast National Marine Sanctuary will foster new opportunities for exploration, education, research, and tourism that benefit Wisconsin's coastal communities and bring increased attention to the Great Lakes' role in the growth of our nation. **ST**

Toward Low-Cost Subsea Autonomy

Iterative Progress Will Enable an Exciting Future in Marine Robotics

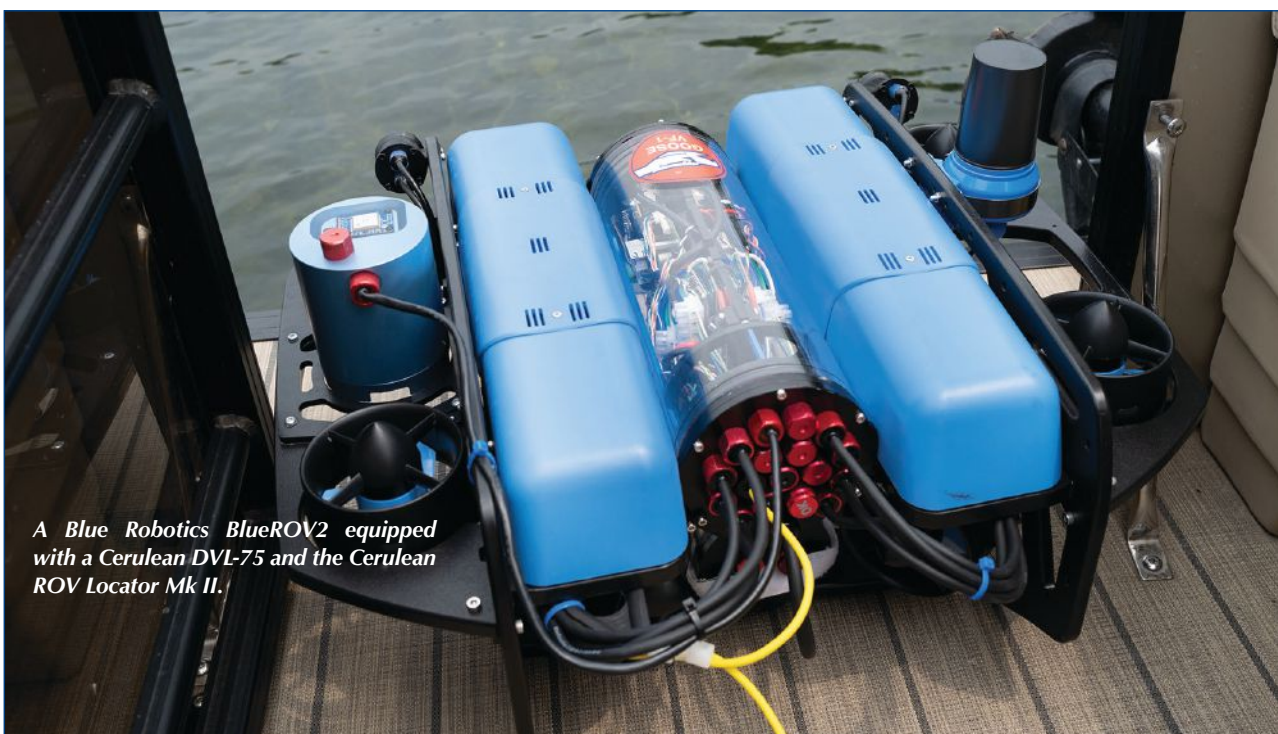
By Rustom Jehangir

The words “autonomy,” “autonomous systems,” “AI” and the like are thrown around in conferences, product marketing materials, research papers, and prospectuses on the future of the marine robotics industry. These terms inspire notions of an exciting future where we ask our robots to perform a task, and off they go.

While such fantastic visions of the future are important for imagining capabilities, equally so are the small steps we take to get there. These incremental stages can provide immense value now, with less financial risk than a solution in the distant future. The earlier we can incorporate low-cost, iterative levels of autonomy into our work, the better our return on investment will be.

The marine environment is primed for opportunities to utilize autonomous systems. Vehicles such as UUVs and subsea gliders have been taking advantage of this technology for years. These systems have benefited from operating in fairly predictable conditions that usually consist of open water with few obstacles. This environment is comparable to the open-sky conditions that enable unmanned aerial vehicles to fly unobstructed.

While open-water autonomy is useful, the next level of value comes from operating in more complicated and hostile environments, such as those where ROVs are typically utilized. In the aerial drone industry, autonomous drones are already creating 3D maps of busy construc-



A Blue Robotics BlueROV2 equipped with a Cerulean DVL-75 and the Cerulean ROV Locator Mk II.



The Seaber YUCO micro-AUV.

tion sites, following and filming athletes in action, and executing complicated flight plans with precision. One can envision similar applications for autonomous underwater vehicles. Picture an underwater vehicle inspecting a ship hull or aquaculture net and generating a report without human assistance. Imagine a small ROV keeping an eye on an underwater welder in a current without the need for an ROV pilot. Repetitive tasks that are critical to business operations present the greatest opportunity for growth in underwater autonomy.

So how do we get there? How will these advanced autonomous capabilities become ubiquitous rather than inaccessible for the majority of underwater vehicle operators? The answer is for the marine robotics industry to create a foundation upon which these capabilities can be built. A foundation that enables development and growth by providing access to advanced autonomous technology at low cost.

This solution requires three things: accessible high-performance sensors, a high rate of system reliability, and core autonomous control software upon which to build advanced mission capabilities. In the remainder of this article, I will share how this foundation is being formed, and what the marine robotics industry can do to further its growth.

Accessible, High-Performance Sensors

Beginning with sensors, anyone who has taken a robotics class or attempted to program a robotic system knows the challenges of working in the absence of capable sensing equipment. Without good sensors, an autonomous robot is blind and does not have sufficient knowl-

edge of its environment to make informed decisions.

Above water, drones and ground robots have access to a wealth of precision sensors, such as RTK GPS, LiDAR, IR obstacle avoidance sensors and computer vision systems, all of which have come down in price by an order of magnitude over the past few years. Unfortunately, it is not possible to use most of these technologies underwater. Once below the surface, GPS signals quickly attenuate and visibility is degraded, thereby rendering many of the aforementioned tools useless. However, marine analogs such as acoustic positioning systems, Doppler velocity loggers (or DVLs, which allow precision velocity sensing and position estimation), and imaging sonars do exist.

To enable autonomy in marine robotics at a larger scale, sensing devices need to be more accessible and easier to integrate into affordable vehicles. Fortunately, there are signs of this happening with exciting new developments in the low-cost sensor space. In just the last year, we have seen new DVLs from Cerulean Sonar, Nortek, Teledyne and Water Linked hit the market that are all available for a fraction of the price of previous alternatives. These new DVLs are small enough to integrate in even the smallest ROVs, opening up new possibilities for low-cost autonomy.

In addition to the progression seen in DVLs, there are advances occurring in other sensor technologies, such as multibeam imaging sonars. These developments will enable vastly more capable autonomous marine systems at a price that allows them to be used at scale. Based on these indicators, I believe that we will continue to see advances in underwater sensor technology and improved

pricing throughout the next few years, and there will be a paradigm shift in the level of autonomy of low-cost underwater systems.

High Rate of System Reliability

While quality, low-cost sensors can enable an underwater vehicle to interpret its environment and improve its autonomy, they are only useful and of value when integrated into a system that is robust and reliable. In the event that an operator is forced to deploy an ROV to search for a vehicle that has not resurfaced, the value and time savings of an autonomous system quickly evaporates.

This reliability prerequisite for autonomy is currently a primary focus for us at Blue Robotics. We have built our company on making marine robotics components affordable and accessible to more people. Now, as these individuals continue to push the limits of how our components are used, we have shifted our focus to making our products unquestionably reliable and dependable so that they may provide a foundation for truly amazing applications.

Blue Robotics has many customers developing autonomous systems that depend on our components, such as Seaber in France, which has created a UUV for autonomous data collection, and RanMarine in the Netherlands, which makes the WasteShark, an autonomous trash-collecting USV. For complex systems like these to be successful, their autonomy must be built upon reli-

“The earlier we can incorporate low-cost, iterative levels of autonomy into our work, the better our return on investment will be.”

able vehicle systems and sensors. Only with this trust in reliability can the scale of autonomy grow.

Core Autonomous Control Software

Furthermore, to enable low-cost autonomy in marine systems, we must create affordable control software that provides core autonomous capabilities. These core functions, such as waypoint following and position holding, will enable other, more advanced mission capabilities, such as mission planning and autonomous surveying of dynamic subsea terrain.

Looking above water, we are again reminded that many such systems exist for drones and ground vehicles that enable out-of-the-box autonomy and sophistication at an affordable price point. In some cases, these solutions consist of free and open-source software, like ArduPilot, which enables advanced autonomy and flight planning. These easily accessible tools allow others to build on top of them, creating mission-specific capabilities without having to start from scratch.

Similar software developed for underwater vehicles that supports autonomous operation in complex marine environments has typically been an expensive add-on, often multiplying the cost of the overall system. However, similar to the new low-cost sensors entering the market, there are new and interesting options appearing in this sector as well. One such option is EIVA's NaviSuite Mobula software, which adds autonomy to vehicles for a small annual subscription price. Also, at Blue Robotics, we develop and maintain ArduSub—a branch of the ArduPilot project that brings free and open-source control software to ROVs. Low-cost solutions like these will provide the foundation to build more advanced, mission-specific autonomous capabilities.

Conclusion

Furthering progress in accessible sensors, high system reliability and affordable core software with autonomous capabilities will provide the foundation to scale the use of autonomy in marine systems. While the progress in these three areas will come one small step at a time, I believe that it inspires visions of an exciting future. **ST**

Rustom Jehangir is the founder of Blue Robotics Inc.

Long-Range: Now Within Range

Cellula Closes In On a Hydrogen-Fuel-Cell-AUV Future

By Nicole Chan

Developing a large-scale, long-range AUV is not a task for the faint of heart. Add in a requirement to be powered by a hydrogen fuel cell and the capability to complete port-to-port missions unaided, and the stakes are even higher.

These are serious goals, particularly as interest in the use of hydrogen and underwater security increases. They're also goals that are closer to becoming a reality, thanks to Cellula Robotics' Solus-LR (Long Range) AUV development program (Sea Technology, November 2019). Following three years' work under a multi-phase Defence Research and Development Canada (DRDC) contract, the British Columbia-based company is closing in on commercial offshore long-range missions that eliminate the need for launch, recovery and support from large, fully crewed ships.

The project, initiated in 2018, was to develop a hydrogen-fuel-cell-powered AUV with a range of more than 2,000 km and an ability to operate autonomously while submerged for multiple months at a time—a feat that no commercial AUV is capable of currently. It's an ambitious goal that supports Canada's All Domain Situational Awareness (ADSA) program, which aims to strengthen Canadian air and maritime surface and subsurface surveillance strategies in the Arctic.

Additionally, the ability to deploy an AUV that's able to travel thousands of kilometers and complete multi-week missions under Arctic ice before returning to a port could provide a new and efficient way to conduct port-to-port geophysical surveys and pipeline inspection services, and deepwater offshore wind survey and inspection operations, in addition to more covert towed-array surveillance operations.

Hydrogen Fuel Cell

Following trials through 2019 and 2020, the Solus-LR platform has been proven, including use of its suction anchor, which allows Solus-LR to rest and "listen" silently

on the seabed, providing AUV persistence while it waits to be tasked. The final milestone to complete the fuel cell is expected by March 2022.

"It's been an impressive journey, going from an idea in a white paper to a fully fledged vehicle and fuel cell within three years," said Adrian Woodroffe, business development manager at Cellula. "Quite a few people have tried and have developed fuel cell power systems for AUVs," he said, "but none have been put together in an operational setting or used over a very long range."

Hydrogen fuel cells offer a number of benefits for long-endurance AUV operations, according to Woodroffe. A key benefit, and one that's even more pertinent during the energy transition taking place around the world, is that hydrogen is a clean, renewable fuel that can be easily produced anywhere.

"There's renewed interest in hydrogen as a fuel source," said Woodroffe. "Some of that is for military applications, where it offers a logistical advantage. You can make hydrogen from water using solar or wind energy through electrolysis. For the military, that's of interest because it removes the need to consider the challenges for supplying diesel for generators. Instead, you could lay out solar panels."

Energy density is also a key element in the choice to go with hydrogen fuel cells. "We are now out-performing lithium-ion for the overall system in this respect," said Woodroffe. "Batteries are dense, and in an AUV you need foam to balance that density, resulting in a larger-sized cell. It's a linear relationship. For long-range systems, that's where the fuel cell starts to win. It's a fixed-size mechanical plant, no matter how much energy you want to store."

The predominant commercial hydrogen fuel cell technology in the market is the proton exchange membrane (PEM) fuel cell. Early on, Cellula had looked at direct methanol fuel cells, but these produce CO₂, which then must be dealt with in a closed system. The com-



Solus-LR.

pany is now using a commercial PEM stack. It operates in a closed system, with high-pressure gaseous oxygen and hydrogen fed in through pumps and blowers to make electricity. “Wastewater” is then captured in ballast tanks, maintaining the vehicle’s trim and buoyancy throughout the mission.

The 250-kWh-capacity gas system stores enough energy to provide continuous power for the vehicle to cruise at 3 kt.—an ideal speed for survey operations—for over 2,000 km. However, the fuel cell does not work in isolation. It’s combined with a rechargeable lithium-ion battery that can provide on-demand power for burst speed, allow for minimizing noise to move quietly, and/or power only certain sensors while at anchor.

“If you need to shut the vehicle down to go super quiet, you can power down the fuel cell and run on the battery alone,” said Woodroffe. “For commercial operations, it’s more about optimizing the fuel cell.” That’s because fuel cells work best when used at their optimal power

rating, he explained. “Trying to draw 20 percent capacity isn’t efficient, so the battery hybrid model is really important. When cruising at 3 kt., the fuel cell produces about the right amount of power, but the battery can fill in if a bit more power is needed. Conversely, the fuel cell will recharge the battery when power is available.”

Vehicle Validation

Cellula has taken a twin-track approach to the development of Solus-LR, working on the vehicle navigation and control system concurrently with the fuel cell development.

The vehicle was completed at the end of 2019 and has been regularly running missions using its battery pack while work continues on the fuel cell. Solus-LR measures 8.5-m long and 1 m in diameter, and has a mass of 3,700 kg. It uses a variable buoyancy engine to maintain optimized trim throughout each mission and actively controlled forward planes for precise low-alti-



(Top) A bird's eye view of Solus-LR during tank testing in 2020. (Bottom) Solus-LR's fuel cell completing underwater testing in 2020.

tude maneuvering. It has a Sonardyne inertial navigation system (INS) with integrated Doppler velocity log (DVL), as well as integrated ultrashort baseline (USBL) and long baseline (LBL) beacon for position correction. Solus-LR's hardware and software has been built to be both modular and reconfigurable. Its software architecture was developed using Robot Operating System middleware. The vehicle itself can be operated with or without the fuel cell, suction anchor or other payload modules.

Full in-water trials started in 2019, first in Port Moody off Burrard Inlet, near Vancouver, focusing on the vehicle's autonomous behaviors. Then, last year, the vehicle proved its 2,000-km-range potential at its 3 kt. (1.5 m/s) optimal cruising speed during full vehicle sea trials in Indian Arm, a 20-km-long saltwater fjord. As well as proving its range capability, these trials focused on control system tuning and hydrodynamic drag analysis. The suction anchor was also tested during these trials. It works by being lowered from the vehicle using a powered umbilical, which then powers a pump that sucks the caisson into the seafloor. Once in place, the AUV's variable buoyancy engine is used to provide positive trim, enabling the vehicle to float back on the umbilical,

away from the seafloor. During the trials, hold tests were conducted, proving the AUV's station-keeping capability using the suction anchor in currents of up to 2 m/s, depending on soil conditions. In these trials, the fuel cell was also integrated into the vehicle, but batteries were used for power.

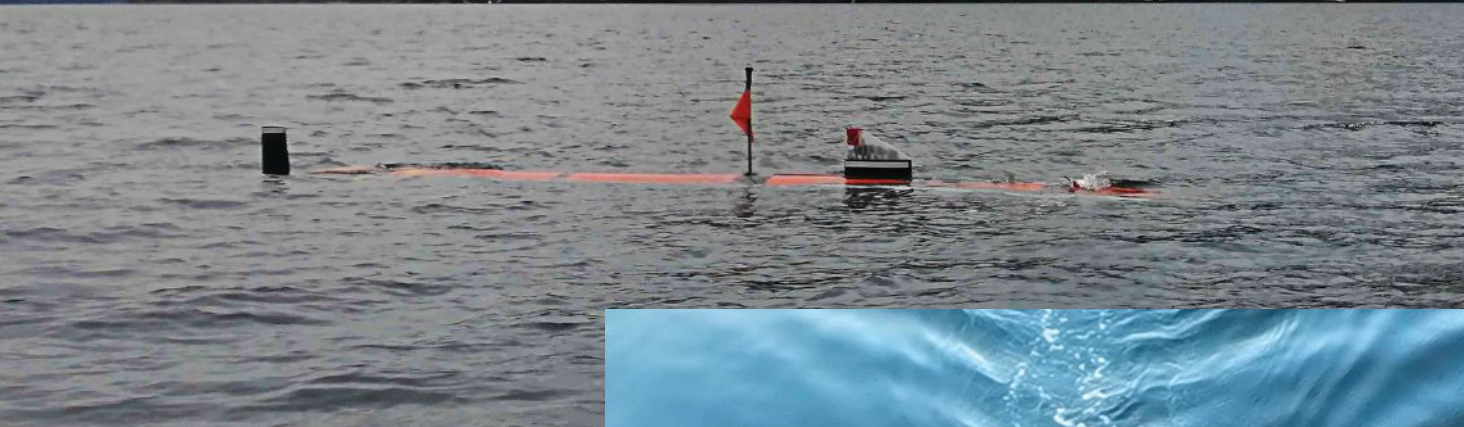
Then, early this year, Solus-LR carried out its first commercial operations with Canadian firm Ocean Floor Geophysics (OFG) to measure and model the magnetic and electric signatures of a naval training vessel for the Royal Canadian Navy. In these operations, data were collected by OFG sensors integrated into Solus-LR. In total, since October 2019, the vehicle has spent 99 days in the water on trials.

Fuel Cell Development

Through 2019 and into 2020, a full fuel cell system was built into a sealed unit and tested in Cellula's 50,000-L test tank. It was then put through multiple underwater and endurance tests.

A key challenge has been the reliability of peripheral fuel cell systems, such as pumps and blowers. This reliability is currently being improved, along with a simpli-

Solus-LR during sea trials in the fourth quarter of 2020.



fication of the control architecture under contract with DRDC, which will be completed in March 2022.

"The focus of the original DRDC project was to get it in the water and to use the fuel cell to power a long-range mission. We didn't quite achieve that," said Woodroffe. "COVID didn't help, but there have also been some technical challenges we had not anticipated. So now we have a project to close that gap, and we're looking at a long-range mission next year."

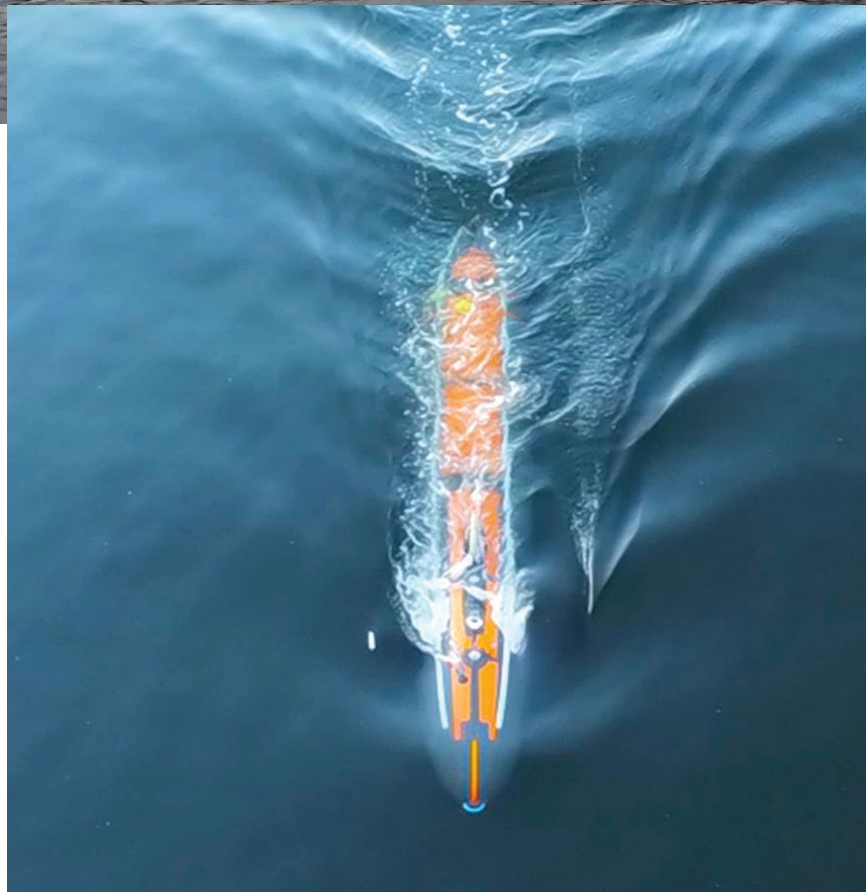
Alex Johnson, AUV product manager at Cellula, is confident about the process. "With the work that we've done, the technology is there. Now it's about improving the reliability," he said. "Most AUVs run 24- to 48-hour missions and they normally have a crewed vessel that follows them, so if they develop a fault they can be picked up and fixed."

"A 15-day mission with the AUV out on its own is something else. The reliability has to be considerably better and the trust in autonomy has to be considerably higher, and we are working on that. The fuel cell is part of that, and testing in steady state, over many weeks, is going to be an important part of our ongoing work. By the end of March, I expect to see 10-day continuous operation tests."

Continuous Learning

There are also further adjustments Cellula is making. On every mission, there are learnings, according to Woodroffe. "Every time we put Solus-LR in the water, we get to learn something and we get to improve it."

"The next steps for the Solus-LR project is to prove



its capabilities in port-to-port operations with a range of commercial and defense payloads," he added.

"Cellula is pursuing commercial survey jobs and technology demonstrations with Solus-LR to build our track record of reliability," said Johnson. "The goal is to ensure Solus-LR AUVs are built for the rigors of commercial and defense operations." **ST**

Nicole Chan is the marketing and communications specialist in Cellula Robotics' business development team.

AUV Bathymetric Survey Data

Developing Standardization, Quality Control

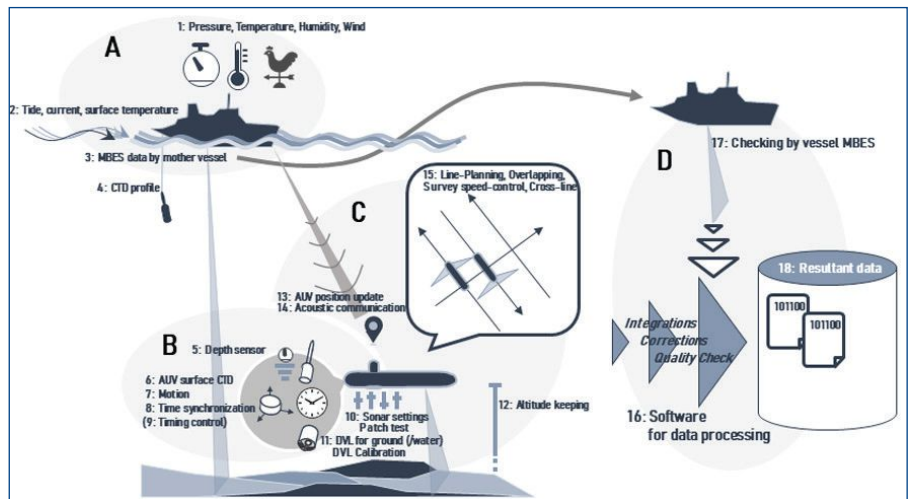
By Masanao Sumiyoshi • Dr. Tadahiro Hyakudome • Dr. Yusuke Yokota

In AUV bathymetric surveys it is possible to acquire bathymetric data with higher resolution in horizontal and vertical directions, with higher precision and less noise, even in deepwater. However, there are many challenges in using AUVs to obtain reproducible seafloor topography. It is necessary to research appropriate settings for each bathymetric sonar, determine the flexibility of an AUV for dynamic performance, and use navigation methods appropriate to each vehicle.

To acquire seamless detailed seafloor topography using multiple AUVs, it is important to unify the observation accuracy of different vehicles. To compare current and future seafloor topography, a standard method must be established for acquiring bathymetric data with high accuracy and sufficiently high reproducibility.

Our project aims to standardize AUV bathymetric survey data for the Hydrographic and Oceanographic Department of Japan Coast Guard (JHOD) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). In the future, we expect that this project will contribute to the unification of essential observation items and result in standard formats of bathymetric data acquired by different AUVs, as well as the temporal comparison of detailed seafloor topography.

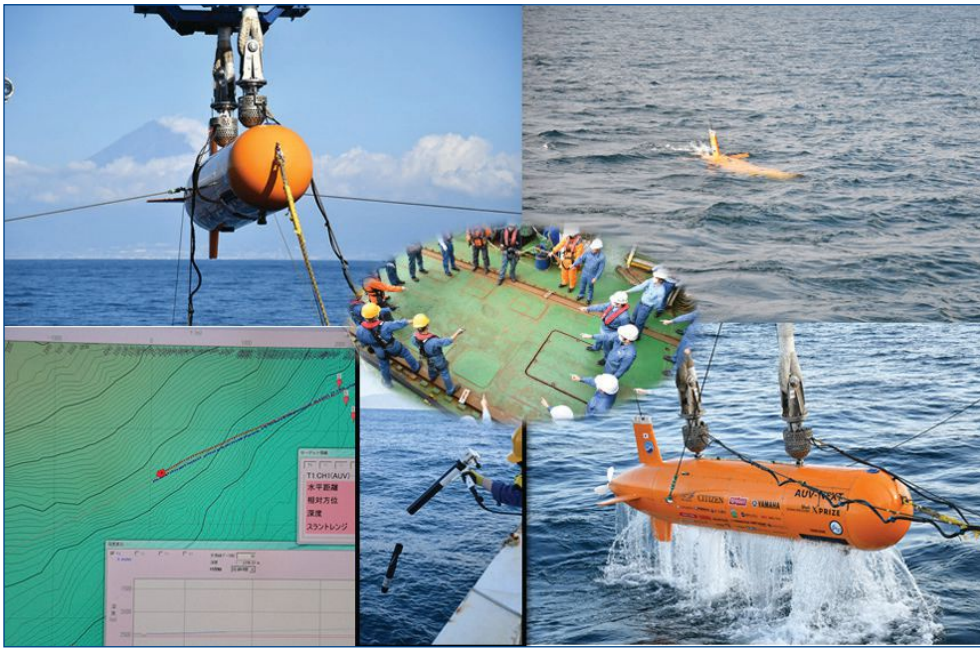
In bathymetric surveys by surface vessels, sonar footprints at the seafloor become larger with increasing depth, and therefore the horizontal resolution of the acquired data decreases with increasing depth. Lower sonar frequency is necessary to obtain deeper bathymetric data, which comes with decreasing vertical resolution in deeper waters.



Checkpoints for standardization and quality control of AUV bathymetric survey data, grouped into four main factors (A, B, C and D).

For the realization of precise bathymetry in deep waters of several thousand meters, many institutions and companies have been developing AUVs that do not restrain vehicle movement by tow cables to conduct high-resolution deep-seafloor surveys and images. A variety of AUVs are being developed all over the world, and no other technologies have been able to replace them so far, especially for deepwater high-resolution bathymetric surveys using swath bathymetric sonar.

Precise surveying of the deep seafloor has proven useful not only for basic understanding of the seafloor, but also for natural resource surveys, volcanic surveys, seismic fault surveys and, recently, crustal movement surveys for earthquake research. Until now, such information has



JAMSTEC performs an operation with AUV-NEXT, a JAMSTEC-developed vehicle that was used by the award-winning team of the Shell Ocean Discovery XPRIZE, KUROSHIO.

only been collected and used for each observation opportunity. There are not enough quality control frameworks and considerations for scientific secondary use. For quality control, it is necessary to ensure data quality that can withstand comparisons and establish data formats, which have already been implemented in other surveying and positioning fields, e.g., RINEX (Receiver Independent Exchange) format in GNSS positioning.

Standardization Framework

There are various types of AUV bathymetric surveys: conducting a seafloor survey for several days with a single AUV; conducting multiple surveys at different observation opportunities; surveying the same area using multiple AUVs of the same type; conducting a seafloor survey using multiple AUVs of different types; and so on. It is difficult to acquire the same quality seafloor data when using various types of surveys. Therefore, we propose a data acquisition method and a quality control method so that the quality of acquired seafloor data is uniform regardless of the opportunity, the AUV equipment and vehicle type.

Since various acoustic devices, measuring devices, propulsion devices, etc. are related to AUV swath bathymetric survey accuracy, it is necessary to set many check items for quality control. To maintain the quality of data, it is necessary to pay attention to four factors. One factor (A) is acquisition of environmental data for correction: pressure, depth, temperature, humidity, wind, tide, current and surface temperature, as well as MBES (multi-

beam echosounder) data from the mother vessel.

A second factor (B) is setting the conditions for AUV-equipped devices: depth sensor, AUV surface CTD, motion, time synchronization and timing control.

A third factor (C) is AUV operation and navigation: sonar setting and patch test; DVL for ground (or water) calibration; altitude keeping; AUV position update; acoustic communication; and setting and operation of survey line (e.g., line planning, overlapping, survey speed control, cross-line, etc.).

A fourth factor (D) is data processing: software, checking via vessel MBES and resultant data formatting.

The first factor (A) is related to support by the mother vessel. The other three factors (B, C, D) are related to the work before, during and after the AUV operation, respectively.

The factor of environmental data (A) is mainly for the purpose of checking and correcting resultant data. The AUV data should be confirmed by the MBES data obtained by the vessel as much as possible. The second factor (B) is a check related to AUV equipment and settings; failing to conduct this check may lead to fundamental (systematic) errors in AUV positioning and swath bathymetric data.

The third factor (C) is the most important item, related to AUV navigation; it has a great influence on both random and systematic errors. Data and metadata related to the second and third factors (B and C) are very important for use and evaluation. Proper metadata conversion and data standardization are necessary for future extensive deployment of AUVs.

The fourth factor (D) of data processing and calibration also greatly affects accuracy. It is necessary to consider the representation of metadata that can properly track the processing for scientific secondary use.

Sea Trials

JHOD and JAMSTEC have multiple AUVs for different purposes. JAMSTEC's observation results from multiple dives are required for the quantitative evaluation of the quality checkpoints we have outlined and the verification of their necessity.

Sea trials were conducted using AUV-NEXT, a JAMSTEC-developed vehicle that was used by the award-winning team of the Shell Ocean Discovery XPRIZE, KUROSHIO. The length of the vehicle is 5.6 m, weight in the air is 2.3 tons, maximum working depth rating is 4,000 m, and normal cruising speed is 3 kt. (max 4.5 kt.). The

main navigation equipment installed in the vehicle is an inertial navigation system (INS) and Doppler velocity log (DVL). The sonar installed in the vehicle is the bathymetric side scan sonar EdgeTech 2205.

The sea trials were carried out in March and November 2020. The survey area was off the Kii Peninsula in Japan. The DVL for the sea trial in March 2020 was a Teledyne RDI Workhorse Navigator, and a Teledyne Marine Tasman DVL was used in November 2020. DVL calibration and corrections of sonar angular misalignments were performed during both sea trials.

Through these sea trials, it was found that AUV positioning and acoustic sonar measurement have particularly large impacts on AUV bathymetric data. These errors are likely to result in bathymetric systematic distortion. In order to improve the accuracy of AUV positioning, it is important to properly conduct DVL calibration, which affects the relative accuracy of DVL-INS navigation of an AUV, and XCTD (expendable CTD) profile observations, which affects the absolute accuracy of the initial AUV position and AUV position updates. In order to improve the accuracy of acoustic sonar measurement, it is important to incorporate standard hydrographic techniques to record high-quality data, such as sonar setting optimization, patch test, survey line planning and bathymetric data processing. High-precision DVL calibration is considered essential in order to acquire reproducible AUV bathymetric data efficiently and sustainably.

Looking Ahead

Currently, we have started a survey for standardization of such AUV surveys and are gradually collecting data, including results of the initial tests above. In the future, it will be necessary to first clarify which checkpoints are indispensable, which ones improve quality and which ones are supplementary. For example, data-format establishment and distribution are essential for future maintenance, comparison, and evaluation of data sets.

We hope that sharing these standardization and format ideas with the international AUV surveying commu-

nity will enable the formation of a global standard for bathymetric survey data.

Acknowledgments

The work discussed in this article was funded by JAMSTEC. This project is progressing through discussions with R. Nagasawa and T. Hashimoto at JHOD, and T. Nakatani, T. Sawa and K. Nagahashi at JAMSTEC.

References

For a list of references, contact Yusuke Yokota at: yyokota@iis.u-tokyo.ac.jp. **ST**

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Dr. Tadahiro Hyakudome is an engineer for underwater robotics research and development with JAMSTEC. His research interests include AUVs, ASVs, and the development of power sources such as fuel cells and batteries.

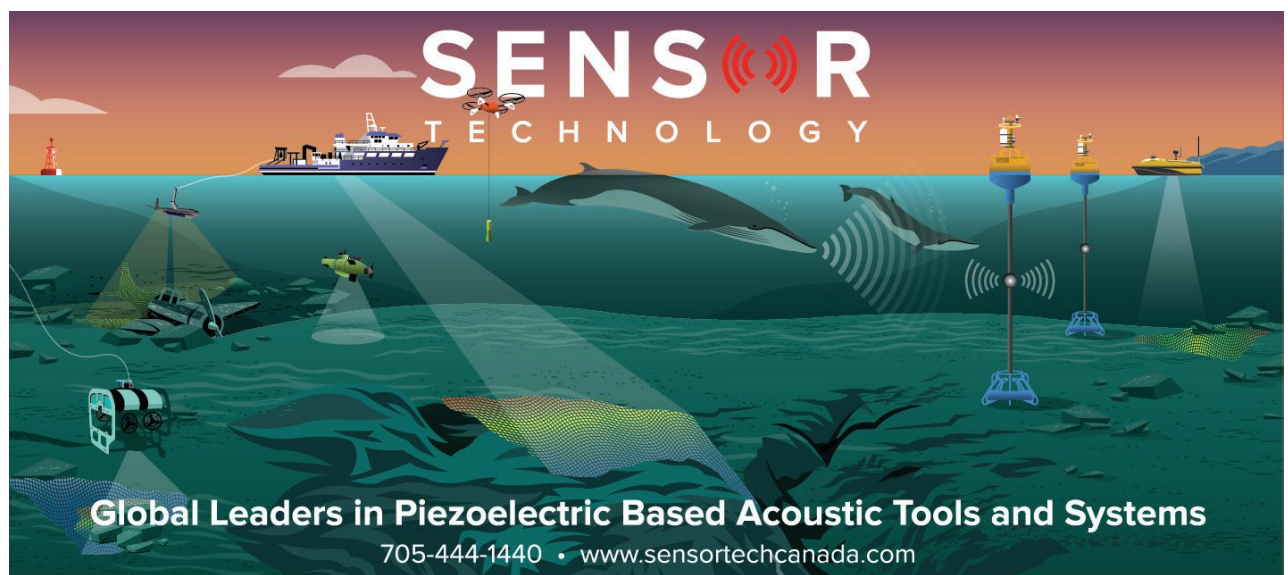


Dr. Yusuke Yokota is an associate professor of seafloor positioning and monitoring systems at the Institute of Industrial Science, University of Tokyo. Before 2018, he worked at the Hydrographic and Oceanographic Department, Japan Coast Guard. His research interests include satellite geodesy, seafloor geodesy, earthquake science, marine acoustics and seafloor surveying.



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Still Seeking Moby Dick

Spotting Whales from Space via Satellites, AI

By Julika Voß • Caroline Höschle • Dr. Grant Humphries

Modern space technology and artificial intelligence have combined to enhance the conservation of marine animals via the new service “SPACEWHALE,” developed by a team of creative scientists in Germany and the U.K., which detects whales from space. Supported by funding from the European Space Agency (ESA) Space Solutions program (<https://spacesolutions.esa.int>), this fundamental research enables whales and other large marine megafauna to be surveyed at an unprecedented scale. Earth observation from satellites is developing fast, and within a few years, space technology companies aim to provide daily high-resolution images of the whole globe. SPACEWHALE makes use of this to boost marine research and conservation.

In contrast to previous limited whale monitoring by ship or aircraft, satellite images cover the global ocean surface. SPACEWHALE not only detects whales but also other large marine animals. Many questions that previously required individual biological studies can now be answered with just a few clicks: Which areas are especially used by marine mammals; when do whales pass through a certain region during their migration? With the answers to these and other questions, solutions can be found that combine species protection on the one hand and human use of the seas on the oth-



Two Humpback whales (Megaptera novaeangliae) from aerial view in the Arctic. (Credit: Michael Schauer)



Fin whale detected from the SPACEWHALE algorithm. (Credit: BioConsult SH)

er. For example, periods can be determined in which oil and gas or offshore wind farm activities cause the least disturbance to wildlife.

Earth observation by satellites is currently developing rapidly. It will only take a few more years for space companies to provide high-resolution images of the entire globe on a daily basis. That makes SPACEWHALE a forward-looking tool, but it already performs very well with the imagery we have today. Over 70 percent of the Earth's surface is covered by water and, thus, large areas are still unexplored. The intelligent use of satellite imagery can now help us to unlock some of the mysteries around life in the open ocean. SPACEWHALE is part of this revolution: It is a fast and efficient means of surveying whales—at a comparable cost to traditional methods, which only cover small areas of the oceans.

Satellite Images, Automatic Recognition

SPACEWHALE uses satellite imagery with a resolution of 31 cm per pixel across the ground, meaning that a 23-m-fin whale has a length of around 77 pixels when it fully surfaces. This is currently the highest commercially available resolution, and though the images appear rather coarse, the resolution is just right to detect large whales.

Automatic image recognition is now widely used for many applications in our daily life, but to be successful, it needs to be based on a large set of training images. To date, there are only few satellite images of large whales available to teach an algorithm. The staff of BioConsult SH and HiDef Aerial Surveying Ltd. found a solution to this problem: They used transformed digital aerial images of the smallest baleen whales, namely the 7- to 10-m-long minke whales, which came from monthly

monitoring flights of offshore wind farms. The researchers were able to show that the algorithm trained in this way could subsequently recognize 23-m-long fin whales and other whale species on satellite images.

Another unique feature of SPACEWHALE is the semi-automatic process of evaluating satellite images, which takes only a few days to a week. Collected satellite imagery is first analyzed by way of an automated deep-learning algorithm that identifies objects throughout the survey area. This automated process is highly effective. A study in collaboration with Stony Brook University in New York and HiDef Aerial Surveying Ltd. from the U.K. showed that the algorithm correctly classified 100 percent of images containing whales and 94 percent of images containing only water. Once the automated process is complete, a large team of expert reviewers validates the results to ensure all objects are correctly classified and identified and that whales are not confused with other objects such as boats, rocks, waves, or foam.

Case Studies

Studies of SPACEWHALE proved successful: In the Mediterranean Sea, SPACEWHALE detected almost twice as many fin whales as a previous manual investigation. The algorithm also successfully counted humpback whales in Hawaiian waters and southern right whales off the Argentinian coasts and other Southern Ocean areas.

In another study, in the Bay of Biscay, the team flew over the area with digital video cameras while simultaneously capturing satellite imagery. Analyses are ongoing, examining the overlap between traditional aerial surveys and modern semi-automated techniques using satellite imagery. Animals are identified to the species level.

Further studies are currently planned in waters off the U.S. and Mexico, yet studies can take place anywhere in the world's ocean.

Conclusion

SPACEWHALE makes a significant contribution to marine conservation. Artificial intelligence combined with satellite images offers completely new opportunities. The application of SPACEWHALE can help identify critical habitats of whales and inform marine spatial planning and impact assessments of offshore developments.

Accelerating climate change is also expected to cause profound changes, especially in Arctic waters, with associated declining ice cover and expanding human activities in whale habitat. Historical ranges of whales are changing. With SPACEWHALE, we want to contribute to the targeted implementation of protection measures for great whales, even in the most remote areas.

"ESA Space Solutions are pleased to support the development of the SPACEWHALE service," said Rita Rinaldo, head of the Partner-led and Thematic Initiatives Section of ESA Space Solutions. "It demonstrates that the possible applications of satellite data are endless and only becoming more so with new satellite capabilities, such as higher resolution imagery and improved coverage, being made available at an ever-increasing rate. This project testifies ESA engagement in protecting biodiversity and natural ecosystems, in support of the European Green Deal objectives."

To learn more about SPACEWHALE, visit: www.spacewhales.de.

References

For a list of references or to send questions, contact Caroline Höschle and Julika Voß at: spacewhale@bioconsult-sh.de.

U.K. contacts are: Dr. Grant Humphries (grant.humphries@hidefsurveying.co.uk) and Dr. Kelly Macleod (kelly.macleod@hidefsurveying.co.uk). **ST**

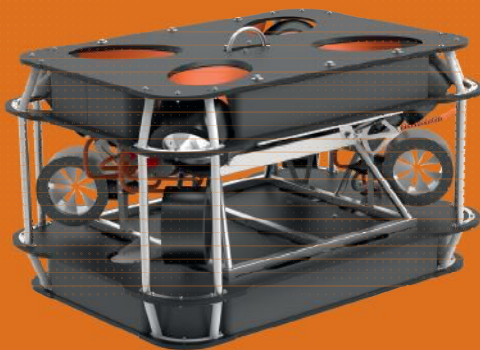
Julika Voß is a marine scientist at BioConsult SH. She graduated in marine environmental sciences from the University of Oldenburg in 2021. Her research focus is on cetacean ecology, and she has gained practical experience in the Azores, Iceland and Italy, as well as statistical experience in analyzing acoustic and visual data from cetaceans.

Caroline Höschle is a marine scientist and research team leader at BioConsult SH, where she has worked since 2009. She graduated from the University of Hamburg with a degree in biology. Her work focuses on applied sciences in the marine environment, including monitoring marine mammals with acoustic and aerial surveys for environmental impact assessments, and researching new techniques.

Dr. Grant Humphries is the lead data scientist at HiDef Aerial Surveying. He completed his Ph.D. in zoology at the University of Otago in 2014. He worked as a post-doctoral researcher at University of California, Davis and Stony Brook University. His work focuses on applying machine-learning algorithms to complex ecological data sets, developing web-based applications for conservation, and building and maintaining large databases.



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3D Holograms and AI

Next-Level Subsea Photogrammetry for High-Accuracy Imaging

By Arnauld Dumont



3D hologram by Avalon Holographics of a subsea valve photogrammetry survey by DimEye.

The 3D measurement technique of close-range photogrammetry has been developed extensively over the last several years, especially in previously inaccessible areas. The main applications are 3D as-built CAD (computer-aided design) modeling of existing installations and 3D mapping of anomalies (e.g., cracks, dents or bulges in subsea infrastructure).

Challenges to making these measurements include the irregular movements of vehicles such as ROVs, strong

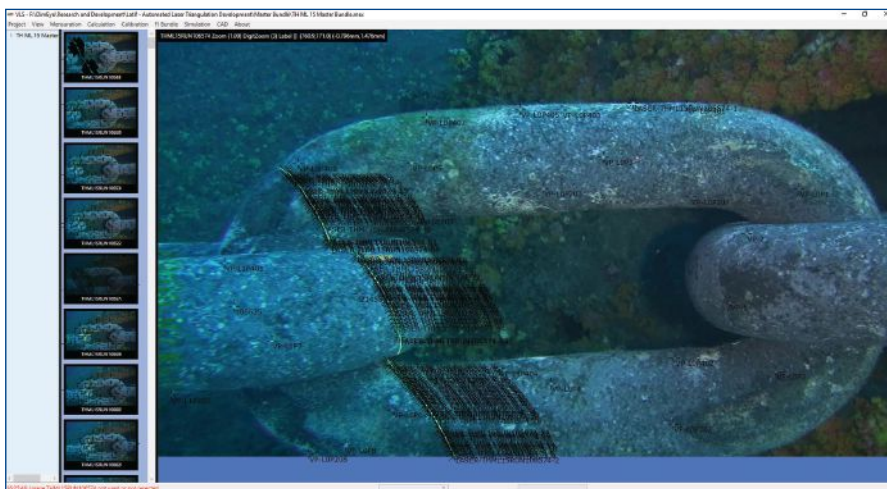
currents, and the variable quality of images depending on weather-related conditions (e.g., bad visibility).

Classic image-processing techniques used for in-air applications can sometimes fail underwater, including for real-time applications. That's where artificial intelligence (AI) techniques can help, ensuring a high level of automation.

In parallel with AI image-processing developments, new tools of 3D representation have emerged and are



(Above) Superimposition of a photogrammetry image on corresponding 3D as-built CAD model, showing all information in one image. (Below) Laser-line detection using classic image-processing technique (top) and AI (bottom) for a mooring chain survey.



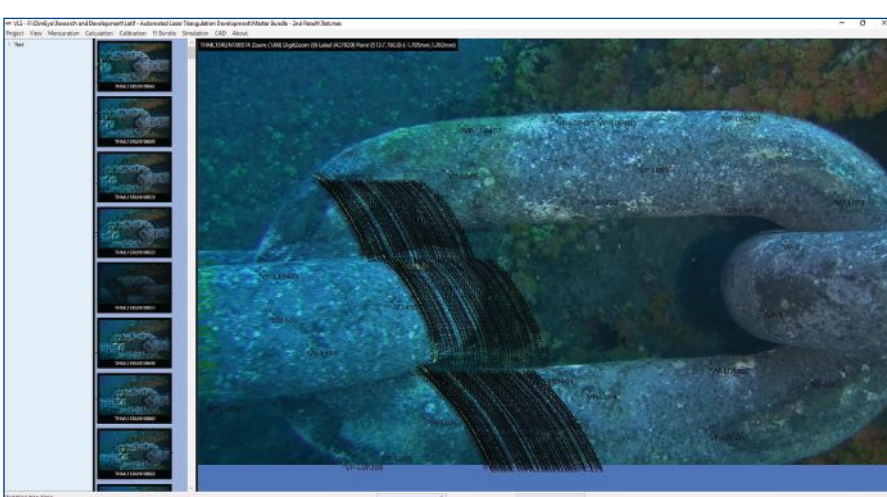
has been developed and demonstrated successfully by Avalon Holographics.

Unlike other measurement technologies, such as LiDAR (light detection and ranging), that capture only distances and angles converted in Cartesian coordinates (X, Y and Z), photogrammetry captures many types of information: point coordinates, geometrical features and texture of objects. The challenge is developing the software functions to detect all these elements on the images as automatically as possible and further compute them in 3D.

DimEye Advanced Photogrammetry Process

The DimEye Advanced Photogrammetry Process can be divided into three main steps: extraction of images from video files; detection of all points and objects; and 3D computation of all detected elements.

The extraction of images from video files entails automatic selection of a number of images (e.g., one image every 30 images), depending on the vehicle's speed and the camera's frame rate. With the



paving the way for a new approach that would have seemed mere science fiction not too long ago. For example, the first hologram of photogrammetry 3D models

increasing capability of the software, we plan to process all images in the future, thus eliminating this step.

The 3D computation of all detected elements is one of

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the unique features of DimEye software, and it includes points and geometrical features, such as cylinders, circles, lines and planes in least-square algorithms.

The detection tools are critical to the level of automation. However, they can sometimes fail subsea because of variable image quality and visibility issues. This is where AI becomes powerful. Among the objects to be de-

tected, DimEye sometimes adds the projection of a laser line to generate a massive point cloud on local anomalies such as cracks or pipe dents, for example (these massive local point clouds can be sent for finite element analysis). However, the laser line (which is only an optical target, in this case, no distance measurement) can quickly be impacted by the ambient light (too much or not enough light), sudden ROV movement, particles in the water, or residual marine growth. As a result, the laser-line detection algorithm will have difficulties measuring points over the entire laser-line length: The operator will have to switch to manual mode and add all the missing points. But if we use AI with a database of a significant amount of images covering all possible scenarios, then measurement can be automatic.

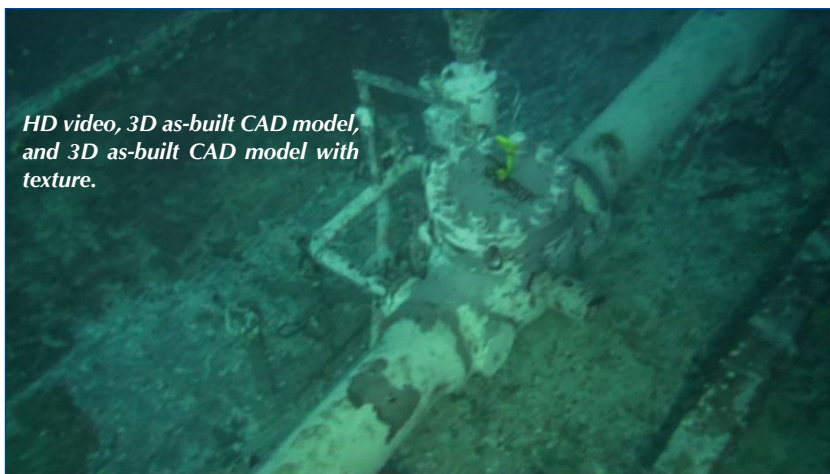
Subsea Examples

We demonstrated this new 3D imaging tech in relation to subsea valve imaging and mooring chain measurement. We conducted a valve survey in 2018 for BP in the Gulf of Mexico that did not include an AI technique but did involve the creation of a 3D hologram in 2021. For another client, we conducted a mooring chain survey for a site integration test in March 2021, where we tested AI successfully for the first time (we did not generate any 3D holograms in this case).

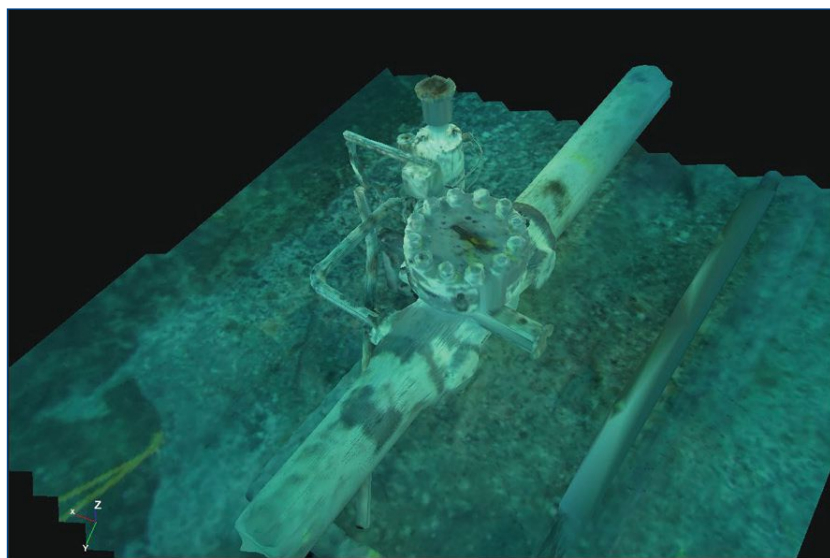
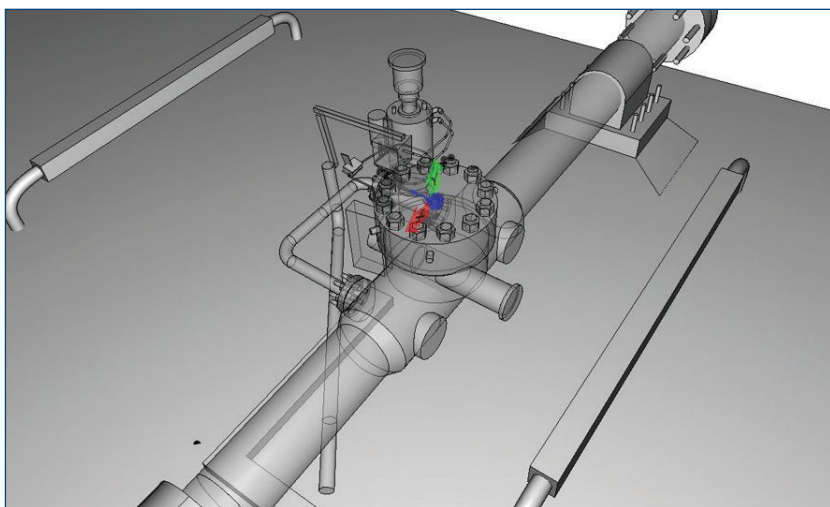
With a classic image-processing algorithm, points are measured on the laser line. Still, some are missing at the extremities and other places (due to the different shape and luminosity of the line). In contrast, by using AI, the detection works on the entire line, and there's no need for additional manual operations. This idea applies to all objects, and DimEye is currently introducing AI into its entire 3D CAD modeling process.

Once we have an accurate 3D as-built CAD model, all the measurement steps are complete. We can make this CAD model even more realistic by applying texture.

When the 3D as-built CAD model is available and can be shared to any CAD/CAM (computer-aided manufacturing) platform, it's time to think about the end-user and how we can facilitate the use of this information. Besides CAD/CAM platforms, numerous free 3D viewers can be used for consultation, navigation and, in some cases, simple measurements. This enables the engineering department and all other teams involved in a project to communicate and work

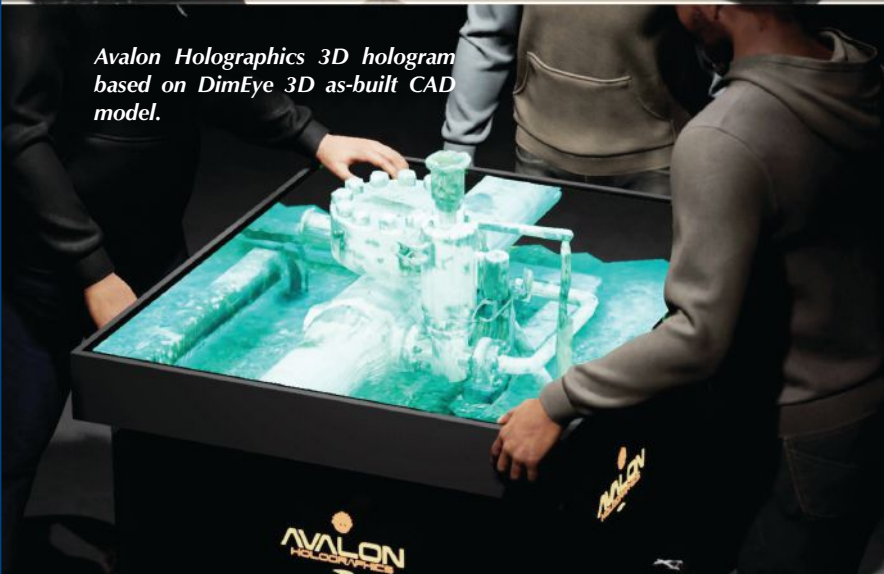


HD video, 3D as-built CAD model, and 3D as-built CAD model with texture.





Avalon Holographics 3D hologram based on DimEye 3D as-built CAD model.



efficiently. But what if subsea objects could be brought to the meeting table, making all conversations and preparation tasks a lot easier and faster?

This is precisely what the 3D hologram developed by Avalon Holographics and based upon DimEye's textured 3D as-built CAD model enables.

We imagine an interactive 3D hologram in the future: The user could, for example, display additional information by pointing to a component in the hologram, or measure any dimension accurately by simply interrogating the hologram. This type of imaging may seem like a dream, but we're working on making it a reality. **ST**

Arnauld Dumont is a surveyor and engineer who has been working for more than 25 years in 3D measurement via photogrammetry and laser technologies in various industries (oil and gas, nuclear, aerospace, civil engineering). He is the CEO of DimEye Corp. (Dimensional-Eye), founded in 2009 and based in California. DimEye specializes in 3D high-accuracy imaging for inaccessible environments. DimEye's operations consist of capturing videos of industrial assets and equipment (e.g., oil rigs, ships, aircraft, telescopes, jigs); processing images; and sending 3D as-built dimensions and CAD models to clients. DimEye has developed and patented the Video Laser Scan (VLS), a combination of advanced photogrammetry and laser techniques.

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VentureWave Capital Invests in XOCEAN

XOCEAN has received an €8 million investment, led by VentureWave Capital, which spearheaded its "Impact Ireland" fund in June 2020. The fund works with high-growth companies to invest and build global technology that will deliver societal benefits.

The new funding will accelerate growth as XOCEAN scales up operations. With ambitious plans to increase headcount from over 100 staff to 350 in the next 24 months while tripling the size of its fleet to over 60 USVs, the business will displace the emission of 1 million tons of carbon within the next five years while simultaneously improving safety by avoiding over 5 million seafarer exposure hours.

Sonardyne Rebrands

Sonardyne Group Ltd., a family-owned global group of companies comprising Chelsea Technologies, EIVA, Sonardyne, Voyis and Wavefront, is rebranding as Cove-lya Group Ltd. Simon Partridge will succeed Ralph Rayner as company chairman.

Carbon Capture in Scotland

ExxonMobil has increased its participation in the proposed Acorn carbon capture project in Scotland by signing an expression of interest to capture, transport and store CO₂ from its Fife Ethylene Plant.

The initial phase of Acorn, which is bidding to be in the first wave of carbon capture clusters to be announced by the U.K. government, has the potential to deliver more than half of the country's target of capturing and storing 10 million metric tons per year of CO₂ by 2030. When expanded further, it will have the potential to store over 20 million metric tons per year of CO₂ by the mid-2030s.

Cyprus Subsea to Represent Seaglider AUVs

Cyprus Subsea Consulting and Services Ltd. has signed an independent sales representative agreement with Huntington Ingalls Industries (HII), to represent Seaglider AUVs to commercial customers in Cyprus, France, Spain, Portugal, Albania, Montenegro, Malta and Norway. Cyprus Subsea is also authorized to provide after-sale services, including mission planning, launch/recovery, piloting, maintenance, training, data management, analysis and reporting.

Ocean Infinity Expands

Ocean Infinity has acquired Red Rock, a technology company with solutions that will enable autonomous port operations, a key enabler for future uncrewed shipping. Red Rock is spearheading the development of digital and autonomous solutions to revolutionize lifting and handling both onshore and offshore.

The acquisition will combine Ocean Infinity's Arma-da robotic vessels and low-emission operations with Red Rock's ability to develop hardware and software solutions for remote and autonomous handling. Together, the two

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businesses will transform port operations and shipping through artificial intelligence-enabled, safe, low-emission movement of vessels and cargo. All of Red Rock's business lines spanning marine, artificial intelligence, software solutions and digital consulting are included as part of the acquisition.

Seatronics to Distribute for RTSYS

Seatronics, the lead brand within Acteon's electronics and tooling segment, has made a global distribution agreement with French manufacturer RTSYS for its AUV and passive acoustic monitoring (PAM) product lines.

RTSYS AUVs will be available through Seatronics global bases, along with the RTSYS range of PAM sensors, including underwater recorders, data buoys and remote stations.

Nautel Acquires Kenta

Nautel has acquired ownership of France-based technology company Kenta, which specializes in radio frequency communication systems, mainly in the area of Global Maritime Distress and Safety Systems (GMDSS) for telephony or voice transmission. The company offers complete turnkey transmitter and receiver solutions for MF, HF and VHF systems and can provide both coastal stations and Maritime Rescue Coordination Centre (MRCC) software. Kenta is a key provider of software-defined radio (SDR) technologies.

EIB, JBIC Cooperate on Global Investments

The European Investment Bank (EIB), the bank of the European Union, and Japan Bank for International Cooperation (JBIC) have agreed to further expand cooperation on a range of globally relevant investments. This includes identifying co-financing opportunities for infrastructure connectivity (transport, energy and digitalization) and projects contributing to carbon neutrality in the European Union, such as subsea interconnectors, offshore wind plans, battery storage facilities and hydrogen technology development. In Asia, Africa and the EU neighboring countries, the EIB and JBIC have agreed to cooperate on co-financing of connectivity (transport, energy and digital) projects. The two banks will also cooperate on developing innovative projects relevant to implementation of UN Sustainable Development Goals (SDGs), including investment in projects on sustainable oceans and the prevention of marine pollution.

Rebrand Focuses on New Technology, Automation

Ian-Conrad Bergan LLC has rebranded, with new leadership and a new direction. Rebranding as Bergan Marine Systems under new President and CEO Kyle Durden, the company will expand its focus to include electronic and computer controls, as well as cloud-based solutions for marine data systems, along with continuing its traditional products.

Brunswick Acquires Navico

Brunswick Corp. has completed its acquisition of Navico, a specialist in marine electronics and sensors, for

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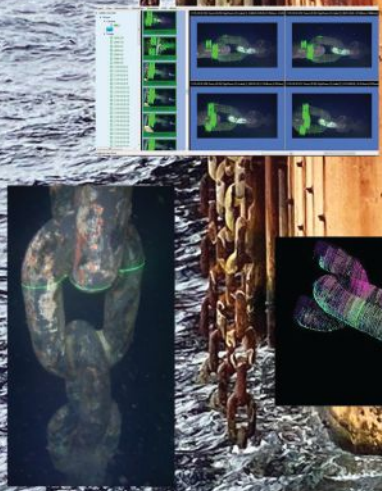
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\$1.05 billion. With this acquisition, Brunswick adds the Navico brands of Lowrance, Simrad, B&G and C-MAP to its Advanced Systems Group (ASG), which includes parts and accessories brands in power management, digital control and monitoring, and networked devices. Navico provides multifunction displays, fish finders, autopilots, sonar, radar and cartography.

Xodus Acquires OGS

Energy consultancy Xodus has continued its global expansion with the acquisition of Houston-based data interpretation consultancy Ocean Geo Solutions (OGS), adding capabilities in geophysical data processing, interpretation and reporting. OGS assesses seabed and subsurface conditions for hazards ahead of deepwater drilling operations and the installation of pipelines, cables and structures, providing its services to oil and gas operators and offshore wind developers.

Xodus currently has offices in Houston and Boston in the U.S., and plans to increase head count in the Gulf of Mexico over the coming months.

Crowley Opens Office for Offshore Wind

Crowley Maritime Corp. has opened its Providence office at Cambridge Innovation Center to serve the development of offshore wind in Rhode Island and surrounding regions. Crowley, through its New Energy Division, will offer its assets and expertise for land-side and marine logistics solutions during all phases of offshore wind development throughout the northeastern U.S.

AAPA Commits to Address Climate Change

The American Association of Port Authorities (AAPA) has committed to address climate change on a national and global scale. Efforts include plans to reduce greenhouse gas (GHG) emissions, support facility electrification, and increase the use of alternative energy sources, while working cooperatively across the maritime industry to advance worldwide climate change initiatives.

AAPA has advocated for the creation of a federal port electrification grant program, become a founding member of the net-zero Blue Sky Maritime Coalition, and has partnered with PortVision50 to align port infrastructure with IMO targets.

NAMEPA Gets New Corporate Member

Chevron Shipping has joined the North American Marine Environment Protection Association (NAMEPA) as its newest corporate member.

NAMEPA is a global and diverse network of individuals and companies partnering to help progress toward a greener future.

More Funding for USV Company

Saildrone has closed its \$100 million Series C funding round, which will enable acceleration of production and scaling of go-to-market functions to meet the rapidly growing market demand for comprehensive ocean data. This new round of funding brings total investment to \$190 million. **ST**

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Fugro Seep Study for Colombia

Fugro performed a joint environmental and exploration seep study in the Caribbean Sea for the Colombian Maritime Authority (Dirección General Marítima, DIMAR) from August to November, building on the success of a similar effort with DIMAR in 2019.

As with the previous collaboration, this year's work involved the acquisition, analysis and interpretation of seabed sediment samples and heat flow measurements to help assess the region's resource potential. Fugro also provided classroom- and vessel-based training to DIMAR personnel before and during off-shore operations.

New to the 2021 scope of work, Fugro and DIMAR examined a set of decommissioned well sites using a specialized camera system.

This work will help DIMAR understand the environmental conditions at these locations to determine whether any mitigating steps may be required now or during future decommissioning activities.

AHC Winch Facilitates Sampling in Pacific Ocean

Hawboldt Industries has installed an ABB winch drive with inbuilt active heave compensation (AHC) software at the heart of a new winch and offshore crane for the RV *Kilo Moana*. The enhanced winch control provides University of Hawaii Marine Center scientists with a safe, efficient and reliable way of deploying water sampling equipment at depths up to 5,000 m in even the roughest sea conditions.

The *Kilo Moana* is owned by the U.S. Navy and operated by the University of Hawaii Marine Center. It enables scientists to conduct tests that increase understanding of the effect of deep-ocean currents on marine life and climate change.

Climate Change Dims Earth

Warming ocean waters have caused a drop in the brightness of the Earth, according to a new study. Researchers used decades of mea-

surements of earthshine—the light reflected from Earth that illuminates the surface of the Moon—as well as satellite measurements to find that there has been a significant drop in Earth's reflectance, or albedo.

The Earth is now reflecting about half a watt less light per square meter than it was 20 years ago, with most of the drop occurring in the last three years of earthshine data, according to the new study in *Geophysical Research Letters*. That's the equivalent of 0.5 percent decrease in the Earth's reflectance. Earth reflects about 30 percent of the sunlight that shines on it.

Specifically, there has been a reduction of bright, reflective low-lying clouds over the eastern Pacific Ocean in the most recent years, according to satellite measurements made as part of NASA's Clouds and the Earth's Radiant Energy System (CERES) project. That's the same area, off the west coasts of North and South America, where increases in sea surface temperatures have been recorded because of the reversal of a climatic condition called the Pacific Decadal Oscillation, with likely connections to global climate change.

The dimming of the Earth can also be seen in terms of how much more solar energy is being captured by Earth's climate system. Once this significant additional solar energy is in Earth's atmosphere and oceans, it may contribute to global warming, as the extra sunlight is of the same magnitude as the total anthropogenic climate forcing over the last two decades.

North Atlantic Right Whale Predator-Prey Study

The North Atlantic right whale population, now fewer than 360 individuals, has been designated by the International Union for the Conservation of Nature as a critically endangered species. In the Gulf of Maine and the Scotian shelf regions, climate change is creating less favorable foraging environments for the right whales. To investigate the

impact of these ocean regime shifts on the North Atlantic right whale, a team from the University of New Brunswick, with collaborators including the New England Aquarium, Canadian Whale Institute, Dalhousie University and snow crab fishers in the Gulf of St. Lawrence, have been deploying ASL's Acoustic Zooplankton Fish Profiler (AZFP). The AZFP and other oceanographic instruments are mounted to a cage that is lowered and raised to collect water column transects in two right whale habitats: the southern Gulf of St. Lawrence, where right whales currently frequent, and the outer Bay of Fundy, where they used to be very abundant but have recently abandoned the area. The AZFP is being used to quantify the distribution of right whale prey, namely the copepod *Calanus finmarchicus*.

The goal is to understand what has changed in the oceanographic conditions in the Bay of Fundy that have caused the right whales to abandon this once-productive foraging ground. Also of interest is the characterization of the new habitat in the Gulf of St. Lawrence.

Discovery: Marine Megaphages

Microbiologists have identified a new family of marine megaphages, bacteriophages, which could change understanding of Earth's carbon and nitrogen cycles. Researchers from the Universities of Leicester, Warwick, Nottingham, Plymouth and the Marine Biological Association have sequenced the largest genome of its type within a newly discovered family of ocean-dwelling bacteriophages, from water in the English Channel.

Bacteriophages are viruses that prey on bacteria and are the most abundant biological entities on Earth. The researchers speculate that these megaphages could potentially alter the metabolism of their as-yet-unknown host in the marine environment.

Ocean bacteria play a major role in carbon and nitrogen cycling; 50 percent of the oxygen we breathe comes from the oceans via carbon fixation. These megaphages might be important in this process. **ST**

productdevelopment

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Digital Toolbox



Cloud-based Blue Insight enables state-of-the-art collection, visualization, contextualization, management and distribution of ocean data. Focusing on marine and meteorological information, the Blue Insight ecosystem provides key value to both scientific and industrial users of the maritime environment. Kongsberg Maritime AS.

ESR Wetsuit

This high-visibility (bright orange), versatile wetsuit is manufactured

from superstretch neoprene, featuring a front-entry YKK zip and molded Velcro closing collar. It can be supplied in 1.5-, 3- or 5-mm thickness. Northern Diver International Ltd.

GPS/GNSS for Future Applications

Compact GNSS modules mosaic-X5 and heading module mosaic-H are being integrated into evaluation kits developed by ArduSimple. These new kits offer triple-band RTK as a plug-and-play solution for the most popular development platforms, such as Arduino, STM Nucleo, Raspberry Pi, Ardupilot and Nvidia Jetson. This enables applications of the future, including robotics, UAV and autonomous systems, to easily try out mosaic, a module offering the latest GNSS positioning tech. Septentrio N.V. and ArduSimple.

Sensing, Monitoring Instruments

Bathy2 provides reliable and accurate density-corrected depth data up to 6,000 m. miniPS2 and uvSVX sensors have unique interchangeable pressure heads to benefit users who work at different depths. SWiFT CTD and SWiFT CTDplus profilers deliver improved accuracy and versatility to those requiring CTD measurements. Valeport Ltd.

ROTV for Autonomous Survey



FlipiX is a remotely operated towed vehicle (ROTV) designed to be operated autonomously from the DriX USV or from a light vessel. FlipiX is a unique conveyance platform for side scan sonars and magnetometers. It operates at towing speeds up to 7 kt. iXblue.

Anti-Jammer for Offshore Vessels

GAJT-410MS is the newest addition to the GPS anti-jam technology portfolio. This low-size, weight and power (SWaP) model of the field-proven GAJT-710MS protects against RF interference with adaptive nulling, including jammer direction-finding and up to three simultaneous nulls for multi-jammer scenarios. Hexagon | VERIPOS.

Multiplexer

NEXUS 8, the latest addition to the NEXUS multiplexer family, is an HD video and multibeam sonar multiplexer, with ultrahigh bandwidth and three full HD video interfaces for up to three HD cameras, able to provide real-time monitoring without any latency, and to run instruments and sensors for measurement, surveys, sonar, manipulation and control. MacArtney A/S.

Bathymetric Data Cleansing

ADMIRALTY GAM Service was developed in collaboration with Teledyne CARIS to classify and remove sonar noise from bathymetric survey data using machine learning

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based on a generalized additive model (GAM). The service uses cloud-computing capabilities to examine and cleanse new multi-beam survey information, removing outlying data points within the data set. UK Hydrographic Office and Teledyne CARIS.

Data-Sharing System

Dualog Drive now integrates with the cloud-based, file-sharing tool Microsoft Sharepoint. Dualog Drive simplifies the distribution and replication of documents, data, software updates, IoT data and large files between ship and shore. Dualog.

USBL System



MicronNav 200 is the latest generation of ultrashort baseline (USBL) positioning designed for small vehicles and diver-supporting applications. New features include: data transfer interleaved with USBL positioning; software integration into Google Maps; smaller, more accurate USBL head; and compatibility with the new Micron Battery Modem. Trittech International Ltd.

Navigation Simulator

SimFlex Cloud is a software-as-a-service solution offering highly realistic navigation training. As a cloud-based training solution, SimFlex offers user-friendly access to mixed-reality simulation, using both virtual reality and augmented reality headsets to maximize realism and immersion. FORCE Technology.

Small Subsea IP Camera

The compact 6,000-m-depth-rated C3-30 provides 2-MP HD video over IP and is the latest addition to the C3 camera range. The C9-GigE camera is rated for 2,000 m, with a 6,000-m titanium option available, and was developed for ROV use, providing GigE Vision-compliant

video in monochrome or color with 3-MP resolution. OceanTools Ltd.

Subsea Hydraulic Hoist

This hoist enables ship repair and husbandry, salvage and recovery, subsea maintenance and repair, and decommissioning of subsea structures. Operators can use it at depths of up to 30 m, and it's available in capacities ranging from six to 50 tons. Ingersoll Rand Inc.

Military Sonar

NS72-36 has been selected for sonar upgrades on the Canadian Patrol Frigate upgrading program. SQS 510 sonar transducer has been upgraded to an Mk II broadband version selected by the Canadian Patrol Frigate sonar program to match the Nautel NS72-36 sonar transmitter. Nautel Sonar.

L-Band Terminals

FB250 is a multifunctional terminal that can act as a standalone primary communications terminal or combine with Intellian's GX60NX and GX100NX for a Fleet Xpress (FX) solution. The Fleet One terminal provides an easy-to-install, reliable voice and data solution, ideal for smaller fishing and leisure vessels. Inmarsat and Intellian Technologies Inc.

Vessel Tracking

Maritime 2.0 is an update that provides marine data on vessel locations, weather conditions and global shipping activity so that organizations can optimize real-time decision making. The update features: smarter, cleaner AIS data; increased global coverage; and improved, scalable delivery using GraphQL. Spire Global Inc.

In-Riser Subsea Landing String

Revolution-7 is an advanced, 7-in. nominal, 10,000-psi-rated system incorporating the Revolution safety valve and PowerPlus technology. The landing string incorporates lower and upper subsea test tree valves, a latch, a retainer valve, and lubricator valve. The system provides high fatigue resistance. Interventek Subsea Engineering Ltd. **ST**



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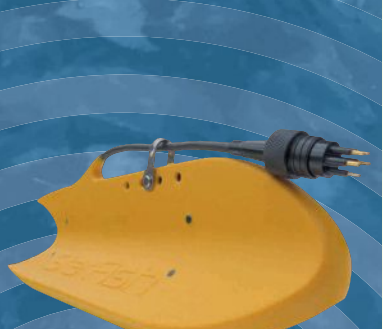
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Collaboration for Korea Offshore Wind Market

ODE, an international renewables engineering and project management company, part of the DORIS Group, has entered into a memorandum of understanding with Korean engineering company DongYang Engineering (DYE) to pursue offshore wind and other prospects across Korea and the global market.

ODE and DYE will collaborate across business development activities and the execution of engineering services, including the joint development of an offshore substation design specifically targeted to Korean offshore wind farms.

Norway Supports Ocean Grid

The Ocean Grid project will receive financial support of 82.7 million NOK through Norway's Green Platform scheme. The project will develop new technology, knowl-

edge and solutions to enable a profitable development of offshore wind on the Norwegian Continental Shelf. It will look particularly at the way offshore wind will be connected to the grid. The work will touch on both bottom-fixed and floating wind farms, and will in the long term enable the creation of green jobs and increased export revenues.

The Ocean Grid project will also address market design and the regulatory framework linked to the development and operation of an offshore grid to connect large offshore wind farms. It will develop Norwegian technology and a supply industry to provide new cable designs, subsea technology, and floating converter stations. Ocean Grid also has a research component, led by SINTEF, that will solve specific research challenges.

Europe has a plan of installing 300 GW of offshore wind capacity by 2050. Norway is poised to take

a significant portion of this market.

Leader for FORWARD-2030

The European Commission has backed Orbital Marine Power's bid to lead a €26.7 million project to deliver floating tidal energy as a key component of the future net-zero energy system. Orbital will lead a pan-European consortium to accelerate the commercial deployment of floating tidal energy as project coordinator and lead technology developer.

The FORWARD-2030 project consortium will receive €20.5 million of grant support from the European Union's Horizon 2020 research and innovation program to develop a multi-vector energy system for the future. This system will combine predictable floating tidal energy, wind generation, grid export, battery storage and green hydrogen production.

The project will see the installation of the next iteration of the Orbital turbine, integrated with a hydrogen production facility and

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battery storage at the European Marine Energy Centre (EMEC) in Orkney. Project partners will design options for integrating large-scale tidal power into future net-zero energy systems while developing environmental monitoring and marine spatial planning tools for large floating tidal arrays.

Co-Development of Offshore Solar Projects

Pondera and SolarDuck have signed a memorandum of understanding detailing the development of 555 MWp of offshore solar projects over the coming years. The companies plan to develop these projects between 2023 and 2025.

Near-term projects will be located in the Netherlands, while those further into the future will be located in Southeast Asia.

The companies plan to deliver solar energy to cities and regions where solar is the cheapest renewable energy source, but that normally have trouble accessing this resource due to land scarcity constraints. SolarDuck technology allows these communities and businesses to obtain clean energy while safeguarding competitive energy pricing. In 2023, the parties aim to develop 5 MWp. By the end of 2025, the companies aim to have developed a total of 555 MWp.

Industrial-Scale Hydrogen Via Wind Power

Lhyfe has inaugurated its first production site in Bouin, Vendée, France. It is the first in the world to produce renewable green hydrogen using wind power on an industrial scale, and is the first of many such sites to come since Lhyfe has already confirmed some sixty or so projects throughout Europe.

A few meters from the ocean in Port-du-Bec in Vendée, Lhyfe is now producing the first renewable green hydrogen in the world, using an electrolyzer powered directly by wind turbines and in industrial quantities, which represents a major technical achievement.

The site currently produces 300 kg a day and will ramp up to a tonne a day in the coming months. Lhyfe's

hydrogen will supply four refueling stations in western France.

Reducing Cost of Substations For Floating Wind Farms

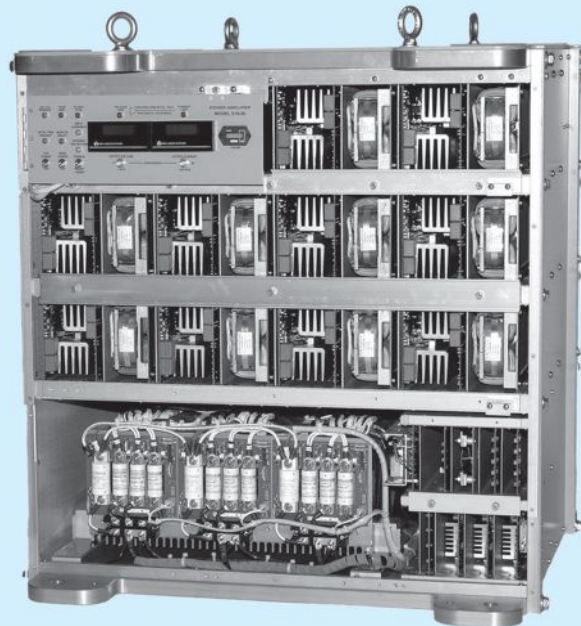
The LISORE R&D collaborative project, led by RTE and France Energies Marines, has been set up to identify technological barriers and potential solutions to reduce the total cost of offshore substations by 2025 for commercial floating wind

farms. Technical feasibility and pre-design studies for floating or subsea substations were carried out, and an associated maintenance plan was defined. A floating configuration was chosen for more in-depth study, as the subsea alternative was deemed to have too many technological barriers to be competitive.

Another R&D project, MOSISS, will specify targets for operation of floating substation components. **ST**

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Fiber-Optic Monitoring For Offshore Fish Farm

Light Structures AS and SalMar ASA have entered into an agreement for delivery of a Fiber Bragg Grating (FBG) technology-based structural monitoring system for installation on the Ocean Farm 1 aquaculture facility, located in open water near Frohavet on Norway's west coast.

Making its debut as the first-ever offshore fish farm in 2017, Ocean Farm 1 is a full-scale pilot facility designed to verify the biological and technological aspects of offshore fish farming. The exposed fish farm concept introduces tangible benefits to the aquaculture workflow, not least with the ability to raise healthier fish due to the continuous flow of water an offshore location enables. Ocean Farm 1 features six huge nets arranged in a circular floating structure, with a total capacity for 1.6 million salmon.

In order to provide more precise structural stress and fatigue data for life-cycle research conducted by Ocean Farm 1 technology partner DNV, SalMar tasked Light Structures to deliver a customized monitoring system using its SENSFIB technology. The fiber-optic stress and fatigue monitoring system is now operational at Ocean Farm 1.

Successful Biofuel Voyage

As part of its long-term sustainability strategy, Tufton completed a successful voyage using 100 percent sustainable marine biofuel in partnership with marine biofuels supplier GoodFuels, together with Stolt Tankers and technical manager Synergy Group.

The sustainable biofuel, derived from feedstocks such as used cooking oil and waste animal fats, was used on board the 20,762-dwt chemical tanker *Monax* on its voyage from North Europe to Canada. This sustainable biofuel delivers a well-to-exhaust CO₂ reduction between 80 and 90 percent compared to fossil fuel equivalents, without requiring modifications to the engine or the fuel infrastructure.

The use of this biofuel is in line with both Tufton's and Stolt Tankers' ambition to significantly reduce the carbon emissions from their combined fleets. As part of the pooling arrangement, both organizations have also agreed to partner on sustainability and environmental projects, including this biofuel testing program.

Fugro Supports Ocean Decade

Fugro has signed a partnership agreement with the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO) to improve the coordination of and access to global ocean science data.

The partnership will directly support the United Nations Decade of Ocean Science for Sustainable Development 2021 to 2030 (the "Ocean Decade"), a multifaceted initiative focused on reversing the cycle of decline in ocean health and creating improved conditions for sustainable ocean development worldwide.

As a participant in IOC-UNESCO's early planning activities for the Ocean Decade, Fugro is committed to addressing the data coordination and access needs of this landmark program. Fugro will provide the IOC-UNESCO Secretariat in Paris, France, with experts to help establish and administer two key ocean science data working groups.

Initially, this work will focus on the development of an Ocean Decade Data Coordination Platform, which will provide a global, cross-sectoral convening framework for the creation of a "digital ecosystem" to share, manage and distribute ocean data and interoperable marine science.

Next, Fugro will help establish a working group of global private sector stakeholders that collect or own ocean science data and are willing to make these data publicly accessible in support of the Ocean Decade. This group will provide a global, cross-discipline and cross-data-type

convening framework for the development of equitable mechanisms to accelerate public access to privately held ocean science data.

Europe's First Seagoing Ferry

The first renderings of the Scottish-led HYSEAS III project, which aims to build Europe's first seagoing ferry powered by hydrogen fuel cells, have been completed. The drawings show what the vessel, which will store energy from renewable sources, is likely to look like. As a double-ended, seagoing passenger and car ferry, it will have capacity for 120 passengers and 16 cars or two trucks.

It has been designed to operate on the route between Kirkwall and Shapinsay in Orkney, where hydrogen fuel is generated through wind power, and will be capable of operating at other ports where hydrogen could become available in the future.

The next stage of the project will seek feasibility approval in principle of the designs from DNV. String testing is also currently underway in Bergen, Norway, to demonstrate the complete fuel cell/battery/multidrive/propulsion. The design will be complete in March 2022, at which point funding partners will be sought to take the approved design to the procurement stage, which will lead on to the eventual tendering and construction of the vessel.

Partnership for Methanol Fuel

Proman, one of the world's largest producers of methanol, together with Stena, a privately owned shipping company operating approximately 140 vessels, have committed to jointly developing a retrofit and supply solution to enable Stena's vessels and third-party vessels to experience the immediate environmental benefits and greenhouse gas emission reductions delivered by methanol.

Methanol produced from natural gas brings an immediate CO₂ reduction, which will be further reduced to over 90 percent as renewable and sustainable methanol becomes more widely available as marine fuel. **ST**

Testing Interoperable Comms For Emergency Response

The ability for emergency responders to communicate across agencies and jurisdictions is essential for a timely and effective response. Crises can easily involve a broad range of disciplines (law enforcement, fire service, emergency medical service); various sectors (local, state, tribal and federal government); and multiple jurisdictions. They need to be able to talk to each other—and the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) ensures that first responders and DHS can exchange information such as voice, video or data through any medium and that interoperability across agencies is paramount upon transition to broadband communications networks, including FirstNet.

FirstNet is the first high-speed, nationwide wireless broadband network dedicated to public safety. It was borne out of the 9/11 Commission recommendations.

S&T has collaborated with local and federal partners to field test FirstNet's Push-to-Talk (FNPTT) application, which is a standards-based, mission-critical push-to-talk (MCPTT) app. The app allows voice, video and data communications with high priority and low delays with the press of a button—a necessity in critical events when reliable and quick access to information is vital.

Over the course of one month, 50 participants from S&T, the U.S. Coast Guard (USCG), Homeland Security Investigations (HSI), U.S. Customs and Border Protection (CBP), and the Oakland (California) Fire Department (FD) tested the app in different scenarios that reflected real-world responses.

MCPTT is the public safety mission-critical standard set by the 3rd Generation Partnership Project (3GPP), which is responsible for LTE and 5G global standards. Representatives from the Joint Wireless Program Management Office (JWP-

MO) and FirstNet AT&T were also involved with the field test.

Currently, CBP, HSI and USCG all use different PTT solutions that are proprietary and noninteroperable. With the feedback from this field test and through collaboration with the partners, S&T aims to help DHS operational components, federal partners (e.g., Department of Justice, Department of Defense) and first responders coalesce toward standard-compliant, mission-critical solutions.

BV AiP for DriX USV

Bureau Veritas (BV) has delivered an approval in principle (AiP) to iXblue for its DriX USV. This AiP covers system architecture, operational envelope, construction and autonomy functions. This certification comes as the USV sector is expanding rapidly.

With a length of 8 m, DriX is equipped with radar, LiDAR and cameras, as well as artificial intelligence, which enable it to adapt to its environment, avoid obstacles and carry out missions autonomously. Designed to support hydrographic and geophysical surveys, water column analysis, and subsea positioning operations, DriX has been used by major hydrographic institutes and energy companies worldwide.

OFG-DOF AUV Alliance

Ocean Floor Geophysics Inc. (OFG) and DOF Subsea AS (DOF) have entered into a strategic alliance for AUV services to the global offshore industry.

The partnership will effectively leverage the two businesses' recent collaboration in the development of the OFG AUV noncontact integrated Cathodic Protection (iCP) inspection system and enable the sharing of resources on several pipeline inspection and geohazard surveys.

It will also provide the framework for a coordinated response to the increasing demand for AUV surveys. OFG's iCP technology delivers greater efficiencies during

AUV pipeline and infrastructure inspections by allowing for anomalies and the overall system health check to be analyzed in near real time offshore. Its miniaturized electronics simplify integration and deployment on light logistics AUVs, ROVs and shallow-water active towfish for pipeline, cable, structure and umbilical inspection.

The shared resources will provide the alliance with a full suite of specialized sensors, such as a CathX laser and photogrammetry system and HiSAS synthetic aperture sonar, on top of the standard sensors capable of performing geophysical and pipeline inspection surveys.

Inmarsat Comms for 2021 Titanic Expedition

The OceanGate Expeditions 2021 *Titanic* Survey Expedition was connected by Inmarsat's critical satellite communications. Inmarsat kept the OceanGate Expeditions crew connected with team members and support services during the six-week expedition to document the important maritime heritage site located more than 400 mi. off the coast of Newfoundland in the North Atlantic Ocean.

"The OceanGate Expeditions' *Titanic* Survey Expedition has taken Inmarsat full circle," said Eric Griffin, vice president of Offshore and High End Fishing at Inmarsat.

"In response to the sinking of the *Titanic* and the appalling loss of life, the 1914 Safety of Life at Sea (SOLAS) Convention developed a radiotelegraphy requirement for vessels to be equipped with radio equipment for continuous communications.

"In 1979, the International Maritime Organization set up Inmarsat to provide reliable satellite communications to mariners as an extension of this original requirement.

"Today, we are proud to have worked with the team at OceanGate Expeditions to make these communications available at high speeds via Inmarsat's Fleet Xpress service for their operations, and to have played a role in the important scientific and documentary work they are performing." **ST**

contracts

Sternula, Aalborg, Denmark, will provide AIS 2.0 (VHF Data Exchange System, VDES), a technology that eases communication between vessels and authorities on land, to strengthen the maritime sector of Ghana and West Africa. Ghana Maritime Authority.

Fugro, Leidschendam, Netherlands, will provide floating wind LiDAR measurements for what will be the world's first offshore artificial energy island, which is being constructed for the Danish government. Fugro will install and operate four SEA-WATCH wind LiDAR buoys at two locations that will act as hubs connecting several offshore wind farms. Energinet.

Trelleborg, Trelleborg, Sweden, has appointed an agent in Japan, and a consultant via subsidiary Japan Marine Sciences (JMS), to promote Trelleborg's safety-focused dynamic mooring solution, DynaMoor. Nippon Yusen Kabushiki Kaisha (NYK Line).

I-Tech AB, Gothenburg, Sweden, has signed a joint development agreement to explore technical opportunities by combining technologies to combat the wide spectrum of marine fouling species. IFF Microbial Control.

The European Maritime Safety Agency (EMSA), Lisbon, Portugal, has awarded a new contract for remotely piloted aircraft surveillance of European waters. CLS and TE-KEVER.

Innovex One, Singapore, will supply its marineM digital platform for the Indonesian Ports of Balikpapan and Belawan as a marine operating system to optimize crucial marine services for vessels. Pelindo.

Light Structures AS, Oslo, Norway, will deliver comprehensive hull stress and fatigue monitoring systems on two newbuild 115,000-dwt AFRAMAX crude oil tankers due for

delivery in 2023. Sumitomo Heavy Industries Marine & Engineering.

Vard Electro, Tennfjord, Norway, has secured an order for its largest battery package to date for a vessel retrofit. It covers the SeaQ energy storage system, with two battery packs and a DC link, to be installed on a subsea construction vessel for the wind sector. Siem Offshore.

GoodFuels, Amsterdam, Netherlands, has entered a long-term agreement for the supply and development of sustainable marine biofuel solutions for the global shipping industry. Renewable Energy Group.

Teledyne Marine, Daytona Beach, Florida, has appointed a distribution and service partner for its Bowtech brand of underwater cameras, lights and strobes. Seatronics Group. **ST**

meetings

Note: The coronavirus (COVID-19) pandemic could affect event dates. Check event websites for the latest updates.

JANUARY

January 5-7—Challenge of Science Leadership Training Course, Plymouth, U.K. info@scienceleadership.co.uk or www.scienceleadership.co.uk.

January 10-13—Nor-Shipping, Oslo, Norway. www.nor-shipping.com.

January 26-27—ACIs Ship Recycling Congress, Rotterdam, Netherlands. +91 9921 81 9902 or skanwar@acieu.net.

FEBRUARY

February 1-3—Euromaritime, Marseilles, France. www.euromaritime.fr.

February 1-4—SPE Offshore Europe, Aberdeen, U.K. www.offshore-europe.co.uk.

February 17-18—Indian River La-

goon Symposium, Fort Pierce, Florida. www.fau.edu/hboi/50/events.

February 21-24—OCEANS 2022 Chennai, India and Virtual. https://chennai22.oceansconference.org.

February 22-24—Blue Innovation Symposium, Newport, Rhode Island. info@blueinnovationsymposium.com or https://blueinnovationsymposium.com.

February 22-24—Subsea Expo, Aberdeen, Scotland. www.subseauk.com.

MARCH

March 1-3—Floating Wind Solutions, Houston, Texas. https://floatingwindsolutions.com/fws-22.

March 15-17—Oceanology International, London, U.K. www.oceanologyinternational.com/london/en-gb.html.

March 27-29—Canadian Underwater Conference and Exhibition, Halifax, Canada. www.cuce.ca.

APRIL

April 25-28—AUVSI XPONENTIAL, Orlando, Florida. www.xponential.org/xponential2022.

JUNE

June 1-2—Navigate, Turku, Finland. info@navigate.fi or www.navigate.fi.

June 7-9—Undersea Defence Technology (UDT), Rotterdam, Netherlands. www.udt-global.com.

June 19-24—Frontiers in Hydrology Meeting, San Juan, Puerto Rico, and Virtual. www.agu.org/FIHM.

June 21-23—Interspill, Amsterdam, Netherlands. +0333 444 1890, info@interspill.org or www.interspill.org.

OCTOBER

October 18-21—EURONAVAL, Paris-Le Bourget, France. euronaval.fr.

For more industry meetings, visit sea-technology.com/meetings. **ST**

people

Anne Quillon was appointed director of procurement, sourcing and supplier management within the Operations and Performance Department of Naval Group. She will manage all of Naval Group's resources in the area of purchasing and define the group's "responsible purchasing" policy while managing its performance. She will also support the group's subsidiaries. She holds a degree in political science and a master's degree in purchasing and supply chain management.



Ocean Safety has appointed **Phil Jenner** as southern area commercial sales manager. He steps up to the role from an initial period as sales coordinator within the internal sales team. Jenner will ensure the continuity of vital support to customers within the shipping, commercial fishing, superyacht, ferry and ship-building sectors in the busy south of England region. Prior to joining Ocean Safety, he had a 10-year career in sales and operations at Lymington Yacht Charters.

The U.K. and Scottish government-backed Global Underwater Hub has appointed its first chair, **Andrew Hodgson**, as Subsea UK transitions into a new strategically focused organization to transform the U.K.'s £8 billion underwater industry into one of the largest and fastest-growing industries in the country, targeting £45 billion in revenues by 2035.

AIRMAR Technology Corp. has welcomed **Diana Sufariu** as director of engineering. She will lead the engineering team in the development and planning of innovative new products. She has more than 20 years of product development and manufacturing experience in industrial sensors.

ROVOP has appointed **Daniel Wheeler** as president for the Americas. Wheeler will lead the company in Houston as it prepares for its next phase of strategic growth and diversification across the region. A U.S. Navy veteran, he has worked in the ROV industry for more than 13 years.

Greensea has hired **John Moran** as OEM program manager. His previous roles include director of new product development at VATA Inc., operations program manager at Apple and product engineer at Teledyne BlueView.

Svitzer has appointed **Gareth Prowse** as its new global head of decarbonization. He has an academic background in marine ecology, with a focus on environmental risk, pollution prevention and ecotoxicology.

Aqueos Corp. has appointed **Walter Aguilar** to the position of vice president of civil, military and renewable services. He has more than 19 years of domestic and international project management experience on major multidisciplinary and multicultural EPCI (engineering, procurement, construction and installation) projects.

Eco Wave Power Global AB has appointed **Avi Waller** as chief operating officer for the Eco Wave Power Group. He is based in the company's headquarters in Tel Aviv, Israel. Waller has more than 20 years of leadership roles, with a proven track record in engineering organizations.

Phoenix has appointed **Chris Williams** as vice president of manned operations. He is responsible for planning, training and execution of Phoenix's diving and atmospheric diving system (ADS) operations, and growing the underwater solutions business.

Sea Machines Robotics has hired **Trevor Vieweg** as chief technology officer, reporting to CEO **Michael G. Johnson**. Vieweg is responsible for the company's overarching technology strategy, as well as continuing to develop a high-performing team focused on the development of advanced marine technology. He previously held technology and product leadership positions at Viasat, where he was most recently head of product development, and Nordson Asymtek. Vieweg has degrees in mechanical engineering and enterprise architecture. **ST**



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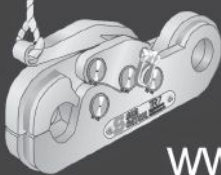
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The Maritime Industry Needs to Accelerate Clean Energy Innovation—Kris Peeters

Kris Peeters is vice president of the European Investment Bank. He oversees transport financing; security and defense financing; operations in Belgium, the Netherlands and Luxembourg; and European Parliament and NATO relations. Previously, he was minister-president of Flanders, Belgian deputy prime minister and minister of Economy and Employment, and a member of the European Parliament.



Throughout Europe's history, maritime transport has been a catalyst for economic development and prosperity. Maritime transport facilitates trade and ensures a secure supply of energy, food, and commodities. It is also the main vehicle for European exports. Almost 90 percent of freight leaving the European Union travels by sea.

Although shipping is one of the most energy-efficient ways to carry cargo—it uses the least amount of energy per tonne-kilometer—direct carbon emissions from shipping activities surged in the past decade as cargo volumes rose globally. International maritime transport is responsible for 2 to 3 percent of global greenhouse gas (GHG) emissions. According to the fourth GHG Study 2020 from the International Maritime Organization, these emissions increased nearly 10 percent between 2012 and 2018, as growth in shipping activity was larger than efficiency gains. The study predicts that without immediate, concerted efforts, emissions from the sector could rise by 40 percent, depending on global economic growth.

Record-breaking temperatures and extreme weather across Europe and North America this summer, as well as the latest report of the Intergovernmental Panel on Climate Change, leave no doubt that we have entered a make-or-break decade on climate. Avoiding irrevers-

ible damage to the planet requires a change of course. To create a sustainable future, the maritime sector, like all other sectors, needs to invest in clean energy now. Moreover, it needs to accelerate its search of new, sustainable ways of doing business and finding creative ways to increase efficiencies and to innovate—and there is not much time left to make a difference.

Climate change is only one of the challenges currently facing the industry. The coronavirus pandemic has also challenged supply chains globally. Multiple national lockdowns disrupted transport and logistics by slowing down or even halting the flow of materials, goods and people. The pandemic shed light on vulnerabilities in global trade, especially in maritime logistics, but it could also push the industry forward, providing an opportunity to reevaluate global supply chains to make them more resilient and sustainable.

Transformational change is happening. The key question is: How can we unlock the scale of capital needed to support decarbonization and move to zero-emission fuels and technologies within 10 years?

One approach is to work closer with the public sector. The European Commission (EC) is leading decarbonization in the maritime sector, starting by laying down transport priorities for the next 10 years, including the development of zero-emission marine vessels for the market by 2030, boosting the use of renewable fuels, and creating zero-emission ports.

Decarbonization can only be achieved via the development, production and significant uptake of low- and zero-carbon energy sources. The private and public sectors must jointly identify workable solutions and make investments to develop projects all the way to market readiness in the little time left to make a difference for our planet.

Public financial institutions such as the European Investment Bank Group have a vital role to play. As the EU's climate bank and one of Europe's largest financiers of innovation, the European Investment Bank, together with the European Investment Fund, a specialized risk finance provider, can help accelerate technological development and deployment. Using our wide array of loans, guarantees, venture capital and debt, as well as public-private partnerships, we can take on more risk and lend to innovative start-ups, technology transfer, research projects, demonstration plants, and commercial deployment of new technologies. Our experience in other transport sectors can also help guide the maritime sector's transition to clean energy. The capital we can provide is risk bearing, long term and has attractive rates, influencing others to invest hundreds of millions of euros in climate-friendly business models and technologies.

Taking responsibility for the planet we live on is one reason why the maritime sector should accelerate its innovation efforts. Economic rationale is another one. The Potsdam Institute for Climate Impact Research estimates that if a mere 9 percent of global investment flowed into climate change projects, this could trigger a tectonic shift toward clean energy and sustainability that would be fast and large enough to limit climate change.

The maritime industry must make hard decisions today for the future. Today's choices, such as investing in sustainable assets, will also determine if the industry can attract investors in the future. Taking the wrong course could leave the maritime industry with assets that have no place in a new world.

Working as strategic partners, the public and private sectors can take on the uncertainty of change and innovation, and accelerate the green transformation. **ST**

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