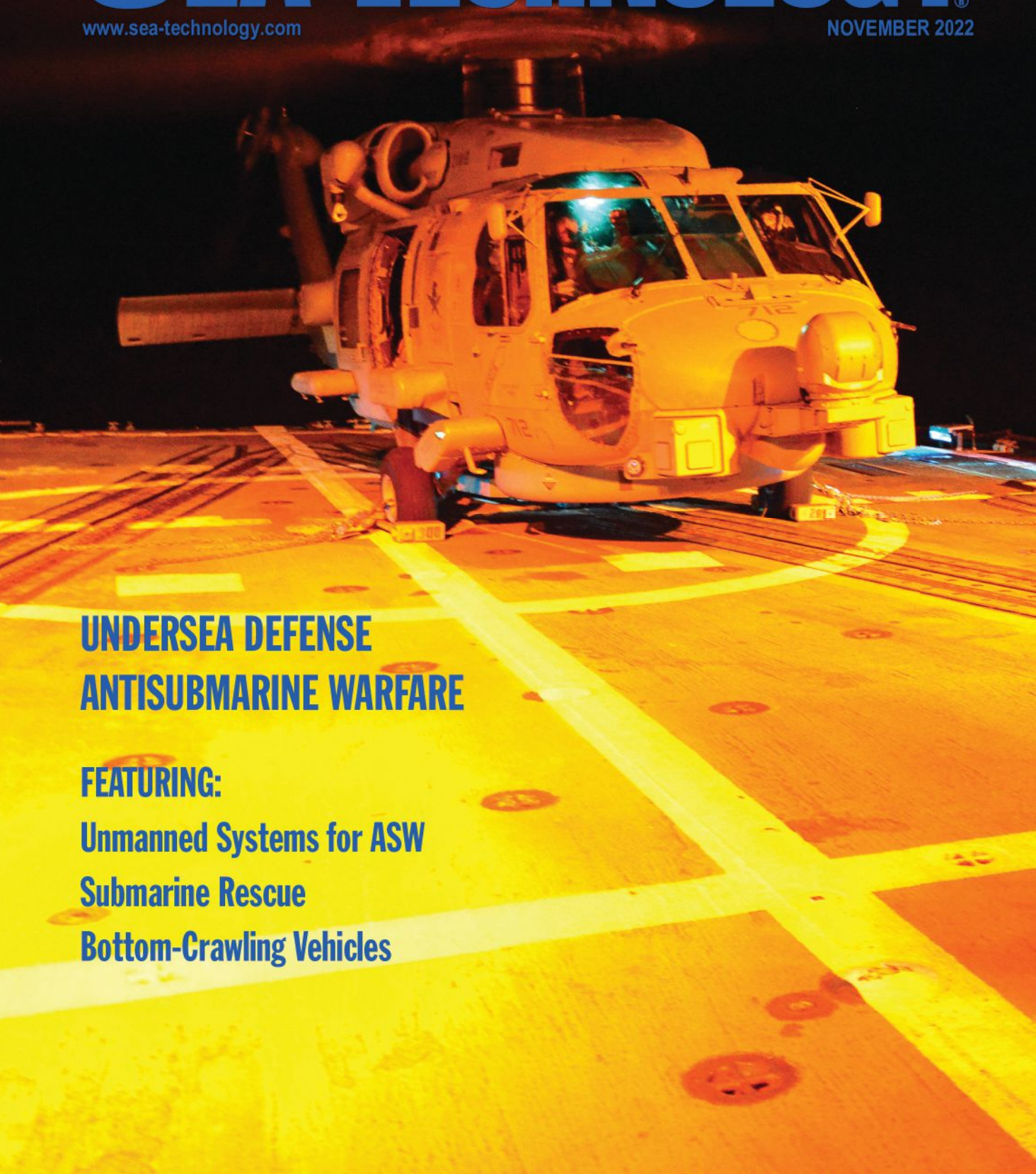


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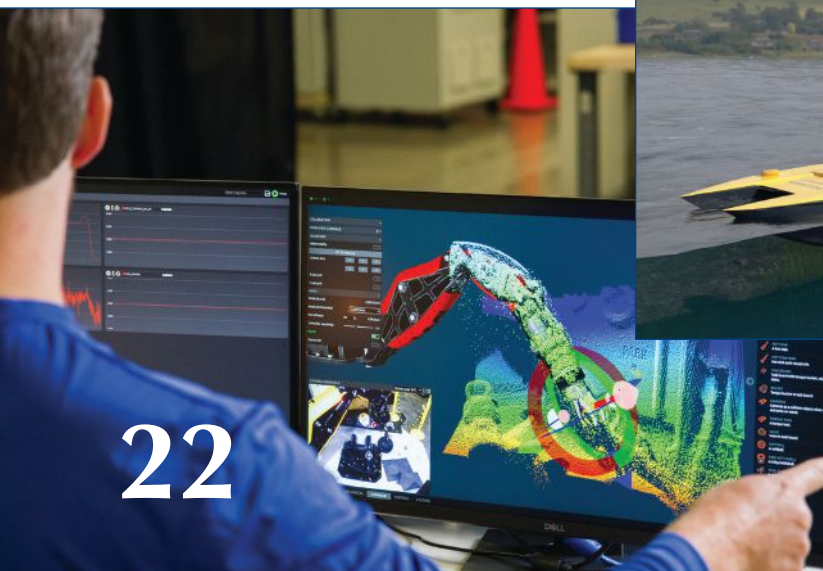
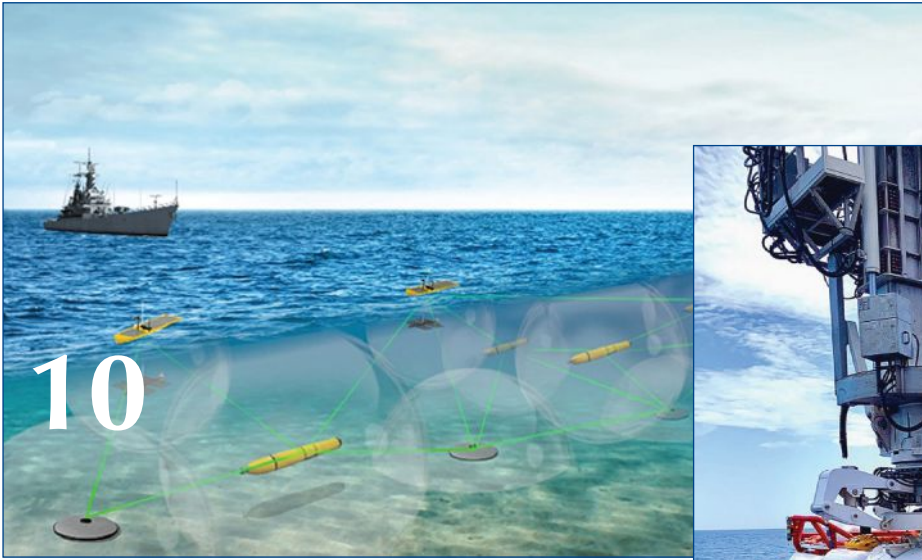


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COVER IMAGE

Sailors aboard the *Arleigh Burke*-class guided-missile destroyer USS *Lassen* (DDG-82) conduct flight operations with an MH-60R Romeo attached to Navy Helicopter Squadron "Spartans" (HSM) 70 during UNITAS LXIII, September 2022. UNITAS is the world's longest-running maritime exercise. Hosted this year by Brazil, it brought together multinational forces conducting operations in and off the coast of Rio de Janeiro through the execution of anti-surface, anti-submarine, anti-air, amphibious and electronic warfare operations. (Credit: U.S. Navy, Mitch Meppelink)

NEXT MONTH

Flexible, snake-like drone for subsea infrastructure maintenance ... Expedition: deepest shipwreck ever discovered ... ROV engineering simulator ... Unlocking the power of 5G at sea ... Q&A: "Wings of Gold: The Story of the First Women Naval Aviators."

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)) Large-Scale Materials Testing for Subsurface CO₂ Storage in North Sea. Welltec has begun extensive testing to identify optimal materials for Project Greensand, an initiative that will store CO₂ in the subsurface of the North Sea. Project Greensand is the most mature project of its kind in Denmark, with the potential of storing up to 1.5 million tons of CO₂ per year by the end of 2025, and up to 8 million tons of CO₂ per year by 2030. The consortium behind Project Greensand consists of 23 different Danish and international partners who all work to deliver a significant contribution to the green transition in Denmark. The launch of Welltec's newly developed Test Flow Loop, a test installation of 18-by-5 m, provides the setting for essential corrosion testing, where the performance of five different materials will be compared in a controlled environment. To identify the final materials, Welltec has designed two test phases. In the first phase, five different materials are tested, and these tests will be decisive in the recommendation of which materials Project Greensand should proceed with for the crucial casing pipes, which run all the way down to the reservoir of sandstone 1,800 m below the seabed. Welltec's work is another step forward in Project Greensand, where tank containers, ships and developed designs for the pump systems that will transport CO₂ down to the sandstone reservoir have already been secured. As before, safety is paramount, and it is crucial that the new casing pipes are subject to rigorous testing. In connection with the pilot project for CO₂ injection, Project Greensand expects to test the first storage of CO₂ in the subsurface of the North Sea around the end of the year.

)) Corvus Leads Hydrogen Power Project. Corvus Energy has been selected to lead a program funded by the Research Council of Norway to promote innovation in the industry. Corvus Energy joins forces with research institute NORCE and other partners for the Optimized Hydrogen Powered Maritime Mobility, or "OptHyMob," project to improve operations of hydrogen-driven marine vessels in order to reduce costs and extend the lifetime of both the hydrogen fuel cells (FC) and the batteries in hybrid configurations. The project builds on the ongoing H2NOR project, funded in part by Innovation Norway, where Corvus Energy and partners will develop, demonstrate and certify the inherently gas-safe modularized maritime PEM-based FC system based on technology from Toyota. This project will run closely with another Research Council-funded project called "Energy efficient operation of hydrogen-powered vessels," or "HyEff," led by NORCE and involving the same partners.

)) Teledyne Software Facilitates Tonga Volcano Mapping. Teledyne Geospatial has partnered with Seabed 2030 in the Tonga Eruption Seabed Mapping Project (TESMaP). In April 2022, New Zealand's National Institute of Water and Atmospheric Research (NIWA) and The Nippon Foundation announced a mission to discover the undersea impacts of the Hunga-Tonga Hunga-Ha'apai (HT-HH) volcanic eruption, which produced the biggest atmospheric explosion recorded on Earth in over a century. Supported by The Nippon Foundation-GEBCO Seabed 2030 Project, TEsMaP had two phases, led by NIWA. Phase one saw scientists survey the area around the volcano with RV *Tangaroa*. As part of phase two, SEA-KIT International's USV Maxlimer was used to conduct further mapping inside the caldera (*Sea Technology*, October 2022). For the duration of TEsMaP, Seabed 2030 and Nippon Foundation-GEBCO Ocean Mapping fellows utilized software provided by Teledyne CARIS. The software facilitated the monitoring of data quality and coverage, with new data being used for comparative studies against previous maps to assess the effects of the eruption on marine life and seafloor composition. Software provided by Teledyne CARIS will also be used to process the data to generate the final products.

)) Winner of 2022 Don Walsh Ocean Exploration Award. The Marine Technology Society (MTS) and The Society for Underwater Technology (SUT) have named the oceanographer Samantha "Mandy" Joye the winner of the 2022 Captain Don Walsh Award for Ocean Exploration. Joye is a Regents' Professor in the Department of Marine Sciences at the University of Georgia whose work has revealed unexpected connectivity between elemental cycles, unanticipated feedbacks between geological elemental and microbial dynamics, and fundamental controls on microbial populations and their activity. For the past two decades, Joye has studied natural seepage and chemosynthetic habitats in the Gulf of Mexico. Her research during the *Deepwater Horizon* oil spill environmental response significantly advanced the understanding of the critical role of microorganisms in degradation of oil and factors that enhance microbial degradation and optimize their environmental response.

)) Marine Sciences Nonprofit Turns 50. Project Oceanology, founded by Howard "Mickey" Weiss, is celebrating 50 years of marine science and environmental education efforts. The nonprofit delivers educational programs on board its research vessels, along the shore and in its coastal research facility. The organization also partners with schools and universities, offers public cruises throughout the year and hosts a series of award-winning summer camps. For the past 50 years, Project Oceanology has sought to make its programs accessible to all students by providing financial-need tuition and other assistance. More than 25,000 adults and children attend the organization's programs annually. Founded in 1972, Project Oceanology was established with a \$59,000 federal grant awarded to a consortium of 14 school districts in southeastern Connecticut. **ST**

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Building Stronger Communication Bridges

Early in his U.S. Navy career, Daniel Conley identified the need for a single mask to help sailors on surface vessels breathe during emergencies, such as evacuations and firefighting. He invented the CONLEY unified breathing mask with interchangeable attachments for all dangerous situations, without the need to swap masks.

Now a lieutenant commander, Conley recently pitched his idea to the Office of Naval Research (ONR), which sponsors technology research and development for the Navy and Marine Corps. ONR provided funding for a prototype. Conley then connected with the Navy's Naval Junior Officer Counsel (NJOC), a new avenue enabling junior officers (ensign through lieutenant commander) to share ideas, insights and concerns with senior leadership. NJOC featured the unified breathing mask prototype at the 2022 Surface Navy Association Symposium, where it received much praise from attendees, and Conley is looking to have it tested for fleet consideration.

Whether the mask remains a prototype or is adopted by the fleet, the buzz it generated demonstrates how NJOC can facilitate interactions between junior and senior officers to put creative ideas by young officers into action and to create better naval technologies and capabilities. At NJOC, we spark the flame of innovation: collecting inputs, refining them, identifying key stakeholders and making valuable connections. By serving as a cross-designator organization, we encourage greater collaboration and best practices across naval communities through information sharing.

NJOC is the Navy's first management advisory group. Our charter was signed in November 2021, and we represent the Navy's more than 35,000 junior officers, across all career fields ("naval designators"). NJOC comprises a core leadership team advised by a board of representatives. These representatives are junior officers from various naval designators (e.g., surface warfare officers, aviators, etc.) and serve as liaisons between NJOC and their respective communities.

Our newest initiative is the Acceleration Series, an online discussion tool enabling thoughts and suggestions from junior officers (as well as enlisted sailors and Marines) to be hashed out constructively, polished and consolidated, and then delivered to appropriate senior leaders. We created the Acceleration Series using Unum at the Department of Defense's National Security Innovation Network. Unum is a social media-style platform connecting members of the defense, academic and venture capital communities to change the way national security innovation works.

At the NJOC community page on Unum, <https://unum.nsin.us/njoc>, users can submit items to three discussion categories on any topic: Problem Series, Solution Series and Writer's Series. The Problem Series collects data on problems that warfighters face across the fleet. The Solution Series enables users to submit answers to naval problems or concerns and serves as a place where senior leadership can present current challenges and ask for solutions. The Writer's Series is where users can submit essays focusing on a particular idea, kept internally, with submitters maintaining publication rights. NJOC's board of representatives reviews submissions; offers advice on how to sharpen or improve them, if necessary; and identifies the right command or senior leader to ultimately receive the submission. NJOC will often also craft a professional, compelling presentation and send it to the senior leader on behalf of the user.

NJOC also encourages civilian partnerships within government, industry and academia to promote naval innovation. You may share ideas and concerns at: <https://unum.nsin.us/njoc> or www.nre.navy.mil/organization/njoc. **ST**

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Annual Review & Forecast

****** *Oceanology International Americas*, February 14-16, San Diego, CA

FEBRUARY

Instrumentation: Measurement, Processing & Analysis

****** *US Hydro*, March 13-19, Mobile, AL

MARCH

Electronic Charting/Vessel Management/ Ports & Harbors/Dredging/Homeland Security

****** *Ocean Business 23*, April 18-20, Southampton, U.K.

APRIL

Offshore Technology/Alternative Energy & Ocean Engineering

****** *Offshore Technology Conference*, May 1-4, Houston, TX

****** *XPONENTIAL 2023*, May 8-11, Denver, CO

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Joining Forces

Maritime Unmanned Systems Augment Conventional ASW

By Dr. Robert Been • Dr. Alessandra Tesei • Dr. Sandro Carniel

With over 60 years of knowledge and experience in undersea research, NATO's Centre for Maritime Research and Experimentation (NATO-CMRE), originally known as SACLANT ASW Research Centre and later as NATO Undersea Research Centre, is a recognized hub of world-class expertise in the maritime domain. It is where scientists from all NATO nations can collaborate and maintain NATO's maritime technological edge.

Today, the CMRE's work encompasses the fields of artificial intelligence (AI), data science, underwater acoustics, oceanography and autonomous systems, supported by a dedicated sea-going capability to conduct cutting-edge maritime research in challenging conditions, ranging from the Mediterranean Sea to the Arctic Ocean. CMRE provides an outstanding environment where internationally recognized scientists and engineers from NATO nations share their knowledge while delivering results in a highly effectively manner.

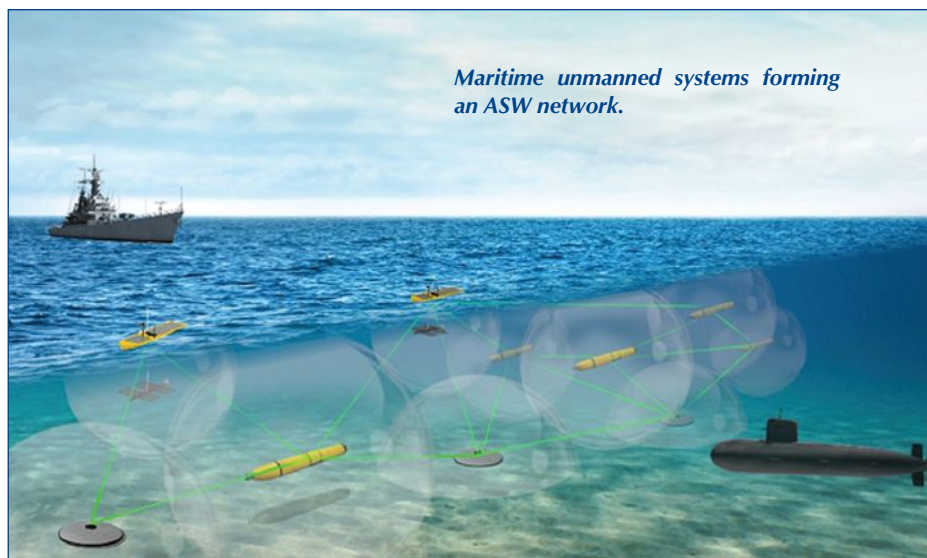
NATO and its allied nations have increasingly placed an enhanced emphasis on fostering innovation by identifying, understanding and acting to adopt emerging disruptive technologies (EDTs). This is well reflected in the NATO 2030 agenda, which represents a forward-leaning approach containing key proposals to invest substantially in maintaining NATO's technological edge.

As part of the NATO Science and Technology Organization (STO), CMRE is actively assessing EDTs and their potential impact on military operations, defense capabilities and political decision making. Thanks to the extensive knowledge base acquired over decades, CMRE is well positioned to ensure that EDTs are exploited in innovative ways across the entire portfolio of projects.

Of the seven key areas identified as priorities in NATO's Coherent Implementation Strategy on EDTs endorsed by NATO defense ministers in February 2021, four—AI, data and computing, autonomy, and quantum-enabled technologies—are inherent elements of CMRE's research and development projects and activities.

Moreover, CMRE's scientific, engineering and IT workforce have continuously developed innovative solutions to operational and scientific requirements and challenges. Innovation is inherent in CMRE's culture, from scientists carrying out basic applied research and feasibility studies to engineers and technologists continuously and successfully exploiting EDTs in prototype systems and in novel enhancements to the capabilities of commercial products.

The majority of the projects and research activities within CMRE's Research Division are carried out within the framework of the NATO Allied Command Transformation (ACT) Maritime S&T Programme, which encom-



Maritime unmanned systems forming an ASW network.

passes four major programs at CMRE: Autonomous Anti-Submarine Warfare (AASW); Autonomous Naval Mine Countermeasures (ANMCM); Data and Environmental Knowledge and Operational Effectiveness (DEKOE); and Maritime Unmanned Systems Enablers (MUSE).

AASW

The AASW program comprises two main research projects: Maritime Unmanned Systems (MUS) for ASW and ASW Decision Support. The aim of these projects is to improve NATO's ability to counter threats in the underwater domain through autonomous security networks. AASW, together with ANMCM, represent long-term investments by NATO in CMRE to engender the exploitation of EDTs such as data science, autonomy and sensing (quantum) to improve capabilities in the respective fields.

Within the AASW program, advanced concepts for ASW operations are being developed and tested at sea, based on heterogeneous, autonomous networks of un-

manned systems, provided with active and passive acoustic sensors, securely communicating and persistently operating with collaborative behaviors for the detection, localization, tracking and classification of submarine contacts. CMRE's ASW team provides decision-support methodologies for manned and unmanned ASW operations; develops assets; demonstrates advanced concepts for ASW performance prediction and analysis during NATO exercises; and advances doctrine for the use of MUS in NATO ASW operations. Finally, the AASW program is investigating the latest highly sensitive, low-noise quantum effect magnetometers that have the potential to provide breakthrough magnetic sensing capability for ASW applications.

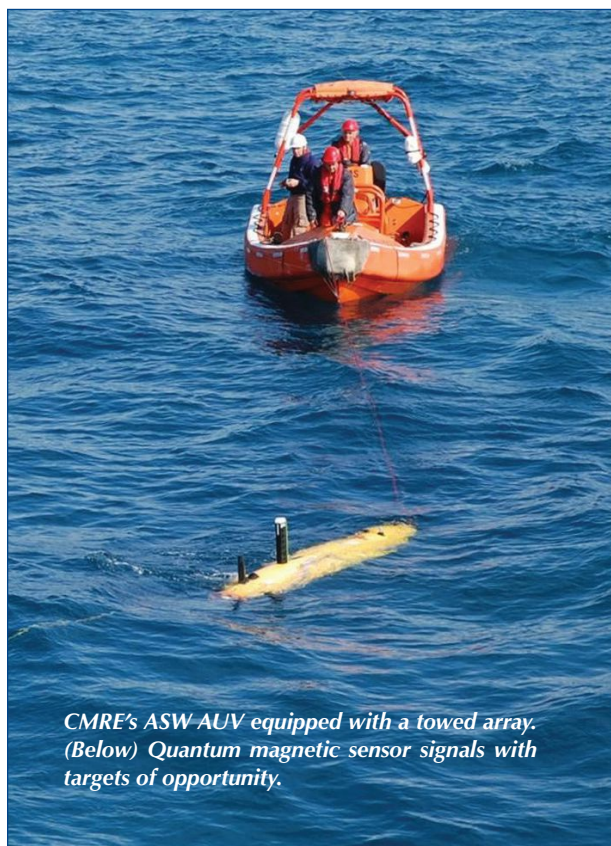
Projects at a somewhat higher technical readiness level (TRL) that have been carried out for ACT and NATO's Allied Maritime Command (MARCOM) include support to MARCOM's In-Stride Debriefing Team during NATO exercises and a technical demonstration with Standing NATO Maritime Group 2 (SNMG2).

Maritime Unmanned Systems for ASW

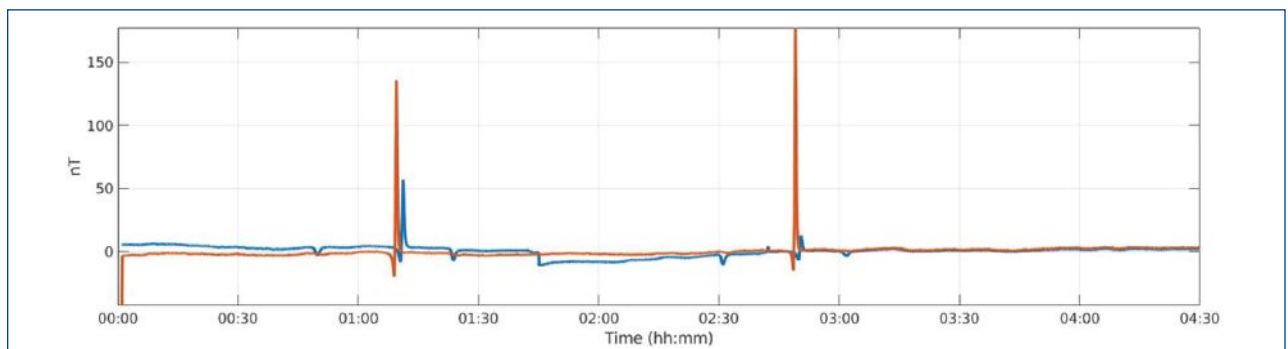
Addressing the submarine threat is critical for the safety of maritime operations and the security of NATO nations. Maritime unmanned systems equipped with advanced sensing technology and artificial intelligence for adaptive and collaborative behavior have significant potential for ASW operations, complementing and augmenting conventional NATO ASW assets. The work carried out under this project focuses on research and experimentation to validate advanced sensing, algorithmic and autonomous platform concepts in operationally relevant scenarios in order to identify the most effective technologies for NATO to counter submarine threats.

The project team has developed and built two low-power consumption, long-endurance bottom nodes equipped with a heterogeneous sensor suite comprising passive acoustic vector sensors, novel quantum magnetic sensors and geophones. The bottom nodes were deployed as a network, with two AUVs towing advanced hydrophone arrays and two sensorized Teledyne Slocum buoyancy gliders during the Robotic Experimentation and Prototyping augmented by Maritime Unmanned Systems, REP(MUS)21, Exercise in Portugal September 2021. One of the AUVs was used as an artificial target by mimicking submarine radiated noise using its active acoustic payload.

The results obtained using quantum magnetic and



*CMRE's ASW AUV equipped with a towed array.
(Below) Quantum magnetic sensor signals with
targets of opportunity.*



passive sonar-sensing capabilities were very promising. During REP(MUS)21, in collaboration with the MUSE program, the team also connected the deployed CMRE ASW capabilities to the exercise command-and-control system for real-time situational awareness and interoperability with other participating assets. Furthermore, a technical demonstration was carried out as part of a submarine-in-distress exercise, with two AUVs performing autonomous search, assisting in the successful localization of the submarine.

ASW Decision Support

The decision support project optimizes the deployment configuration of unmanned systems conducting ASW missions. Through a combination of operations research studies and simulation, the overall effectiveness of large numbers of heterogeneous unmanned platform types conducting network or area search ASW operations is ex-



plored. Results obtained may be transitioned into tactical advice for incorporation into relevant NATO doctrinal publications.

Leveraging “brute force” optimization methods, closed-form search algorithms within a linear programming framework have been implemented, providing faster results while guaranteeing an optimum solution for the deployment of various numbers of different types of unmanned platforms for both bar-

Two FREMM frigates—the French Navy’s Aquitaine-class ship FS Languedoc (left) and the Italian Navy’s Bergamini-class ship ITS Virginio Fasan—during the NATO MARCOM ASW exercise Dynamic Manta in the Mediterranean Sea off Sicily March 2022. (Credit: NATO Maritime Command)

rier and area-search ASW missions.

The effects of varying sensor performance along the length of an ASW barrier—as may occur because of changes in the environmental conditions—have been included, such that the optimum result now indicates how many, and in which barrier section, each type of platform should be deployed. The framework can be expanded to account for varying sonar depth, additional logistic constraints and range-dependent acoustic predictions. Analyses of the optimum deployment configurations have revealed patterns that can be converted into guides and/or measures of effectiveness to update NATO unmanned ASW experimental tactics. A tabletop exercise was conducted with ASW operators and subject matter experts to evaluate the perceived utility of unmanned ASW networks during naval operations.

Supporting MARCOM’s In-Stride Debriefing Team During NATO ASW Exercises

NATO conducts a number of live ASW exercises on an annual basis in which large numbers of naval assets perform training serials. The MARCOM-led in-stride debrief-

An advertisement for the Knudsen 320N radar system. The background is a dark, cloudy sky over the ocean. In the foreground, a large, black, rectangular radar unit with a handle and a screen is shown. The unit has "320N" and "DESIGNED" printed on it. Below the radar unit, a naval ship is visible on the water. The text "The Smart Solution" is in large red letters at the top, followed by "New & Retrofit Naval Fleet Navigation" in white. The "320N" is also written in large white letters on the left. At the bottom left is the Knudsen logo, and at the bottom right are the sales websites: "U.S. SALES: KNUDSENSYSTEMS.COM" and "INTERNATIONAL: KNUDSENENG.COM".



Night-time recovery of an ASW AUV during PASSEX21.

ing team (IDT) serves an important role in providing participants with a performance analysis through a reconstruction of asset positions and reported contacts. Ultimately, this analysis informs participants if a submarine was successfully prosecuted or not. The IDT provides this feedback shortly after the completion of each training serial in order to ensure that any lessons identified may be quickly learned.

CMRE seeks to augment the IDT analysis through detailed acoustic modeling, predicting ASW sonar detection ranges accounting for a range-dependent environment and actual sonar and submarine depths. A comparison of predicted detection with a reconstructed range between the ASW asset and submarine target highlights detection opportunities. Further analysis explores the factors contributing toward detection performance, such as the depth of the sonar and submarine relative to acoustic layers and submarine aspect.

In 2021, CMRE staff supported NATO Exercises Dynamic Manta, Dynamic Mariner and Dynamic Mongoose; the same number of exercises is targeted for 2022. The analysis performed on site at CMRE

used the Rapid Acoustic Prediction Services (RAPS) to provide fully automated sonar detection performance predictions as a function of sonar depth, submarine depth and aspect throughout the exercise area. Further analysis scripts combined the reported platform positions with precalculated sonar performance data in order to highlight detection opportunities along with the contributing factors. This detailed analysis provided added training benefits to exercise participants by directly correlating environmental and tactical factors with ASW performance.

Technical Demonstration With SNMG2

In October 2021, CMRE conducted a PASSEX (a cooperative exercise that demonstrates interoperability, collaboration, coordination and partnership with partner and allied navies) with the Standing NATO Maritime Group 2 (SNMG2) off the Ligurian coast, including the NRV *Alliance* and CRV *Leonardo*, as well as other assets. The objectives of the PASSEX included familiarization of naval staff with MUS technology for ASW; submarine detection using conventional ship-based

platforms in concert with AUVs using multiple sources and multiple receivers; and data collection for machine learning. A multi-static active ASW network was deployed for the exercise composed of two mid-size AUVs and a Liquid Robotics Wave Glider surface vehicle as a gateway buoy, relaying messages between the above- and underwater domains. The AUVs were equipped with towed hydrophone arrays and onboard signal processing for real-time detection and localization of possible targets. The use of multiple transmitters and receivers, combining high-resolution range- and Doppler-resolving waveforms and exploiting spatial diversity, greatly improves the effectiveness of ASW operations.

Despite adverse weather conditions, advanced concepts for unmanned ASW were successfully tested and demonstrated together with the SNMG2 team, including Italian and Turkish vessels. The PASSEX was concluded with an immediate after-action review on board the SNMG2 flagship, demonstrating the benefit of close collaboration between NATO's research and development community and military operators.

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“NATO and its allied nations have increasingly placed an enhanced emphasis on fostering innovation by identifying, understanding and acting to adopt emerging disruptive technologies (EDTs).”

Joining Forces: The Future of ASW

Today's geopolitical situation implies ASW operations in both deep and shallow water, involving increasingly heterogeneous threats, ranging from AUVs to midget (unmanned) subsmersibles to diesel-electric and nuclear submarines. This will affect required NATO future capabilities and will surely point toward the necessity of having a variety of sensing modalities, advanced algorithms (including AI), manned-unmanned teaming concepts, interoperability, and operations research and analysis, with consideration of how fast oceanic properties are changing as a response to global climate change dynamics.

Current research at NATO-CMRE is focused on the application of MUS and the topic of interoperability, command, control and computing (C3) in order to facilitate integration with conventional ASW assets. REPMUS22 and NATO's first unmanned system exercise, Dynamic Messenger (DYMS22), in September 2022 in Portugal are important stepping stones in order to achieve that goal. A successful future of ASW in NATO necessitates MUS joining forces with conventional platforms. **ST**

Dr. Robert Been is a principal scientist and the ASW department head at NATO-CMRE. He leads a multidisciplinary team working on the development and at-sea testing of advanced autonomous unmanned systems that comprise cognitive sonar components and advanced algorithms to tackle the challenging field of ASW. The team also supports NATO ASW exercises with operational research and data analysis expertise.



Dr. Alessandra Tesei received her Ph.D. in telecommunications in 1996 from the University of Genoa, Italy. In the same year she joined NATO-CMRE, where she started to conduct theoretical and experimental research in passive and active underwater acoustics. Since 2015, as a senior scientist, she has been leading the Maritime Unmanned Systems for ASW project. Her major interests are in physical acoustics, structural acoustics, acoustic signal processing and maritime autonomous vehicles.



Dr. Sandro Carniel is the head of NATO-CMRE's Research Division. He is an associate editor of Scientific Reports, Ocean Dynamics and Progress in Oceanography.



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New Depths in Rescue

Advanced Submarine Rescue Vehicle for Naval Sector

By Chris Buckle

The coronavirus pandemic has affected many industries, including subsea and defense, as lockdowns imposed travel restrictions that have disrupted supply chains. Fortunately, subsea and defense industry reports indicate an upward trajectory, with record levels of spending and a forecast of considerable value growth into 2026. This is particularly true in the Asia-Pacific (APAC) region, which is demonstrating substantial growth expected to continue into 2032 due to increased demand.

With money to spend, companies are turning their attention to new innovations to support their uptick in projects. It is within this environment of industry renewal that Forum Energy Technologies' (FET) subsea division is thriving, particularly in APAC. With expert submarine technology and a proven track record, FET has grown into a technology leader supporting the subsea sector around the world. A recent development has been the creation and testing of its new, highly advanced submarine rescue vehicle (SRV). This follows the success of previously supplied solutions, such as the NATO Submarine Rescue System, which, according to industry experts, "remains the benchmark" since its delivery in 2008.

LR11 Design

FET's latest SRV, also known as the LR11 with its classification from Lloyd's Register (LR), incorporates a variety of



FET's LR11 during sea trials in Vietnam.



FET's ROV during sea trials in Vietnam. (Below right) LR11 command module and manipulator claw.

the newest technologies available, making it the most advanced of its kind in the market. The LR11 joins a small group of rescue systems available for emergency operations in offshore environments.

Building on 45 years of FET's support to the naval/defense sector, the LR11 features a design and build from two leading brands in subsea: Perry Slingsby Systems and Sub-Atlantic. Vessel updates include increased speed and depth, with the vehicle able to reach almost 4 kt. and dive down to 600 m. This is powered by the LR11's advanced auxiliary thrust control system. The SRV can rescue up to 17 people in hazardous subsea environments.

The FET SRV technology features rechargeable energy storage systems (RESS), which are stored on each side of the LR11 in cylindrical pods. These storage systems utilize lithium chemistry to maximize performance, lifespan and safety within the vehicle.

Through the power provided by the RESS, the SRV uses 20-kW electric propulsors, which provide forward

thrust, and dual 23-kW hydraulic power units, which deliver fluid power for auxiliary thrusters. The RESS also powers numerous control and tooling systems.

The RESS comprises six batteries to provide energy for the propulsion and life support systems and can provide redundancy for each of these critical systems. The submersible uses the latest automotive technologies incorporating CAN bus networking and a high-voltage interlock loop safety feature.

The vessel's sensor suite includes a Doppler velocity log (DVL), fiber-optic gyroscope and sonar and depth sensors, which are fully embedded into the software to ensure advanced functionality with automatic depth, heading and piloting capabilities.

Deployment and Operation

The LR11 is designed to complement a wider rescue system, which can be supplied by FET, that is mobilized once a "SUBSUNK" alert has been triggered within a navy. SRV mobilization takes place by one of two methods: through the containerization of a portable system that can be transferred by flight, or by a mothership that houses the full complement of the rescue system.

Typical deployment is via the mothership method, with the full rescue system comprising the SRV, an ROV, the launch and recovery system (LARS) and a hyperbaric chamber facility. This chamber facility is required to

safely depressurize the rescues in the event of elevated pressures on board the distressed submarine (DISSUB).

In a critical DISSUB situation, the ROV is also a crucial technology. As soon as communications are established with the DISSUB and the mode of failure for the submarine has been determined, the ROV has the potential to resolve the issue. If the submarine has simply become entangled in debris such as fishing nets, an ROV can be used to cut the DISSUB free. If the problem is more severe and the ROV is limited in providing assistance, it can still survey the site of the incident, recording important data such as the DISSUB orientation, obstructions, currents and

visibility. A locating pinger can also be deployed onto the DISSUB by means of the ROV attaching it so that the distressed vessel can be located quickly for further visits.

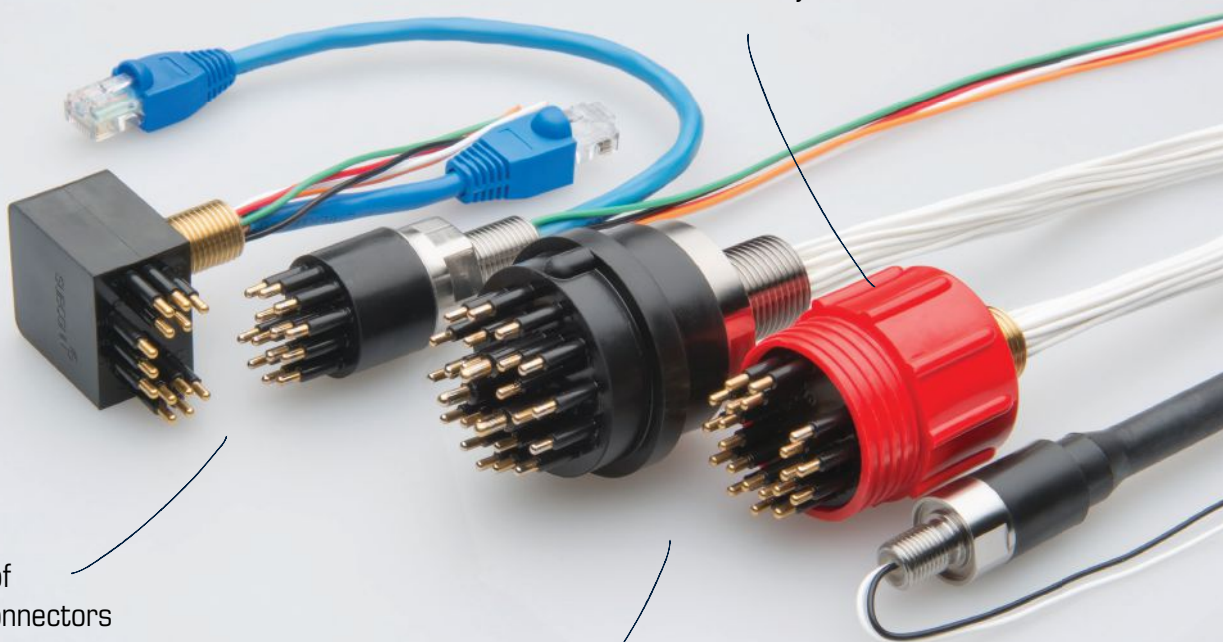
By collecting these data and feeding them back to the team aboard the SRV, rescue operations can then be prepared, including the charging of all systems. This primar-





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ily consists of the life support systems, which, when first deployed, can run for 108 hr. with 20 personnel on board at one time.

Once data have transferred to the vessel and its team, the SRV is deployed toward the DISSUB, with or without the ROV's tracking data. The SRV has a complete suite of the latest navigation and communication technologies, including a DVL, fiber-optic gyro, sonar, underwater telephone (UWT) and pinger locator. FET's software enables auto-depth, auto-heading and autopilot functionalities.

Once deployed, the LR11 is operated from the vehicle's command module as it makes its way to the rescue site. The vehicle is steered by one of two senior pilots from the front of the command module at the fore of the SRV, where there is a large acrylic window providing the pilot a wide view of the DISSUB and its surrounding area. The second pilot is seated at the back of the module, operating the advanced sensors and life support system and moving ballast water when necessary. These pilots typically have military experience and can operate the vehicle during heightened risk severity.

Behind the command module, in the remaining two-thirds of the vehicle, the LR11 features the rescue chamber, which is manned by the third member of the crew, known as the rescue chamber operative (RCO). The RCO is crucial to the rescue of distressed submariners because this person prepares the chamber for the rescue of up to 17 individuals (the maximum capacity per rescue trip). The RCO is also responsible for the operation of the rescue hatch and must be able to communicate with potentially injured or incapacitated individuals who may be suffering from toxic gases or decompression sickness (the bends).

Following location of the DISSUB and the removal of obstructions, the SRV is piloted so the transfer skirt (the hemispherical weldment underneath the rescue vehicle, at the base of which is a rubber seal to facilitate the removal of water) is situated above the rescue hatch of the DISSUB. This can be done at extremely precarious angles, supporting highly complex rescues with its capacity to attach above 40°.

So that the SRV and the DISSUB become fully bonded, the rescue vessel is lowered until the skirt seal is directly over the rescue hatch and the seal is in place. A pair of ballast pumps then pumps out the water so a



Internal view of the LR11's rescue hatch and chamber.

transfer of personnel can be conducted.

Prior to entry, the crew conducts vital communications to identify potential hazards, including toxic gases or the potential for pressure differential. The hatches are subsequently opened, and the submariners can be transported to the mothership. It is here that the necessary treatment of the rescued subsea personnel can be further conducted, following their transfer into the hyperbaric treatment complex. While a transfer is taking place, the life support systems aboard the SRV are also recharged, ensuring that multiple trips can be undertaken.

Successful Testing

Originally designed, built and tested in FET's Kirbymoorside facility in North Yorkshire, U.K.,

which features a 600-cubic-meter test pool and a hyperbaric chamber, the original tests were able to assess the SRV down to 750-m pressure. This was done alongside classification expert LR, with the SRV having been built to include full LR class certification.

Following this, the SRV completed sea trials in 2021 ahead of its deployment for the Vietnamese Navy. This navy, alongside LR, which offered third-party verification and supervision of the testing, was closely involved with the sea trials, which took two months to complete.

Naval testing proved the capabilities of the rescue vessel by ensuring it completed many of its most challenging functions at sea, including deep dives, navigation and connecting with a mating target and DISSUB, all of which are crucial for the rescue activities of a DISSUB and the extraction of potentially injured subsea personnel. Over these two months of in-country testing, nine of FET's experts were deployed to assist throughout the trial period.

As defense needs continue to evolve in an ever-changing geopolitical environment, FET's new SRV design ensures that the safety and security of submariners is in reliable hands.

References

For a list of references, contact Chris Buckle at: ROV.sales@f-e-t.com. **ST**

Chris Buckle is a chartered engineer who has worked at FET since 2004, developing subsea systems such as the NSRS and LR7 SRVs. His more recent projects include management of the delivery and sea trials of FET's latest SRV (LR11) to the Vietnamese Navy in 2021.

Bottom Crawlers

Obtaining Reliable Data in Land-Sea Transition Zones

By Arnis Mangolds

The transition from sea to shore is notoriously difficult when it comes to obtaining up-to-date data, so it will always represent a challenging area to exploit. The very shallow water (VSW), surf zone (SZ) and craft landing zone (CLZ) are harsh and unforgiving, as the dynamic environment confounds maneuvers, sensors and communications links while also being easily observed by opposition forces.

These challenges compound the innately difficult and dangerous tasks of approaching, mapping or surveying shorelines. Getting a vehicle there in the first place is a difficult task, getting it to reliably operate in demanding conditions is more difficult, then getting it to securely share a high volume of data before exiting the mission successfully and undetected add further levels of difficulty.

In the U.S., historically, responsibility for clearing assault lanes has been divided between the Navy, Marine Corps and Special Operations Command by zones. The segregation of responsibility has created a disjointed approach of tactics, technical equipment and priority. Since beaches and tactical situations all vary, any technical solution must be flexible enough to allow the commander to tailor his response to the required tasks, whether it be caching supplies, surveillance, hazard detection, neutralization or mapping.

Bayonet System Design

Bayonet Ocean Vehicles Inc. (Bayonet), a new company formed by Greensea Systems Inc., has created a family of optionally manned amphibious tracked crawler vehicles that fit a range of host platforms and can attack a variety of threats. The vehicles carry and support multiple payloads and missions and provide several control methodologies that operate seamlessly across the entire VSW/SZ/CLZ environment.

The advent of reliable, long-distance, autonomous,

amphibious bottom crawlers adds an entirely new dimension to cross-domain undersea warfare. Initially pioneered by C-2 Innovations Inc. (C-2i), the breadth of new applications quickly overwhelmed the small company. Bayonet recognized this potential, and with greater resources, staff and access to the Greensea Systems EOD Workspace software, the bottom crawlers transitioned from engineering prototypes to everyday working systems.

Bayonet systems range in size from man portable to systems that can haul over 2 tons of materials. The Bayonet 150, 250 and 350 amphibious systems can be deployed from sea or shore to collect bathymetric, seafloor, water column, video and environmental data with their integrated or guest sensor packages.

The Bayonet 150 is one-person portable, and the Bayonet 250 and 350 are two-person portable using in-field, tool-free assembly. Operating all vehicles takes one person. All systems are rated to 100-m depth and have a 10-mi. underwater range with a single set of batteries.

For mapping and characterizing the surf zone, the Bayonet systems have carried penetrometers for traffability assessment, acoustic Doppler current profilers, forward-looking and side scan sonars, neutralization disruptors and Bandolier line charges, among other payloads.

The vehicles' low domestic power draw allows for long-term station-keeping of up to 100 days for tidal or current observations, and the sink gauge will negate any scouring. The system can be programmed to collect tidal data using the pressure sensor.

Standard vehicle range is 10 mi. submerged and 24 mi. dry, and a 1.5-kt. speed provides high sounding density. Single or dual GNSS receivers provide precise positioning and heading when dry, which can be augmented by RTK. Positional data are blended with the INS to provide precise navigation when the vehicle is submerged, whether operating in autonomous or tethered modes.



Bayonet Ocean Vehicles has three bottom crawler systems that can operate in the transition zones between sea and shore. Essentially undersea trucks, they can traverse on dry land and on the seafloor and carry various payloads to fit the mission.



Most water column errors are removed by operating on the seafloor. Depth determination is from a high-precision inclinometer and a pressure sensor allowing operators to survey on the ellipsoid or reduce soundings to a local datum. The inclinometer allows operators to remove large wave motion from the data set and generate a continuous data set across the wet-dry divide.

Additional multibeam and side scan payloads to meet feature detection requirements have small sound velocity (SV) uncertainties due to operating in the same depth layer with an integrated SV sensor.

The system has negligible altitude or speed-over-ground uncertainty through the use of a sink gauge, being on the seafloor and measuring distance over ground with track movement.

Advantages of Undersea Trucks

Bottom crawlers are essentially undersea trucks that can carry large and irregular payloads across the spectrum of the littoral environment, from subsea to beach exit. By operating within the boundary layer and maintaining a low profile, the Bayonet bottom crawlers routinely operate in Sea State 3 surf. Unlike ROVs and USVs, buoyancy and balance are not design drivers, so users can freely add cargo, mission packages, or active components such as trenchers or samplers.

Bottom crawlers have several unique characteristics.

Since they consume no energy when stationary, they can remain in place for months. With ground pressures an order of magnitude less than a human, they can transit sensitive and low-bearing capacity soils, providing access to typically inaccessible terrain. This important attribute means that any tracks the vehicles leave in intertidal areas are much more rapidly washed away than human footprints, plus, they are less damaging to sensitive marine environments.

Effortless stability provides an ideal platform for neutralizers, manipulators or sensors. The proximity to the ground provides maximum sensor response in detecting buried objects. The ability to provide a stable platform has been used to support trenchers, samplers and small dredging assemblies for burying cables or sensors.

Communications and control in the surf zone are nearly impossible with legacy technologies. Vision is blocked, radio frequency (RF) and sonar are attenuated, and surface buoys are not survivable. In contrast, if communication with an operator is lost, it's no problem for a Bayonet system, which will apply its own sensing, logic and autonomy—effectively, its own decision making—to continue the mission until communication is regained.

Ongoing improvements in Bayonet vehicles' obstacle detection and avoidance and auto target recognition



software not only extend the detection ranges in marginal-visibility water, they also offer a vastly improved level of autonomy. Communication with the vehicles can be conducted acoustically, autonomously or via RF links as a function of the environment feeding Neptune, COIN and ATAK systems.

Adding to the versatility of the Bayonet platforms is the capability of mounting and launching UUVs, ROVs and UAVs from the deck, providing transportation across otherwise inaccessible environments and mission capabilities that could not be achieved by any single platform. This low-signature, deliberate and unconventional approach opens areas that would otherwise be considered denied territory.

Defense Community

Though different in size, Bayonet's various class systems share components, software and commonalities across different Department of Defense systems. Several militaries, including the U.S. military, are looking at Bayonet Ocean Vehicles for use in surf zone explosive ordnance disposal (EOD).

The U.S. Defense Innovation Unit issued an invitation to tender in January 2022 for an autonomous amphibious

response vehicle. According to the tender details issued by the North Carolina Defense Technology Transition Office, the problem of surf zone EOD will require "a state-of-the-art amphibious unmanned system capable of detecting, identifying, localizing, navigating to, inspecting, and neutralizing explosive hazards from very shallow water (40 feet or less) through the surf zone to the beach exit."

Bayonet's bottom crawlers would be an ideal fit for surf zone EOD missions, to name just one example of their possible applications. The marriage of autonomous vehicles with high-end Greensea software enables the Bayonet systems to operate and navigate across the land-sea interface seamlessly. **ST**

Arnis Mangolds is vice president of programs at Bayonet Ocean Vehicles Inc. He has 35 years of U.S. government and civil program development experience, with a record for technology transition leadership. He was the founder and president of C-2i. Prior to that, he worked on a variety of defense programs, including the Bandolier modular line charge, and was group director and vice president at Foster-Miller, where he was responsible for identifying new technologies for military and commercial transition. He has a B.S. in geology from Rutgers University and an M.S. in mining engineering from Penn State University. He holds several patents in nets, decoys, line charges, and breaching tools, logistics and robotics.

Subsea Drones

Robotic Platforms Support Defense Applications

By Donnelly A. Bohan

In 2020, global defense spending reached the highest annual level since 1988 at \$1.98 trillion. In 2029, the global maritime market is expected to be worth almost \$800 billion; of this total, the global submarine and unmanned underwater vehicles sector is forecast to be worth \$287 billion, according to the UK Defence Solutions Centre.

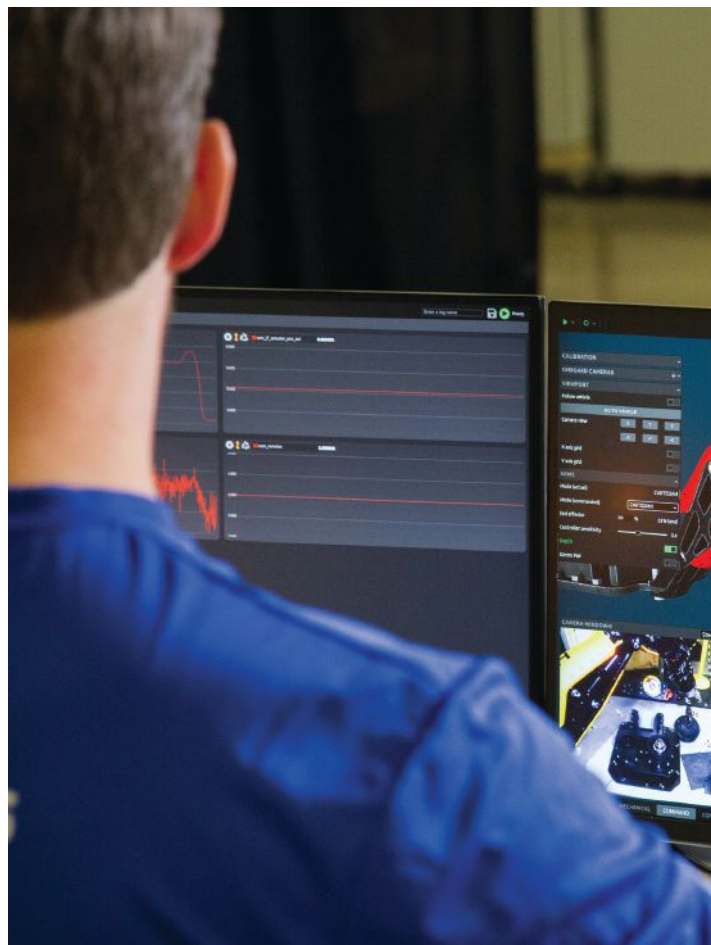
The deployment of robotic platforms in maritime environments has already begun to shift the methods that have historically been adopted to carry out defense-related missions. Advanced marine robotic technologies are being developed for applications that include intelligence, surveillance and reconnaissance (ISR); mine countermeasures; port security; and subsea infrastructure monitoring.

The Navy Unmanned Undersea Vehicle Master Plan maps out employment scenarios for UUVs, evaluating their capabilities and analyzing their strengths to allow for an accurate planning of acquisitions and technological research. The plan recognizes UUVs as a potential force multiplier in the operational scenario and a risk reduction tool for human operators.

The ISR abilities of UUVs can increase the capabilities of systems historically operated by humans, increasing maneuverability and object identification in complex environments, in high-risk areas for humans, and even in shallow water where conventional systems are unable to operate.

UUV capabilities also include hosting payloads with a variety of sensors (e.g., sonars, hydrophones, magnetometers and optical or infrared cameras). Through these devices, the vehicles are able to conduct a rapid search task aimed at the identification and localization of underwater targets and objects in confined areas, such as piers, harbors or other regions of interest.

advancement of AI capabilities in tandem with AUVs. An immediate benefit of this technology is that it eliminates the need to send divers or manned submersibles in harm's way on missions to detect and disable improvised explosive devices (IEDs), naval mines and unexploded ordnance (UXO). Additional benefits of using AUVs in-



Design Considerations

One focus of marine robotic developers has been the

clude the ability to be held in an indefinite standby posture for rapid deployment and long service duration times that are only limited by AUV power requirements. AI-controlled AUVs can accomplish higher level tasks and make decisions without human supervision. This technology truncates the amount of data a vehicle needs to receive to operate while maintaining continuous control at the same level of attention.

In the context of underwater surveillance, robotic systems are required to be indefinitely persistent, regardless of sea conditions, while maintaining a high level of effectiveness. Such persistence requires the development of innovative launch and recovery systems (LARS) and docking stations capable of resupplying autonomous marine robots at sea. All this involves a number of engineering problems that need to be tackled.

To date, one of the key challenges that researchers face



is the precise positioning of underwater vehicles, where the constraint of the drift of error over time becomes a crucial barrier to long-term surveillance missions. Lowering vehicle energy consumption by improving the efficiency of power supply and propulsion systems is essential to the development of robots that can stay in service for days to months to meet mission requirements.

Autonomous Command and Control

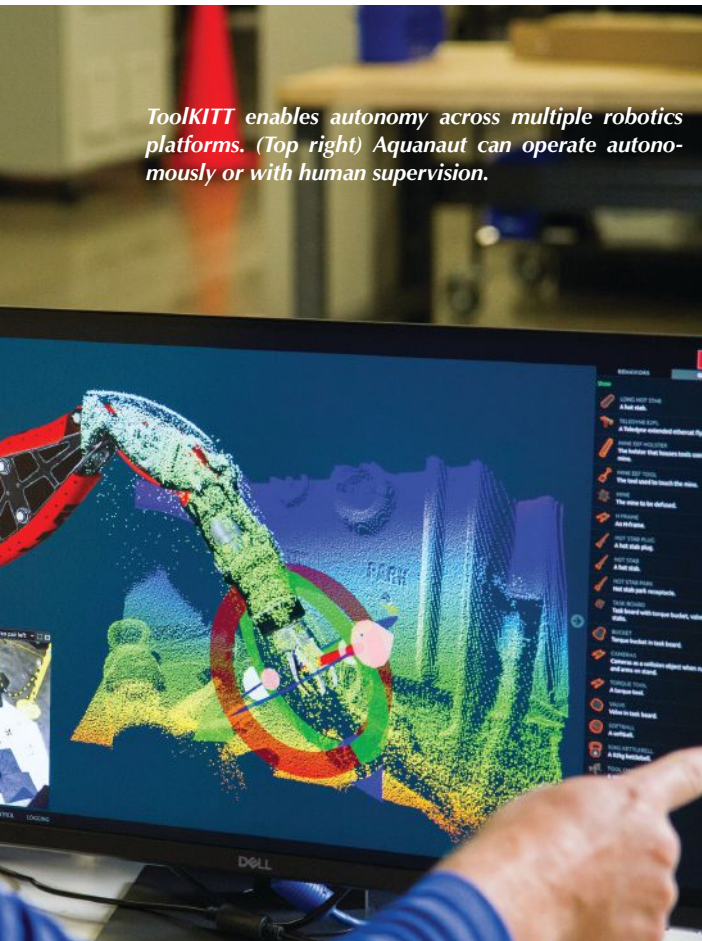
Houston-headquartered Nauticus Robotics has been awarded a contract by the Defense Innovation Unit (DIU) to prototype its proprietary autonomous command and control software platform called ToolKITT aboard the Navy's new multi-mission underwater drone. Specifically, the deal calls for testing the platform on the VideoRay Mission Specialist Defender ROV.

"We are committed to offering the best in maritime robotics and autonomy and are pleased DIU and the U.S. Navy have recognized our efforts with this award," said Todd Newell, senior vice president of business development at Nauticus. "We think ToolKITT is a transformative technology platform within the ocean services market that can result in reduced personnel requirements, cost and environmental impact."

ToolKITT's intended host, the Mission Specialist Defender, was designed for more precise control of vehicle position and orientation and heavier payloads. It can perform demanding intervention missions, such as defusing unexploded ordnance or cleaning nets for offshore fish farms. With seven thrusters, the Defender is able to move in any direction and maintain active pitch to face the vehicle in an upward or downward orientation, according to VideoRay.

Nauticus's ToolKITT was developed through internal investments and advancements sponsored by commercial and government customers. It is a unified software

ToolKITT enables autonomy across multiple robotics platforms. (Top right) Aquanaut can operate autonomously or with human supervision.





platform utilizing advanced autonomous behaviors to identify, classify and perform complex underwater activities, which help keep warfighters out of harm's way. ToolKITT was specifically designed for ease of integration to enable autonomy across multiple robotics platforms.

Aquanaut

ToolKITT is used in Nautilus's flagship product, Aquanaut, a robot depth-rated to 3,000 m. Aquanaut can collect sensory data with its perception capabilities and then plan and execute an autonomous action upon a recognized object with its manipulation capabilities.

This form of autonomy utilizes machine intelligence with no human participation required. Aquanaut can also utilize a "human-in-the-loop" approach to autonomy when an onshore supervisor is required to monitor or manage crucial actions taken by the platform. This provides an additional layer of protection for assets and the surrounding environment. Using supervised autonomy and a proprietary sea-to-surface network, Aquanaut can operate completely tether free. For longer projects, Aquanaut can utilize a subsea wireless network to receive instructions and transmit data back to the remote control center.

Aquanaut is an all-electric subsea robot that trans-

(Top left) Aquanaut transforms from a long-range AUV to an untethered ROV with two robust arms. (Bottom left) Aquanaut's arms have force sensors and grippers to conduct a range of manipulations tasks. (Top right) Aquanaut is deployed from Nauticus's small surface vessel, Hydronaut, which provides transportation, recharging and communications for Aquanaut, in addition to other tasks.



forms from a long-range AUV to an untethered ROV with two robust arms. In AUV mode, with the arms enclosed in its hydrodynamic hull, the underwater robot can cover over 50-nautical mi. in one mission, owing to its onboard lithium-ion battery and thrusters for propulsion. Along its journey, Aquanaut's onboard high-precision geophysical instruments enable it to survey the seabed and collect data.

Once the robot reaches its destination, it transforms into ROV mode. The top half of the hull raises and the head swivels into place to expose stereo cameras and powerful 3D sensors. Additional thrusters emerge to provide better maneuverability. Two, eight-axis arms unfold with built-in force sensors and grippers, and the bot is ready to perform a range of manipulation tasks. These can include waterjet cleaning, inspection of cathodic protection (a common corrosion mitigation method for submerged metal structures), flooded member detection, and other tasks to assess the condition of seafloor infrastructure. Communication is facilitated via an onboard acoustic modem. A small unmanned surface vessel relays signals between the robot and communication satellites, enabling the robot to be controlled from anywhere in the world.

Aquanaut is deployed from Nauticus's small surface vessel, *Hydronaut*, which provides transportation, recharging and communications for Aquanaut, in addition to other tasks. Together, this robotic pair function as a unified team that can offer novel capabilities to conduct subsea missions for defense. It can also be used to perform tasks for the offshore services industry. The autonomous capabilities of robotics platforms such as these will support defense and commercial stakeholders in their transition to safer and more efficient operations.

References

For a list of references, contact Ivana Beveridge at: ibeveridge@hexagroup.com. **ST**

Donnelly A. Bohan is the chief operating officer of Nauticus Robotics. She has held senior positions in the defense industry, including vice president, division manager and director of global development and strategic mergers and acquisitions at Leidos. Bohan holds an MBA from the University of Maryland, College Park.



Optimizing UXO Detection

Fluxgate Sensor Array to Survey North, Baltic Seas

By Sören Themann • Wolfgang Süß

While the North Sea and Baltic Sea are certainly not the only maritime regions in the world where the presence of unexploded ordnance (UXO) is hazardous to marine engineering developments, it is certainly one of the most difficult environments to make safe.

The problems are manifold, from the dumping of explosives and ammunition during and immediately after World War II to disposal of more modern ordnance by NATO countries as recently as the Nineties. The historic presence of what experts estimate to be more than 2 million tons of UXO across the entire North Sea and Baltic Sea is further compounded by conditions above and below the water that create a highly mobile seabed, where

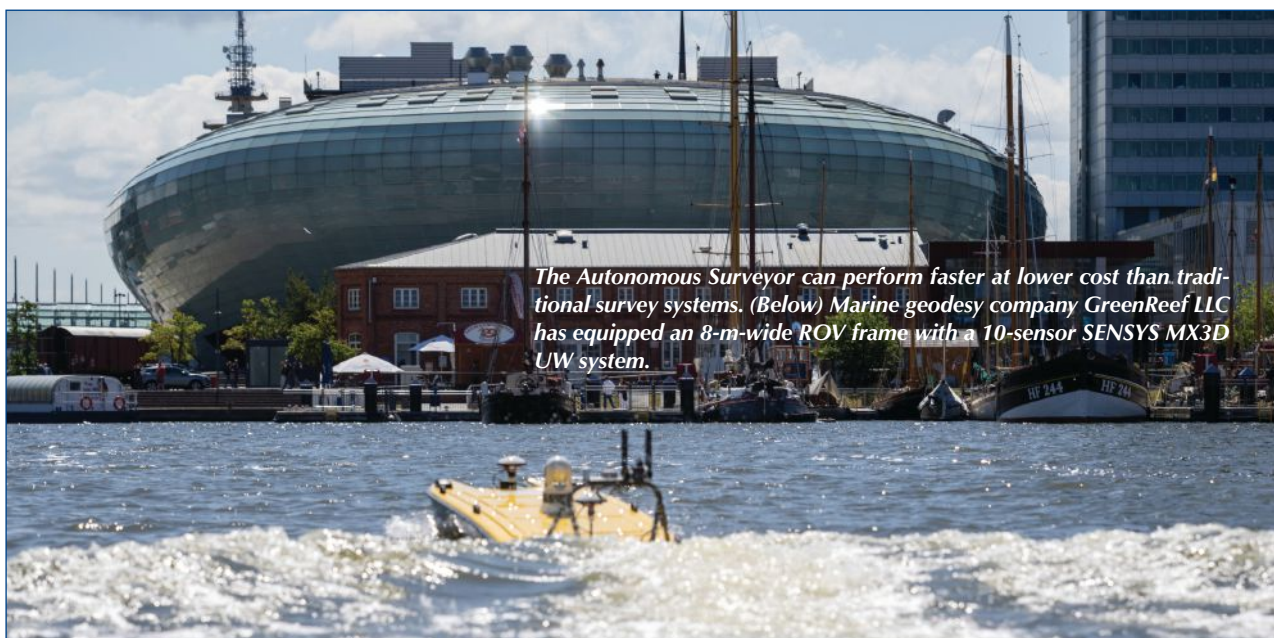
explosives somewhat safely buried in sand, sediment and mud can become more of a problem according to changing currents, sea levels and tides.

The challenges surrounding UXO in the region have primarily been the burden of oil and gas companies seeking to explore and drill for oil, build new platforms and lay subsea pipelines. A new field development should receive a risk rating of ALARP—as low as reasonably possible—and a sign-off before engineering works can start, but getting to this point can be a long and costly exercise.

Other stakeholders include construction and service companies, charged with building tunnels, bridges and underwater infrastructure. Furthermore, as the magni-



Subsea Europe Services' Autonomous Surveyor, based on MARTAC's MANTAS T12, and magnetometer towfish.



The Autonomous Surveyor can perform faster at lower cost than traditional survey systems. (Below) Marine geodesy company GreenReef LLC has equipped an 8-m-wide ROV frame with a 10-sensor SENSYS MX3D UW system.



results below the seabed, as well as a combination of multibeam echosounders, side scan sonar and sub-bottom profilers to ensure a complete and trustworthy data set is acquired.

UXO experts will then analyze the collected data to create a list of targets that they believe may be UXO. Targets above a certain threshold will be further investigated with divers and/or ROVs. In order to reduce these costs and the associated HSE (health, safety and environment) risk, it's vital that the desk study and offshore survey refine the number of possible targets to ALARP.

Overall, it's a hazardous, sometimes drawn out and technical process that adds millions of euros to field development pre-planning budgets.

In addition, the UXO survey process is ongoing throughout the life of a field and will need to be conducted at designated intervals, or when any structural expansions—new platforms or sub-sea infrastructure—are required.

While the expense has been necessary as the North Sea oil and gas sector has thrived, the financial and time restraints of the next energy production residents in the region—offshore wind farms—demand that the search for UXO is more efficient, faster and cheaper than the status quo. Other drivers for change include tourism, environmental protection and demonstrating value to governmental bodies tasked with building UXO strategies.

New Wind

While the U.K. has taken an early lead on developments in its section of the North Sea, Germany's coalition government set a further wave of greenhouse gas reduction measures in the spring of 2022 that include

tude of the UXO problem becomes clearer, governments are assessing, planning and carrying out the removal of UXO even in areas where there are no immediate plans for construction projects. Cost is unsurprisingly one of the biggest barriers to establishing national or international UXO strategies.

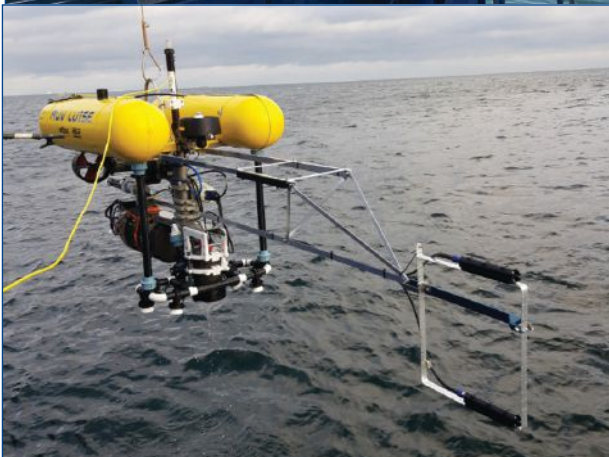
Current Workflow

The established workflow for UXO detection starts with a desk study that compares data from as far back as the 1950s to more recently available data as a way to highlight potential areas of interest. This phase often uses open-source data and requires the input of UXO experts to make calls on specific data points that should be investigated.

An offshore UXO survey comes next, using a commercial marine survey vessel. Surveyors would generally use a large and expensive cesium vapor magnetometer as their primary sensor, which provides super-accurate



MX3D UW as part of an RS Diving survey. The system is small and light enough for use on diverse platforms. (Below) MX3D UW magnetometer used in a GEOMAR AUV survey.



The financial challenge to offshore wind energy is compounded by international laws governing who is responsible for UXO clearance and detection. There are an estimated 500,000 tonnes of UXO in the German North Sea and 1,600,000 tons in the Baltic Sea; however, state funding for detection and clearance stops at 12 mi. from shore. While governments decide if they will act regardless of specific project requirements, this makes the wind farm developers and energy supplier responsible for UXO costs offshore, which is where most of the new wind capacity is likely to be located.

The UXO survey approach used by the oil and gas industry is well established, but it is clear that the marine survey industry must continue to accommodate the needs of its renewable energy customers and look at technologies and methodologies that will make the entire process faster and cost less. Here, new workflow enabled by autonomous survey platforms should unlock the survey capacity and cost efficiency needed by the offshore wind industry and governments.

USV vs. UXO

As the world moves to more sustainable means of energy production, the marine survey industry is moving toward a more autonomous way of working, in both the survey vessels used and the systems that collect and analyze subsea data. It's a novel approach to deep integration of platform and sensors that German companies Subsea Europe Services and SENSYS are seeking to exploit in response to the predicted spike in demand for UXO survey for new wind farm developments.

A key enabler of their solution is recognition that UXO surveying in the relatively shallow North Sea, for instance, doesn't necessarily require a cesium vapor magnetometer. While objectively a very suitable technology for the job, cesium vapor magnetometers are expensive, large and very heavy. Most importantly, they are overkill for the task of detecting and identifying UXO at sea—other types of magnetometers can be used instead.

While not as precise as the industry standard cesium vapor system, other magnetometers, such as three-axis fluxgate sensors, can provide highly accurately and trustworthy data. Usually, these systems are much smaller, lighter, more integrated and lower cost, which means a wider range of vessels can be used as the UXO survey platform. One such system is the SENSYS multi-channel MX3D UW, a three-axis fluxgate sensor array that detects and tracks objects and structures underwater. The submersible measurement system is equipped with FG-M3D UW high-resolution, three-axis fluxgate sensors, sampling at up to 2,000 Hz. The sensor data are digitized

increasing offshore wind production by 30 GW by 2030.

Barring any further target increases, this will require circa 11,000 new wind turbines to be built, which will be spread across hundreds of new wind farm sites in the German North Sea, requiring thousands of kilometers of cable to be laid in the sediment. While dwarfed by the cost of turbines, installation, power infrastructure and engineering works, the cost of marine data for engineering and UXO applications is significant and will affect the cost per megawatt hour to the consumer.

via 24 bits by the MX3D UW recording unit and synchronized with DGPS or other third-party sensor data, allowing for data output via TCP/IP.

The MX3D UW is an ideal solution for UXO search, with many successful campaigns already under its belt. The marine geodesy company GreenReef LLC, for instance, has equipped an 8-m-wide ROV frame with a 10-sensor MX3D UW system for efficient, large-area subsea scans for UXO and debris in the Black and Baltic Seas. Baltic Taucherei, an established German offshore service provider for UXO search, also includes MX3D UW systems within its detector portfolio.

The system can be used with various software solutions, such as QPS Qinsy, EIVA NaviScan, BeamworX and HYPACK, and has a scalable structure with a flexible default data transfer protocol, making it easy to integrate into existing infrastructures, such as vessels, AUVs, ROVs or ROTVs.

The attributes of this sensor array are helping Subsea Europe Services to develop a next-generation UXO survey system using smaller, faster and more agile USVs. The team has designed a unique configuration for the company's Autonomous Surveyor USV, which downsizes and introduces more autonomy within the UXO survey workflow to increase speed and capacity while providing data for the customer that is just as actionable as data acquired by larger-scale and far more expensive traditional approaches.

Based on the MANTAS T12 platform from Florida-based USV specialist MARTAC Systems Inc., the Autonomous Surveyor is established as the world's fastest and most agile commercial survey USV. At just above 3 m in length, it can still carry a full payload of hydrographic survey equipment capable of acquiring bathymetric data to the highest International Hydrographic Organization S-44 standards while also having space for an MX3D UW on board. The MANTAS T12 electric motor and propulsion system is more than capable of pulling three to four tow-fish mounted SENSYS magnetometers, essentially forming a gradiometer for even higher performance UXO detection and classification performance.

The combination of the MX3D UW and the Autonomous Surveyor's standard hydrographic payload make for a formidable match in terms of acquiring actionable data, fast. This is great as a one-for-one replacement for crewed UXO survey vessels and work-class ROVs, as the cost of data can be reduced significantly due to the autonomous nature of the MANTAS T12 requiring less manpower to operate and the reduction in fuel use due to the all-electric propulsion.

The pairing of a magnetometer and bathymetric system with the multibeam, side scan capabilities and precise positioning of the Autonomous Surveyor's standard payload can be scaled up quickly and easily. The team is calling this the mothership concept, where a vessel as small as 15 m can be used as the launch and recovery system and operations center for, say, three similarly equipped MANTAS T12 USVs with tow-fish mounted MX3D UW systems.

Through this method, survey coverage is significantly

expanded but without the cost of, in this example, three traditional survey vessels, three cesium vapor magnetometers and three full complements of crew and UXO specialists.

It's clear that this approach will deliver a significant return on investment, considering the data acquisition capacity will exceed that of the established UXO survey workflow.

AI Operations

Further savings are to be made by adding more autonomy to the process. Already, Autonomous Surveyor is capable of running survey lines without human intervention, but, currently, the sensors it uses for bathymetry and UXO search and classification require trained operators to ensure data quality is maintained. Forthcoming developments in multibeam echosounder technology will bring with them more autonomous data handling and analysis, which will unlock the door to flexibility in a survey, as the sensor's AI controller can tell the Autonomous Surveyor to take another look at a target if needed.

Similar functionality is expected for the SENSYS magnetometers. The GEOMAR - Helmholtz Centre for Ocean Research Kiel has added the MX3D UW to its survey and detection equipment pool within the BASTA project, which aims for AI support methods for munition detection and clearance in the seas. While this work is in its early phase, the use of AI in the magnetometer UXO survey workflow will enhance speed, efficiency and cost reduction.

As AI advancements develop, the Subsea Europe Services and SENSYS team can provide a system with the cost savings and UXO survey capacity increase needed by all the new wind farms that will develop in the next eight years. Just the use of one Autonomous Surveyor and towed magnetometer in place of a survey vessel streamlines a UXO survey, and scaling up to multiple, integrated units unlocks exponential operational and financial value, especially when considering bathymetric survey for seabed mapping and engineering purposes can be conducted at the same time from the MANTAS T12 platform.

Autonomy for USVs and sensors systems will play a role in enabling the massive growth of offshore wind energy production capacity. UXO remains a challenge during the planning, building and operation of a wind farm, but Subsea Europe Services and SENSYS's new solution to locate and identify UXO will be a contributing factor to enabling the lower cost of wind energy. Further, with wider public knowledge about the problem of UXO in the North Sea and Baltic Sea, pressure on governments to act will demand new and efficient ways of working, which the application of autonomous USVs and sensors can provide. **ST**

Sören Themann is the CEO of Subsea Europe Services.

Wolfgang Süß is the managing director of SENSYS.

Pioneer Harbor Tug

Digital technologies from ABB have enabled the harbor tug *Maju 510* to become the first vessel in the world to receive Autonomous and Remote-Control Navigation Notation from the ABS classification society and the first Singapore-flagged vessel to receive the Smart (Autonomous) Notation from MPA. The notations acknowledge the breakthrough performance of the tug, demonstrating autonomous collision avoidance capabilities in trials conducted at Raffles Reserved Anchorage, off Singapore Island, in March 2022.

Keppel Offshore & Marine (Keppel O&M) is the project lead for the autonomous solutions on the *Maju 510*, which is owned and operated by Keppel Smit Towage, a member of Rimorchiatori Mediterranei. The vessel has already distinguished itself as the world's first vessel to se-

cure the ABS Remote-Control Navigation Notation, following initial remote operation trials at the Port of Singapore in April 2021.

The latest trials verified the next level of autonomy, demonstrating automated situational awareness, collision avoidance and maneuvering control provided by ABB Ability Marine PilotVision and Marine Pilot Control.

The 32-m-long harbor tug demonstrated its ability to autonomously avoid collisions in various scenarios, such as when two other vessels approach simultaneously on colliding paths and when a nearby vessel behaves erratically. The trials were supervised by an onboard tug master.

Milestone Deal for Small-Boat Electrification

The Swedish electric car maker Polestar will provide battery and

charging systems for Candela's revolutionary hydrofoiling speedboats. The deal will enable Candela to scale up production swiftly, bringing mass-market electric boats one step closer to reality. The deal between the two Swedish companies is an attempt to overcome the two major hurdles for electrifying boating. The first hurdle is the massive energy consumption of conventional powerboat hulls, which so far has resulted in poor performance of electric boats. This obstacle has been cleared by Candela's hydrofoil technology that cuts energy usage of powerboats by up to 80 percent. The second hurdle has been the prohibitively high cost of marine batteries for electric boats.

Industry-Wide Collaboration For Cybersecurity

The Association for Uncrewed Vehicle Systems International (AU-VSI) and Fortress Information Security have initiated an industry-wide collaboration focused on devel-

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oping an enterprise cybersecurity model and a suite of voluntary standards to address cyber risks specific to uncrewed systems and robotics.

Industry collaboration among buyers and vendors/suppliers is a proven cybersecurity strategy. Using previous Fortress work that led to the development of voluntary risk-based standards for the utilities industry as a blueprint, AUVSI will spearhead an effort to build consensus, establish standards and facilitate proactive cybersecurity policies and actions among uncrewed systems manufacturers and suppliers.

Big Rise in Data Usage Among Commercial Vessels

Data usage on commercial maritime vessels has jumped more than threefold since 2019, according to Inmarsat. This underlines the shipping industry's reliance on digital connectivity to enhance operating efficiency and safeguard crew welfare during a period of unprecedented disruption to seaborne trade.

The internal study reveals that maritime demand has continued to rise as commercial shipping recovers, following the peak of the COVID-19 pandemic, with data usage among Inmarsat maritime customers rising almost 70 percent in the 12 months leading to mid-2022.

Analysis of data usage by leading vessel operators shows year-on-year demand for data was highest among container shipping companies, more than doubling (108 percent) in June 2022 compared to June 2021, while use of connectivity increased by 70 percent among oil tanker operators and by 47 percent on bulk carriers over the same period.

AI for Voyage Optimization

Wallenius Wilhelmsen said it has become the first global shipping company to adopt a fully AI-based approach to voyage optimization. Having implemented live streaming of vital data on board 65 vessels, this new approach will help reduce fuel consumption by up to 10 percent. Wallenius Wilhelmsen aims to reduce emissions by 27.5 percent by 2030. The company has been working with Athens-based mari-

time technology company DeepSea to rigorously test and further develop its vessel performance software.

AI informs a vessel captain of optimal route and vessel speed, based on sailing conditions, with weather forecast prognosis updates.

K-Sim DP Simulator for Japan Training Center

Kongsberg Digital (KDI) has delivered a full mission K-Sim Dy-

namic Positioning (DP) Simulator to MOL Marine & Engineering for the new MOL Dynamic Positioning Training Centre (MOL DPTC) in Tokyo, Japan. MOL DPTC is the first DP training center in Japan to be accredited by the Nautical Institute (NI) to provide NI-approved dynamic positioning training courses.

KDI will also deliver a digital version of the DP2 cable-laying vessel *KDDI Cable Infinity*. **ST**

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STR Center of Excellence

Subsea Technology and Rentals (STR) has launched a global technology and innovation center of excellence after investing £1 million into the facility to drive its innovative solutions and support its growth plans. The 30,000 sq. ft. facility in Great Yarmouth, U.K., will be a hub for STR's research and development with state-of-the-art engineering and product development suites, mechanical and electronic assembly and testing areas, supported by the recruitment of 19 new employees, bringing the Great Yarmouth headcount to 53.

The firm has experienced rapid growth during 2022, following an investment from Baird Capital.

AAL Recovers Heavy Tugs in Tasmania

AAL Shipping has performed a salvage operation to remove two tugs from the Mersey River in Devonport on the northwest coast of Tasmania that had been sunk by a cement carrier in January. Chosen for the job was the 31,000-dwt, 700-tonne heavy-lift vessel, the AAL *Melbourne*. Work involved the lifting of the tugs and their onward shipment to Brisbane. New South Wales-based emergency response, salvage and environmental support specialist United Salvage engaged AAL to supply a vessel from its longstanding "Asia to Australia East Coast Liner Service."

Svitzer Achieves Deep Emissions Cuts

Svitzer, a global towage operator and part of A.P. Moller-Maersk, has successfully prevented 1,000 tonnes of CO₂ from being emitted into the atmosphere as a result of its Aim for 8 speed initiative, which asks tug crews to navigate at a maximum speed of 8 kt. during mobilization and demobilization.

A pilot of the Aim for 8 initiative started in late 2021 across Svitzer's U.K. operations and is part of the company's multifaceted decarbonization strategy that was launched in May 2022. The initiative proves that small behavioral changes, when implemented alongside more ambitious and long-term shifts, such as fuel and tug design, can have an immediate and measurable impact on the CO₂ emissions of the global fleet.

OceanTools Turns 25

OceanTools is celebrating its 25th anniversary. The company founder, Kevin Parker, said, "OceanTools has come a long way since I cobbled together the industry's first PC-based video overlay system on my dining room table in 1997." That overlay, having evolved over the years, is still in production in 2022, with several thousand units sold.

The company now produces subsea video cameras and lighting systems, a sophisticated dye and leak detection system, and advanced subsea pressure housings. Export sales exceed 50 percent of turnover, with markets including oil and gas, scientific research, renewables, defense and trawling.

Ashtead Acquires WeSubsea

International subsea rental equipment and solutions specialist Ashtead Technology will expand its mechanical solutions service offering with the planned acquisition of WeSubsea. The transaction is expected to close during the fourth quarter of 2022 and will be the group's sixth acquisition in the past five years.

Founded in 2010, WeSubsea is a specialist in subsea dredging technology solutions, supporting customers globally from its operating base in Aberdeenshire, U.K.

EIVA Acquires SensorSurvey

EIVA a/s has acquired SensorSurvey a/s, a Danish hydrographic survey company that has been working with EIVA for many years. This will benefit the development and testing of a variety of survey and inspection solutions, ranging from autonomous USV survey capabilities in NaviSuite Kuda, EIVA's hydrographic survey software, to photogrammetry visualizations in NaviSuite Mobula, EIVA's ROV control and inspection software.

Falcon Joins Maldives Research

A Saab Seaeye Falcon has joined a fleet of submersibles on the Nekton Maldives Mission to help the Maldives government carry out the first systematic survey and sampling of the Maldives from the surface to 1,000-m depths. As an official partner, Saab Seaeye has donated the use of a Seaeye Falcon to work alongside human-occupied submersibles, autonomous systems and research technologies.

The Maldives state is 99 percent ocean and 1 percent land, sitting on average at 1.5 m above sea level. As a result, the nation faces a growing threat from rising seas. For the first time, the mission will establish a "baseline health check" on the status of the Maldives ocean and provide data to scientists and policymakers worldwide to enable the protection of critical nurseries, spawning habitats and related ecosystems.

The Nekton Maldives Mission will help create extensive new protected marine areas and ensure the ocean continues to provide for the Maldivian people.

Nekton is a nonprofit, U.K.-based research foundation working with the University of Oxford and a wide range of partners to accelerate the scientific exploration and protection of the ocean.

Woolpert Africa Forms

Woolpert has integrated the staff, resources and local experience of its two geospatial companies in Africa, Southern Mapping Co. and AAM, to form Woolpert Africa. The team will provide geospatial data collection, processing and management to support common applications in Africa, including services in mining, power, infrastructure, agriculture and the environment.

Woolpert acquired Southern Mapping Co. in 2019. Based in Johannesburg, Southern Mapping specializes in LiDAR, hyperspectral imagery and remote sensing technologies. AAM is a photogrammetric mapping, surveying and GIS firm headquartered in Australia. AAM joined Woolpert in 2021. It has offices in Johannesburg and

Cape Town and staff across multiple African countries and the Gulf States.

Greensea Adds Office

Greensea Systems Inc. has opened a third location to accommodate its growing workforce and strengthen its local presence. The new office, located in San Diego, California, provides ample room to accommodate the local team, new hires, as well as a spacious production area. It also allows Greensea to take advantage of the technology hiring pool found in southern California in anticipation of further expansion.

Greensea also has offices in Richmond, Vermont, and Plymouth, Massachusetts.

IMS Chosen for USCG CB-OTH V

IMS (Inventech Marine Solutions), manufacturer of Life Proof Boats recreational vessels, has been selected as the manufacturer of the U.S. Coast Guard's (USCG) new CB-OTH V in a 200-boat contract.

The CB (cutter boat) OTH (over the horizon) is typically a 25-ft., tactical, high-speed vessel that the Coast Guard uses to intercept and pursue other vessels. These boats are usually carried aboard larger Coast Guard cutters and on board polar icebreakers.

Crowley Expands Design Capabilities, Invests in Zero-Emission Tech

Crowley has expanded its vessel design services with the strategic integration of the Seattle-based marine interior design company JE Russell Consulting. This addition will give Crowley's engineering services group the capability to complement vessels' existing designs with interior designs, consulting and other service offerings.

In more Crowley-related news, Zero Emission Industries (ZEI), a hydrogen technology company for maritime, has conducted the first close of its Series A funding round. The round was led by Chevron New Energies, with additional investment from Crowley. The new funds are expected to enable ZEI to roll out its next-generation fully integrated marine power system and scale quickly to meet the demand in the maritime industry for zero-emission propulsion solutions.

Multiband VSAT Platform for MEO

Cobham Satcom's 2.4-m, multi-orbit, multiband satellite antenna platform, the Sea Tel 2400, has been successfully tested on SES's O3b medium Earth orbit (MEO) system. It will enable new capabilities and services for the maritime, energy and government segments.

Phoenix Wet-Welding Approval

Phoenix International Holdings Inc. has a new Class A Underwater Wet Weld Procedure, qualified to all positions groove and fillet by ABS. This procedure meets all requirements of American Welding Society D1.1 (Structural Welding Code – Steel), as well as D3.6 (Underwater Welding Code). This latest certification complements Phoenix's more than 50 certified welding procedures already in place. **ST**

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Oyster Aquaculture Could Improve Potomac River Estuary
Oyster aquaculture in the Potomac River Estuary could result in significant improvements to water quality, according to a new NOAA and U.S. Geological Survey study published in the journal *Estuaries and Coasts*. The study found that oyster farming could remove 40 percent of the river's nitrogen load, which is a major source of pollution for the estuary. [Read more](#)

Navy's Laser Weapon Ready for Summer Deployment
Navy engineers are making final adjustments to a laser weapon prototype that will be deployed aboard a ship in the summer. The prototype, an improved version of the laser weapon system, was tested in the Gulf of Mexico for at-sea testing in the summer. Navy leaders have made the weapon a top priority to counter what they call asymmetric threats, including unmanned and light aircraft and small boats that could be used to deny U.S. forces access to certain areas. [Read more](#)

Ferry Sinks Off Coast of South Korea
A ferry carrying 463 passengers and crew sank off the southern tip of South Korea, according to a report from the Associated Press. At least 460 people on the ship were rescued for a hospital trip to the mainland. The rescue effort, which has been ongoing since the ship sank, is still in progress. [Read more](#)

Pay Increase for Sailors Soon to Come
Sailors working for the U.S. Coast Guard are set to receive a pay raise. The new pay scale, which was approved by Congress, will increase the pay for sailors from \$10.50 an hour to \$11.50 an hour. The raise will take effect on January 1, 2023. [Read more](#)

US Senate Reviews DOE Budget Request
The U.S. Senate is reviewing the Department of Energy's budget request for fiscal year 2023. The request includes a \$2.1 billion increase in funding for the Department's research and development programs. The Senate is expected to vote on the budget request in the coming weeks. [Read more](#)

US Technology Helps in Search for Missing Plane
A U.S. Coast Guard cutter used advanced technology to locate a missing private plane in the Gulf of Mexico. The cutter, the USCGC Spencer (WMEC-903), used its advanced search radar to find the plane, which had been missing for several days. The plane was successfully rescued and the crew was returned to the cutter. [Read more](#)

offshore oil & ocean engineering

JF Renewables Establishes Partnerships in Taiwan

James Fisher Renewables (JF Renewables), a part of James Fisher and Sons, is growing its local capabilities in the Asia-Pacific (APAC) region through strategic partnerships with Dong Fang (DFO) and Ho Lung Power Engineering (HLPE).

Through these partnerships, JF Renewables will provide the technical knowledge transfer to selected local teams, operations and maintenance, termination and testing, and other selected services.

JF Renewables will be able to provide a valuable local content offering to the Taiwanese market to address the shortage of skills while enabling customers to optimize their local content requirements.

DFO, the largest Taiwanese maritime engineering, procurement and construction contractor, will provide local vessels, crew and

project management to JF Renewables for offshore wind projects in the country. Through HLPE, a leading Taiwanese electrical company promoting the development of offshore wind power and onshore power systems, JF Renewables will have access to local project teams of skilled personnel and project equipment to complete services for termination and testing, cable repair and fault detection in Taiwanese offshore wind farms.

Oceaneering to Provide ROV Services in Brazil

Oceaneering International's Subsea Robotics segment has been awarded a multi-year service contract supporting Petrobras projects off the coast of Brazil.

Oceaneering will provide survey and ROV services for AKOFS Offshore's subsea equipment support vessel *Aker Wayfarer*.

The scope of work includes the provision of two Millennium Plus work-class ROVs, complete specialized tooling packages for each ROV, ROV personnel for simultaneous operations, and survey equipment and personnel.

Helix Decom in Thailand

Helix Robotics Solutions, the robotics division of Helix Energy Solutions Group Inc., has been awarded a 180-day firm-plus-options contract by a local Thailand contractor to perform decommissioning services using the subsea construction vessel *Grand Canyon II*.

The contract scope of work includes DP3 vessel services, crane support and ROV services in connection with subsea well abandonment and decommissioning operations in multiple Thailand offshore fields and is scheduled to begin in the late fourth quarter of 2022.

CCUS Potential in Australia

Chevron Corp., through its affil-



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iate Chevron Australia Pty Ltd., is part of three joint ventures that have been granted an interest in three greenhouse gas assessment permits offshore Australia. The blocks, including two in the Carnarvon Basin off the northwestern coast of Australia and one in the Bonaparte Basin offshore Northern Territory, total more than 31,500 km² or nearly 7.8 million acres, an area larger than Belgium.

As part of its global lower carbon strategy, Chevron is focused on carbon capture, utilization and storage (CCUS), primarily through hubs with third-party emitters as partners and customers: renewable fuels, hydrogen, offsets and other emerging technologies.

Tendeka to Provide Sand, Inflow Control Tech for NCS

Global completions specialist Tendeka has signed a new multi-year contract extension to exclusively deliver standardized sand-face completion equipment across all Equinor's assets on the Norwegian Continental Shelf (NCS). The agreement, which also includes options for further extension periods, will see Tendeka manage the complete supply chain of sand and inflow control equipment through standardization.

TechnipFMC Subsea Work In Brazil

TechnipFMC has been awarded an engineering, procurement, construction and installation (EPCI) contract by TotalEnergies for its Lapa northeast field in the pre-salt Santos Basin offshore Brazil. TechnipFMC will reconfigure and install umbilicals and flexible pipe in a new configuration that will further secure the production of the field.

By offering the flexibility of a phased campaign, TechnipFMC is helping TotalEnergies accelerate its schedule and begin production sooner.

Well-Safe to Decommission Neptune Energy Wells

Well-Safe Solutions and Neptune Energy have agreed on a contract for the Well-Safe Protector jack-up

rig to plug and abandon (P&A) at least four subsea and 21 platform wells in the Dutch and U.K. sectors of the North Sea.

The one-year contract allows Neptune Energy to take up Well-Safe's range of decommissioning engineering services if required, with optional extensions.

Hydrocarbon Finds in Guyana

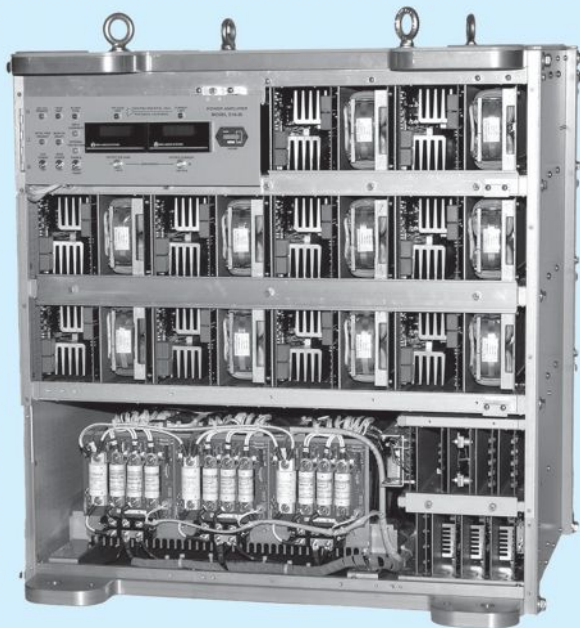
ExxonMobil has made two new

discoveries offshore Guyana to the southeast of the Liza and Payara developments in the Stabroek block. The discoveries at Seabob and Kuru-Kuru are the sixth and seventh in Guyana this year, with the total number of discoveries in Guyana at more than 25.

The company's 2022 investment plans include further exploration drilling and resource development in Guyana. **ST**

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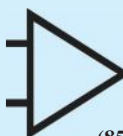
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AI Ship Support



Route Pilot AI is a cloud-based AI-powered ship operation support system that utilizes high-frequency data to calculate the most advantageous propulsion settings for upcoming voyages. The AI, which uses digital twin modeling to simulate operational parameters, will enable ship and shore-based personnel to calculate optimal working parameters to lower fuel consumption and realize the most energy-efficient voyage. Yara Marine Technologies AS.

Vessel Management

Sperry Marine Vessel Performance enables vessel owners to collect and analyze onboard data in real time for efficient fuel usage, regulatory compliance and optimized voyage routing. The new solution relies on several modules of the ABB Ability OCTOPUS - Marine Advisory System, such as motion monitoring and forecasting, performance monitoring and access to a web-based fleet portal where vessel data can be visualized and analyzed onshore. Sperry Marine and ABB Ltd.

High-Voltage Shore Power

BLUE CONNECT seamlessly facilitates a vessel's connection to a port's electrical grid in order to power the vessel's systems and equipment while at berth. This enables the ship's diesel generators to be switched off, with a resultant reduction in noise and emissions, such as particulate matter, nitrogen oxides, sulphur oxides, carbon oxides and volatile organic compounds. ERMA FIRST.

Submersible Fish Pen

SeaProtean is rugged and lightweight with smooth buoyancy control to alleviate fish stress and simplify operation. It is made from high-density polyethylene (HDPE) and can be raised and lowered by a single worker by simply opening a valve to easily avoid rough seas or storms that would batter traditional surface pens. Innovasea Systems Inc.

Variable-Speed Generator Set

This new range of gensets makes it possible to build vessels with smaller battery banks and charge them while on the move, which makes the switch to hybrid-electric marine propulsion more cost efficient and accessible. The direct-current grid system is easy to upgrade with alternative power sources and has the flexibility of modular installation. Volvo Penta AB.

Rugged Tablet



M700DQ8-EX is a 7-in. ATEX Android PDA powered by Qualcomm Snapdragon 660 Octa-core at up to 2.2 GHz. It supports comprehensive wireless connectivity and sensors to assist and keep workers connected, even in the most remote locations. It meets U.S. military 810G standards for vibration, shock and 5-ft. drop. The IP65 rating means it's protected against dust and water splash. Winmate Inc.

Digital Twin

Digital twins enable new ways of working and interacting with data

and operational insights. The first areas this maritime twin supports are trim advisory, 3D visualization of the vessel and situational awareness around it, including weather conditions. The twin is powered by real-time data from the Vessel Insight data infrastructure and its ecosystem of applications. Kongsberg Digital AS.

Ku-Band in Mideast



THOR 10-02 Ku-band service on the Newtec Dialog platform is now available to clients in the Middle East, offering the increased speeds and bandwidths that were previously available only on THOR 7 Ka-band services for maritime and offshore energy customers. The service can be fixed or mobile. Telnor Satellite AS and ST Engineering iDirect.

Dual-Fuel Engines

Cat 3500E-series marine engines can be modified to run as dual-fuel methanol in the future. This will provide a pathway to greenhouse gas reduction for customers across a wide range of applications and vessel types that are powered with these engines. Caterpillar Marine.

Freshwater Generator

Compared to the single-stage AQUA

Blue E1, the two-stage AQUA Blue E2 produces twice as much freshwater for a certain amount of waste heat, or the same amount of freshwater using around half the waste heat. Doubled capacity can meet an increased need for freshwater in connection with alternative fuels. Alfa Laval AB.

Waste Heat Recovery

HeatPower 300 Marine generates clean electricity from low-temp waste heat produced by a ship's engines. It can produce up to 355 kW of carbon-free electricity from a single unit and suits larger vessels with an engine size of at least 15 MW. Climeon AB.

Remote Compliance Verification

NAUTConnect is a service hosted on the Veracity platform to enable the optimal performance and safety of navigational systems. It is a continuous remote compliance verification system for electronic navigational systems and integrated network equipment. DNV.

Engines for Sustainable Fuels

Series 2000 and Series 4000 mtu marine diesel engines will be ready in 2023 for EN15940 synthetic diesel fuels, including the sustainable fuels BtL (biomass to liquid), HVO (hydro-treated vegetable oil/renewable diesel) and PtL (power to liquid), such as e-diesel. Rolls-Royce Power Systems AG.

Cellular Vessel Monitoring System

NEMO is a VMS beacon offering cellular connectivity coupled with a satellite (backup) option that can

help assist fisherman in need while at sea. NEMO features a distress and assistance button, Bluetooth and a self-sustaining solar panel. It is suitable for coastal state and regional fisheries programs. Woods Hole Group Inc.

AC Subsea Lamp

Available as either a floodlight or a spotlight, the L6 lamp has been designed to be used on underwater vehicles and installations at 120 V AC/DC. Illumination is up to 10,000 lumens, with flicker-free dimming using RS232, RS485 or analog control and a range of color temperature options. L6 is depth rated at 4,000 and 8,000 m. OceanTools Ltd.

Waterproof LCD Monitor

SRMW-21.5Z is a 21.5-in. monitor that can operate in direct, bright sunlight or other high-ambient-light conditions. With 1,000 Nits brightness, it is four times brighter than standard monitors and features 1,920 x 1,080 HD resolution. The NEMA 4X fully waterproof stainless steel enclosure can withstand rain, snow, sleet and seawater. The exclusive TRU-TUFF treatment ensures shock and vibration protection. TRU-Vu Monitors Inc.

Compact Laser Scanner

Insight Nano can generate high-resolution 3D modeling in difficult-to-reach places, e.g., on the seafloor or in a municipal water pipeline. It provides a complete visual understanding without requiring auxiliary sensors as it conducts continuous, high-speed 360° scanning. Voyis Imaging Inc. **ST**



Survey Vessel for USACE

Silver Ships Inc. has delivered the largest marine surveying vessel of its series, designed for the U.S. Army Corps of Engineers (USACE) Venice Sub Office in Venice, Louisiana. The 49-ft. marine surveying vessel, *Tobin*, is the latest expansion in Silver Ships' Endeavor series of workboats. It is custom designed for USACE to hydrographically map the mouth of the Mississippi River.

This mission-specific vessel will allow researchers to accurately and effectively obtain and document data on the rapidly changing waters in the Mississippi River. With the intent of keeping waterways open and preventing obstructions to marine navigation, *Tobin* is equipped to handle challenging river terrain.

US Coast Guard Museum Under Construction

The U.S. Coast Guard has commemorated the new construction of the National Coast Guard Museum with a formal ceremony on the City Pier, New London Waterfront, New London, Connecticut. Adm. Linda L. Fagan, commandant of the Coast Guard, officiated the symbolic "keel-laying" ceremony for the museum's main building, which will memorialize more than 230 years of service into one central location to honor the legacy and heritage of the Coast Guard. The museum will comprise six floors and 80,000 sq. ft. of exhibit space.

New Director of BSEE's Pacific Region

The U.S. Bureau of Safety and Environmental Enforcement (BSEE) has selected Bruce Hesson to serve as the new regional director of BSEE's Pacific Region. Hesson has 40 years of experience in oil and gas operations at both the state and federal levels.

As the Pacific regional director, Hesson will oversee the production of conventional energy resources on the federal Outer Continental Shelf, which extends seaward of California, Oregon, Washington, Hawaii and the Pacific U.S. territories. He will lead an experienced team of approximately 40 petroleum engineers, structural engineers, geologists, geophysicists, environmental scientists and administrative staff.

Hesson graduated from Texas A&M University in 1983 with a B.S. in petroleum engineering and has been a California registered professional engineer since 1997. He previously served 29 years with the California Division of Oil, Gas and Geothermal Resources, where he worked his way up from field engineer to district deputy for the Ventura District, serving 13 years in that capacity until his retirement from the state in May 2016.

Most recently, he served with BSEE for six years as the permitting section chief and regional supervisor for the Office of Field Operations in the Pacific Region's Camarillo office.

\$17.4 Million to Address Fishery Disasters

U.S. Secretary of Commerce Gina M. Raimondo has announced the allocation of \$17.4 million to address

fishery disasters that occurred in multiple tribal salmon fisheries on the West Coast from 2014 to 2019.

The following have been declared fishery disasters: 2019 Fraser River & Skagit River Salmon Fisheries (the Swinomish Indian Tribal Community, Tulalip, Upper Skagit Tribes); 2015, 2016, 2017 and 2019 Fraser River and Nooksack River Terminal Area Sockeye, Chinook, Chum, Coho and Pink Salmon Fishery (Lummi Nation); 2019 Puget Sound Fall Chum Salmon Fishery (Squaxin Island Tribe); 2014 and 2019 Fraser River Sockeye and Puget Sound Chum, and Coho Salmon Fishery (Port Gamble S'Klallam Tribe); and 2019 Klamath River Fall Chinook Salmon Fishery (Yurok Tribe).

The funds will help improve the long-term economic and environmental sustainability of the impacted fisheries. Funds can be used to assist fisheries participants, including commercial fishermen, charter businesses, shoreside infrastructure providers and subsistence users. Activities that can be considered for funding include: fishery-related infrastructure projects, habitat restoration, tribal and fishing permit buybacks, job retraining and more.

USCG Drafts Study to Improve Navigation In Response to More Traffic Along Pacific Coast

To address the significant growth of waterway use along the Pacific Coast, the U.S. Coast Guard has drafted the Pacific Coast Port Access Route Study (PAC-PARS). This is the first comprehensive evaluation of vessel traffic patterns that use Pacific coastal waters off the coasts of California, Oregon and Washington.

The main goal of the PAC-PARS is to evaluate historic and future waterway usage to determine navigational risk and provide recommendations to uphold safety of navigation. To do this, the study examined vessel tracking data from the past 10 years and considered environmental data, existing and planned offshore development infrastructure, and historical marine incident data, among other data sets. The Coast Guard also considered concerns and recommendations from key maritime stakeholders and members of the public.

The draft PAC-PARS recommends establishing new voluntary fairways for coast-wise and nearshore vessel traffic with connections to existing traffic separation schemes and ports. These fairways would facilitate safe and predictable traffic patterns as the demand for and use of Pacific coastal waters increases.

US House Science Committee Hearing On Next-Generation Weather Satellites

The U.S. House Committee on Science, Space, and Technology's Subcommittees on Space and Aeronautics and Environment has held a hearing on NOAA's next-generation of weather satellites. The ability of the National Weather Service to provide accurate and life-saving forecasts often starts with data collected by these satellites. As NOAA and NASA embark on the next generation of weather satellites to follow GOES-R and JPSS, it's important to understand the metrics being used to develop future programs. **ST**

Greensea to Continue Developing Autonomous Hull-Cleaning Vehicle

Greensea Systems Inc. has been awarded a contract for a two-year, phase-two option period by the U.S. Navy's Office of Naval Research to continue the technology development for an autonomous hull-cleaning vehicle. This is a continuation of the work that Greensea has been conducting through a Small Business Technology Transfer program since 2018.

The focus of the earlier phase one and two efforts were to design, characterize, develop and test a navigation system that can provide the required accurate on-hull navigation.

The focus of the newly awarded option period is to continue to refine the navigation and autonomy technology, demonstrate the capabilities through proactive cleaning of a vessel of significance to the U.S. Navy, and deliver a complete data package for the cleaning system.

US Navy Orders More Defender ROVs

VideoRay LLC has received a large and diverse order for its Defender ROVs from the U.S. Navy. As the Navy is standardizing its VideoRay Defender Mission Specialist system, VideoRay's customer support for the Navy includes training facilities and staffing on the U.S. East Coast in Pottstown, Pennsylvania, and the West Coast in San Diego.

The Defender ROV offers ease of repair in the field. All of its components are modular and designed to be easily swapped out by warfighters during operations.

Kongsberg Propellers, Shaft Lines For New German Frigates

Kongsberg Maritime Sweden AB has received a contract award from Damen Naval to supply four ship sets of KONGSBERG Controllable Pitch Propeller systems, along with associated hubs, blades, hubcaps and shaft lines, for the German Navy's new F-126 frigates.

The F-126 platform, due to enter service from 2028, will have an overall length of around 160 m and displacement of approximately 10,000 tons. It will accommodate

up to 114 crew members with 80 additional berths. The multipurpose frigate is capable of operational missions in all maritime warfare domains, and it can perform other duties, such as: enforcing naval embargoes, counterpiracy missions, long-duration maritime patrolling, maritime escort and convoy tasks, the support of special forces, and acting as a command ship for task groups.

JFD Submarine Rescue System Exercise

JFD has successfully completed Northern Crown, a NATO Submarine Rescue System (NSRS) exercise that involved mobilization of the system onto the Swedish Navy vessel HSwMS *Belos* in September and October 2021. The exercise is completed every two years as part of the memorandum of understanding between the NSRS participant nations and the Swedish Navy.

HSwMS *Belos* already has a transfer-under-pressure system and launch and recovery system installed, so interface equipment was used to enable the NSRS Submarine Rescue Vehicle to be launched, recovered and connected.

Sea Serpent ASW Demo for Coastal Trident

MIND Technology Inc. has completed a successful demonstration of its Sea Serpent low-cost, anti-submarine warfare (ASW) system as a part of the U.S. Navy's Coastal Trident 2022 exercise. The system was deployed from a USV and executed an autonomous mission to detect a realistic underwater target.

Sea Serpent is based on MIND's commercially developed SeaLink seismic streamer technology. Sea Serpent can be used for harbor security, maritime domain awareness or ASW and provides a cost-effective, highly capable, low-power, robust and scalable solution that can be easily customized. This system also provides a rapidly deployable subsea intelligence, surveillance and reconnaissance capability from fully autonomous platforms.

Joint R&D on Underwater Signal-to-Noise Ratio

Naval Group and the Indian Institute of Technology Goa have agreed to conduct joint research to improve the analysis of data collected by underwater sensors, using neural systems and artificial intelligence. Applications include underwater surveillance, submarine imaging and drones. **ST**



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environmental monitoring

Seagrass Monitoring Solution

A new, noninvasive method to measure and monitor seagrass biomass on the seabed around England's southwest coast is being developed as part of an ongoing, collaborative project. The innovative technique is being trialled by local companies HydroSurv and Valeport, working with the University of Plymouth and Natural England, supported by a grant of more than £266,000 from Innovate UK's Smart Grants program.

It builds on the concept of the acoustic reflectivity of seagrass providing valuable information to characterize submerged aquatic vegetation. A full-stack solution comprising a Valeport VA500 altimeter installed onto a HydroSurv REAV-28 USV was specifically developed for this project. A large, validated signal library and deep-learning algorithm, developed by the University of Plymouth, deciphers the survey data to predict seagrass distribution. The data are visualized and interpreted in a cloud application created by HydroSurv.

The USV platform facilitates accurate repeat surveys that can be compared to monitor temporal changes in seagrass coverage for the planning of protection and regeneration projects at biodiversity-rich work sites. The full solution, which was demonstrated successfully to project stakeholders for the first time in May 2022, is set to change the way seagrass meadows are monitored in the future, complementing traditional diver surveys to cover much larger areas and enable rapid re-survey work as required.

Baseline for Vessel Emissions In North America

The Blue Sky Maritime Coalition (BSMC) has released a report that provides a current benchmark for CO₂ emissions from the major vessel sectors that make up maritime transportation in North America.

"Having a complete view of the North American maritime industry's carbon footprint helps us better un-

derstand the sum of the challenge ahead of us and the solutions needed to address those challenges," said David Cummins, BSMC president and CEO. "This report drills down to the sector level, helping us focus and prioritize our efforts where they can have the biggest impact."

Developed by the Finance, Commercial and Chartering Workstream, the report found that CO₂ emissions from North American waterborne transportation was approximately 47 million tonnes in 2018. Of the total North American maritime-related emissions, the offshore support vessel fleet and the inland tug and push-boat fleets make up nearly 50 percent of all emissions. Coastal and harbor tugs and ferries make up another 14 percent, and tankers and articulated tug barges contribute 6 percent.

Climate Change Affects Lake Colors Worldwide

If global warming persists, blue lakes worldwide are at risk of turning green-brown, according to a new study that presents the first global inventory of lake color. Shifts in lake water color can indicate a loss of ecosystem health.

While substances such as algae and sediments can affect the color of lakes, the new study finds air temperature, precipitation, lake depth and elevation also play important roles in determining a lake's most common water color.

Blue lakes, which account for less than one-third of the world's lakes, tend to be deeper and are found in cool, high-latitude regions with high precipitation and winter ice cover. Green-brown lakes, which are 69 percent of all lakes, are more widespread and are found in drier regions, continental interiors, and along coastlines, the study finds.

The new research was published in *Geophysical Research Letters*. The researchers used 5.14 million satellite images for 85,360 lakes and reservoirs around the world from 2013 to 2020 to determine

their most common water color. While prior studies have used more complex and finer scale metrics to understand overall lake ecosystem health, water color is a simple yet viable metric for water quality that can be viewed from satellites at the global scale, the authors said. This approach provides a way to study how remote lakes are changing with climate.

Additionally, changes to water color may have recreational and cultural implications in locations such as Sweden and Finland where lakes are culturally prevalent. As warming continues, lakes in northern Europe will likely lose their winter ice cover, which could affect winter recreational and cultural activities.

Monitoring Equipment for Port of Tyne in UK

OceanWise has recently won a contract with the Port of Tyne in the U.K. to provide an environmental monitoring solution to support operational decision making across the port's jurisdiction. The project involves installation of new monitoring equipment, as well as integration with a suite of existing sensors to deliver accurate, reliable, real-time tide and weather data.

The Port of Tyne is one of U.K.'s most innovative and efficient deep-sea ports. OceanWise will support port operations by installing Port-Log, a system will enable access to key data and customized alerts for port operators and pilots detailing the dynamic tide and environmental conditions in the port.

Pollution Study on Coastal Central America Barrier Reef

A new study in *Ocean and Coastal Management* traces the vast majority of nitrogen pollution that flows into the Mesoamerican Reef Region back to agricultural operations as the source.

Coral reefs are located in nutrient-poor waters, where they have adapted to these conditions. An increased influx of nutrients can disrupt ecosystem functioning. Knowing the pollution source could help managers with mitigation. **ST**

contracts

Fugro, Oslo, Norway, has been awarded a marine site characterization contract for the Sørige Nordsjø II offshore wind farm. This will include mapping the seafloor and subseafloor to expand understanding of the site's geological features and support future developmental phases of the project, which will be one of Norway's first large-scale offshore wind farms. Norwegian Petroleum Directorate.

Ocean Technologies Group (OTG), London, U.K., has agreed to deliver ChartWorld's On-board Familiarisation System (OFS) on OTG's Ocean Learning Platform. ChartWorld.

Rolls-Royce Power Systems, Friedrichshafen, Germany, has received an order from a Spanish shipyard to supply nine mtu hybrid propulsion packs for nine new ships for the Italian high-speed maritime passenger transport company Liberty Lines. The vessels are scheduled to enter service between 2023 and 2026. Armon.

OneWeb, Hamburg, Germany, has signed a memorandum of understanding to explore opportunities for advanced low Earth orbit (LEO) satellite technology to support the next generation of marine expertise and autonomous shipping. HD Hyundai Avikus.

DNV, Milan, Italy, has signed a memorandum of understanding with maritime technology leaders to collaborate on autonomous ship technology developments. HHI, AVIKUS and Liberian International Ship & Corporate Registry.

NAVTOR, Egersund, Norway, has agreed to unite its ship operations platform NavFleet with ScanReach's wireless IoT platform for a seamless performance monitoring and optimization solution. ScanReach.

Korean Register, Busan, South Korea, will co-develop new propulsion systems capable of handling

green fuels, including ammonia and hydrogen. Daewoo Shipbuilding & Marine Engineering.

Innovex One, Singapore, will co-develop an advanced and innovative analytics dashboard that will enhance digital port management information systems, giving ports better visibility on their operations and supporting strategic decision making. Aventura Group.

Modus, Darlington, U.K., will perform autonomous surveys and light interventions with over-the-horizon control at the Johan Sverdrup field via its Saab Sabertooth hovering AUVs, to be resident in the field for a significant period. Equinor. **ST**

meetings

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

DECEMBER

December 12-16—AGU Fall Meeting, Chicago, Illinois, and virtual. www.agu.org/Fall-Meeting.

2023

JANUARY

January 25-26—Coastal Futures, London, U.K. <http://coastal-futures.net>.

January 30-February 1—Floating Wind Solutions, Houston, Texas. <https://floatingwindsolutions.com>.

January 30-February 2—ASNE Technology, Systems, and Ships Conference and Combat Systems Symposium, Arlington, Virginia. www.navalengineers.org/Symposia/TSSCSS23.

FEBRUARY

February 13-15—Geo Week, Denver, Colorado. www.geo-week.com.

February 14-16—Oceanology International Americas, San Diego, California. www.oceanologyinternationalamericas.com.

February 27-March 1—World Ocean Summit, Lisbon, Portugal. <https://events.economist.com/world-ocean-summit>.

MARCH

March 12-16—US Hydro, Mobile, Alabama. www.thsoa.org/us-hydro.

March 26-28—Canadian Underwater Conference & Exhibition (CUC), Halifax, Canada. www.cuce.ca.

March 28-30—MCE Deepwater Development, London, U.K. 713-447-8559, Sara.Wilkins@GulfEnergyInfo.com or <https://tinyurl.com/456e9yjb>.

APRIL

April 18-20—Ocean Business, Southampton, U.K. www.oceanbusiness.com.

MAY

May 1-4—Offshore Technology Conference, Houston, Texas. <https://2023.otcnet.org>.

May 8-10—World Utilities Congress, Abu Dhabi, United Arab Emirates. www.worldutilitiescongress.com.

May 8-11—XPONENTIAL, Denver, Colorado. meetings@auvsi.org or www.auvsi.org/events/xponential/xponential-2023.

May 9-11—UDT, Rostock, Germany. team@udt-global.com or www.udt-global.com.

JUNE

June 5-8—OCEANS 2023, Limerick, Ireland. <https://limerick23.oceansconference.org>.

June 6-8—Capitol Hill Ocean Week, Washington, D.C. <https://marinesanctuary.org/chow-2023>.

SEPTEMBER

September 11-15—London International Shipping Week, London, U.K. <https://londoninternationalshippingweek.com>.

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

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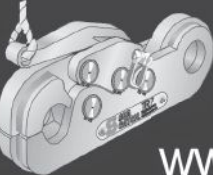
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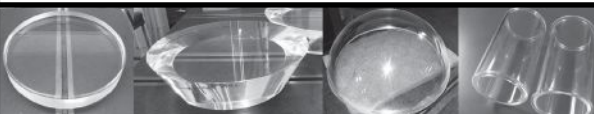
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Gustavo Lopez (pictured) is senior market access manager at Septentrio. With over 19 years of experience working with GNSS technology, he is a senior expert with in-depth knowledge of various GNSS applications and use cases. Maria Simsky is a technical content writer for Septentrio. She has a degree in engineering and several years of experience working in the high-precision GNSS industry.



With the industrial growth of automation and robotization, the demand for accurate and affordable navigation is on the rise. When selecting a GPS/GNSS positioning receiver, it is crucial to understand the vulnerabilities of these sensors and the effect they could have on the navigation system.

Most autonomous navigation technologies include an inertial navigation system (INS), comprising a GNSS receiver and an inertial measurement unit (IMU) sensor. While the GNSS receiver provides absolute positioning in terms of geographic global coordinates, the IMU measures heading, pitch and roll angles, which give orientation information of a moving system.

The IMU's measurement of relative movement is subject to cumulative error called drift and needs regular recalibration. In a GNSS/INS system, both sensors are fused in such a way that the GNSS provides regular IMU calibration and the IMU provides angles and extrapolation, or "smoothing" of GNSS.

For robots and autonomous devices, availability of signals/data is key to ensuring continuous and reliable service. Safety also needs to be considered for robots/drones operating close to people. GNSS jamming or spoofing needs to be detected and flagged immediately so that other sensors can take over if necessary.

Spoofing is a threat to GNSS-based INS systems because it is an intelligent form of interference that makes the receiver believe it is at a false location. Since spoofing takes place at the level of the GNSS signal, sophisticated methods can be employed within the receiver to detect and mitigate spoofing.

Jamming is a kind of radio interference that overpowers weak GNSS signals, causing accuracy degradation and possibly even loss of positioning. Unintentional jamming sources include radio amateurs, maritime and aeronautical radiolocation systems, as well as electronic devices located close to the GNSS receiver. There are also intentional jamming devices (jammers) that can disrupt signals.

Jamming results in loss of positioning because the GNSS receiver in an INS solution becomes ineffective. This can lead to longer INS initialization times or a switch to dead-reckoning mode that relies solely on the IMU, causing position drift. Jamming can also result in measurement outliers, which impact GNSS/INS algorithms (i.e., deep or tight coupling).

Compared to jamming, spoofing poses the highest security risk for GNSS/INS systems. During a spoofing attack, an INS solution could be "hijacked" if the spoofer uses small increments in positioning, which can go undetected by common anti-spoofing methods.

Using sensors other than GNSS, such as an IMU or odometer, can help flag spoofing by detecting inconsistencies between the GNSS and other sensors. While such sensors help reduce spoofing risks, they do not provide full protection because they only output relative positioning, which is subject to drift.

For example, the GNSS/INS systems can have a drift of a meter or more when visibility of GNSS satellites is lost for longer periods. Spoofers can exploit this drift phenome-

non to hijack positioning gradually, in increments comparable to the expected drift. If the spoofing attack keeps positioning increments within the allowed thresholds for drift, it would go undetected. That is why, for best system protection, anti-spoofing resilience should be built into system components in both the GNSS and INS.

An INS system will be more resilient if the GNSS receiver can indicate spoofing or, even better, if it can mitigate spoofing by itself. Thus, when integrating GNSS/INS solutions it remains crucial to understand the role of protection mechanisms in GNSS and to select a GNSS receiver with a strong internal anti-spoofing defense system or a warning system. A Septentrio receiver, for example, provides lots of information about GNSS signals, allowing users to get insights into the spoofed signal with data such as time stamps and power levels.

A GNSS receiver that implements effective security measures in its design will include spoofing resilience at various levels, like the Septentrio AIM+ (advanced interference mitigation) system that has anti-jamming and anti-spoofing components built into receiver hardware and software. The GNSS receiver and the INS each have their own mechanism for spoofing protection. However, the best resilience comes from the combination of detection and mitigation mechanisms working together at the component level.

Continuous improvement is needed to maintain effective anti-spoofing and anti-jamming mechanisms. GNSS manufacturers must strive for the most effective security methods as threats increase for today's GNSS users. By investing in GNSS receivers with built-in resilience, integrators can leave the security maintenance to the GNSS manufacturer so they can focus on their core business. **ST**

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