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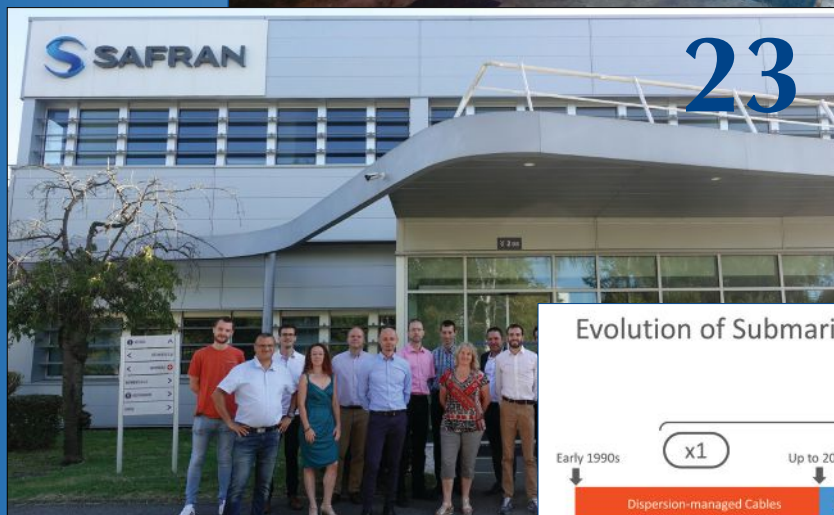
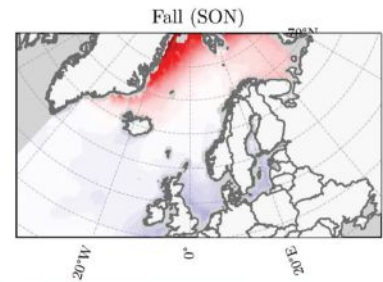
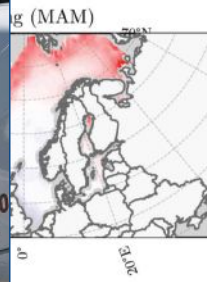
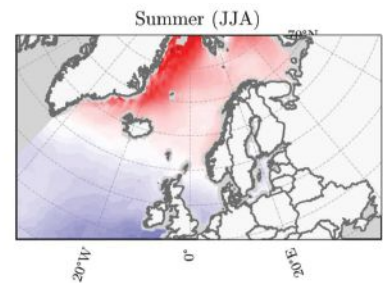
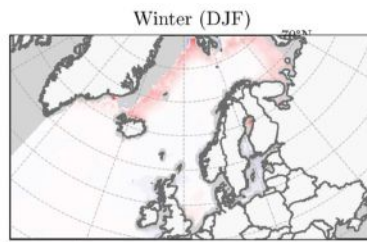
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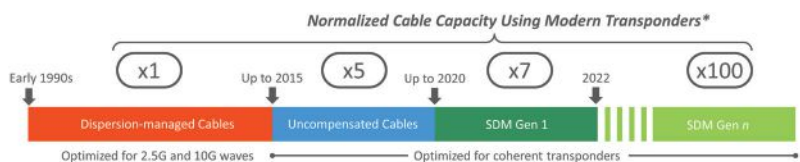


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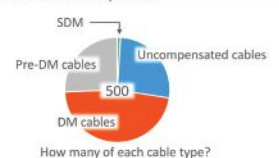


Evolution of Submarine Cables



*Compares total cable capacity for trans-Atlantic distance using fifth-generation coherent transponders

There are only a few SDM cables today, but SDM is the accepted architecture for new long-distance submarine cables



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COVER IMAGE

Ships participating in exercise Baltic Operations 2023 (BALTOPS 23) transit the Baltic Sea, June 4, 2023. BALTOPS 23 is the premier maritime-focused exercise in the Baltic Region. The exercise, led by U.S. Naval Forces Europe-Africa and executed by Naval Striking and Support Forces NATO, provides a unique training opportunity to strengthen the combined response capability critical to preserving the freedom of navigation and security in the Baltic Sea. (Credit: U.S. Marine Corps, Shawn Coover)

NEXT MONTH

Subsea imaging sensor ... Seismic data acquisition and processing ... How tech is lighting up the ocean's dark depths ... Radar imaging with low bandwidth ... Q&A: Edie Widder.

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Instruments

)) Public Development Banks Commit to Ocean Sustainability. Several public development banks have committed to working together on a Blue Finance Roadmap to take rapid action on the protection and sustainable use of the ocean. Titled “A Call to Deliver Positive Action For The Ocean,” the pledge was launched by the Agence Française de Développement (AFD), the Asian Development Bank (ADB), the Development Bank of Latin America and the Caribbean (CAF), Cassa depositi e prestiti (CDP), the European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB), the Inter-American Development Bank (IDB), Germany’s KfW Development Bank and the West African Development Bank (BOAD). The initiative will help improve coordination among public development banks to align their actions. The Blue Finance Roadmap will bring together the know-how and experience from all of the ocean investments carried out by the participating organizations, ensure accountability, and identify remaining financing gaps and realistic funding opportunities. Development banks can support biodiversity and a sustainable blue economy by financing ocean pollution reduction through wastewater, stormwater and solid waste infrastructure. The banks can also invest in marine protected areas, eco-ports, greener shipping, renewable ocean energy, circular economy, emerging sectors such as sustainable aquaculture (including seaweed and mariculture), blue biotechnologies, ocean data, restoration and blue carbon sequestration. The declaration also emphasizes that public banks must adhere to the “do no harm” principle, aligning with the guidance from the UN-convened Sustainable Blue Economy Finance Initiative and not compromising the ecosystem services of blue natural capital. Additionally, these banks are encouraged to strive for a proactive approach by “doing maximum good.” This entails making significant contributions to climate action, biodiversity preservation and the advancement of sustainable livelihoods.

)) Industry Faces Challenge of Access to Carbon-Neutral Fuel Supply. Faced with tough competition for greener fuels from other sectors, new 2030 maritime emission targets hang in the balance, according to the latest edition of DNV’s Maritime Forecast to 2050, which reveals the shipping industry will find it challenging to secure enough supply of carbon-neutral fuels. The report emphasizes the need to consider all alternative approaches to reducing emissions and to take action now to secure future success. Increasing regulatory pressure to decarbonize, including stricter targets set by the International Maritime Organization (IMO) this July, means the shipping industry now needs to achieve a 20 percent reduction in emissions by 2030 and net-zero emissions by or around 2050. To meet the anticipated demand of 17 million tonnes of oil equivalent annually by 2030, the maritime sector needs to access 30 to 40 percent of the projected worldwide carbon-neutral fuel supply. Shipowners must therefore focus beyond fuels, in particular on what can be done now to achieve energy efficiencies and carbon emission reductions. The Maritime Forecast to 2050 presents an updated look on a range of regulations and drivers for the decarbonization of shipping, the most important being new IMO regulations, the inclusion of shipping in the European Union’s (EU) Emissions Trading Scheme and incoming well-to-wake requirements. These regulations will increase the operational cost of using carbon fuels, incentivizing shipowners to put plans in place today to reduce their carbon output. To overcome decarbonization challenges, the sector can adopt operational energy efficiency measures, such as air lubrication systems and wind-assisted propulsion. The latter has already been installed on 28 large vessels, delivering fuel savings of 5 to 9 percent to date. The potential when retrofitted on existing ships can reach 25 percent. In addition, technologies such as onboard carbon capture and storage and nuclear propulsion can address the competition for sustainable biomass and renewable electricity.

)) Grants, Loans Can Catalyze Offshore Wind in Emerging Market Countries. A new report published by the World Bank’s Energy Sector Management Assistance Program (ESMAP) and the International Finance Corp. (IFC) finds that concessional climate financing is essential to unlock offshore wind in emerging markets and estimates that \$15 billion in concessional climate financing, consisting of both grants and loans, could catalyze offshore wind deployment in up to 10 emerging market countries. As a large-scale, clean, reliable electricity source, offshore wind is critical to achieving global decarbonization and the UN Sustainable Development Goals. Concessional climate financing for offshore wind investments, delivered through existing channels, could directly avoid 416 million metric tons of greenhouse gas emissions over the life of the projects.

)) First Maritime Sustainability Standard. The International Marine Purchasing Association (IMPA) and GP General Procurement Co. Ltd. (GenPro) have partnered to create an industry-first maritime sustainability standard: MSCSS (Marine Supply Chain Sustainability Standard). The shipping industry has more than 400 sustainability standards available but has lacked a dedicated and industry-specific sustainability standard. Currently, shipping companies (operators and managers) are expected to communicate their sustainability reports without being able to verify across the board. At the same time, marine suppliers and/or service providers lack an industry-approved and accepted sustainability standard to guide their extended supply chain. The MSCSS Standard will be rolled out from January 2024 with a suite of resources and a dedicated website. **ST**

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The Long Blue Line: USCG Evolves During Prohibition

Of Prohibition, U.S. Coast Guard (USCG) Commandant Edwin J. Roland said: "The story of the 'Noble Experiment' is in large part a Coast Guard story." In 1919, the 18th Amendment to the Constitution was ratified to outlaw alcohol, and the Volstead Act followed to enforce Prohibition. In America's territorial waters, including its lakes, inland waterways and thousands of miles of coastline, the U.S. Coast Guard was the lone enforcer of this unpopular law.

Enforcing Prohibition would become the largest law enforcement mission in USCG history. By 1922, the Federal Prohibition Commission counted hundreds of motherships hovering off U.S. shores in "Rum Row," stationed off of Boston, New York, New Jersey, the Chesapeake Bay, New Orleans and West Coast ports. By 1923, USCG Commandant William Reynolds admitted his cutters could prevent "only a small part" of the onrush of illegal booze, which was "entirely unprecedented in the history of the country."

Congress had not appropriated any funds to the Coast Guard yet to stem the tide of rum runners, but by October 1923, Reynolds submitted a plan to Treasury Secretary Andrew Mellon to deal with the situation. Reynolds called for 20 new high-seas cutters, 200 coastal patrol cutters and 90 fast picket boats. He asked for \$20 million in supplemental funding for this vast fleet and 3,500 more personnel. At the time, it was an incredible request for funds.

Based on Reynolds' figures, Mellon recommended enlarging the Coast Guard at a cost of \$28.5 million, over three times the service's 1923 annual budget. Congress agreed to Mellon's proposal, but appropriated only half the amount, primarily for fleet expansion and increased manpower. By 1924, the funds began to flow. New high-seas cutters requested by Reynolds were shelved in favor of 20 mothballed U.S. Navy destroyers that could be refurbished quicker than new construction. Cutter inventory did increase, though, and the new cutters were made of steel rather than wood. Personnel increases, new boats and refurbished destroyers quickly burned through the funding.

In 1922, USCG officers had convinced service leadership that aerial patrols could observe far more of the water's surface than cutters. And so began the permanent establishment of Coast Guard aviation. In May 1925, temporary Coast Guard operations were set up at Squantum Naval Air Station in Massachusetts. The service's first aerial law enforcement assist took place on June 20 that year, and the first Coast Guard aviation interdiction took place four days later.

In the early 20th century, development of the radio had brought new ways to communicate and locate transmissions both at sea and on shore. As early as 1919, the radio direction finder (RDF) had come into use in a primitive form on the cutter *Androskoggin*. During Prohibition, these devices aided in detecting lines of bearing on transmissions from motherships, rum-running boats and their clandestine shore transmission stations.

The Prohibition era, which ended in 1933, saw the Coast Guard take on its largest law enforcement mission, and the service experienced the largest peacetime fleet expansion in its history. With 320 cutters and destroyers, and hundreds of smaller boats, the service's budget mushroomed from \$9.3 million in 1923 to over \$24 million in 1927, with personnel levels more than doubling from 4,000 men to 10,000. And the service saw many firsts, including the first time Coast Guard crews manned Navy warships and the permanent establishment of a Coast Guard aviation branch. It also saw extensive use of the radio and RDF. All of these factors shaped the service into a force better prepared for its next great challenge: World War II. **ST**

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JANUARY

Annual Review & Forecast

****EUROMARITIME 2024**, January 30-February 1, Marseille, France

FEBRUARY

Instrumentation: Measurement, Processing & Analysis

****Oceanology International 2024**, March 12-14, ExCel, London, U.K.

MARCH

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

****UDT 2024**, April 9-11, ExCel, London, U.K.

****OCEANS 2024 Singapore**, April 14-18, Singapore

****XPONENTIAL 2024**, April 22-25, San Diego, CA

APRIL

Offshore Technology/Alternative Energy & Ocean Engineering

****Offshore Technology Conference**, May 6-9, Houston, TX

MAY

Communications, Telemetry, Data Processing

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Seafloor Mapping/Sonar Systems/Vessels

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Climate Change and Security

The Role of New Technologies at NATO

By Fabio Lissi • Aniello Russo • Dr. Sandro Carniel

Climate change (CC) is a defining challenge of our time, and the world is facing a double dilemma: how to curb greenhouse gases (GHG) emissions to meet the 2016 Paris Agreement and, at the same time, adapt to the consequences of a changing climate.

Based on the Climate Change and Security Action Plan (CCSAP), endorsed by NATO heads of state and government at the 2021 Summit in Brussels, and the last Strategic Concept (SC), agreed upon in Madrid in June 2022, Allies have put an emphasis on adapting to and mitigating CC in the defense and security domains, as well as raising awareness and outreach about this paramount topic.

CC is a “threat multiplier” that significantly shapes the Alliance’s strategic environment, both in the Euro-Atlantic area and in its broader neighborhood. The effects of CC will be felt across all NATO’s operating domains. Military forces will need to operate in more extreme climate conditions, facing new and demanding operational requirements. Infrastructure and assets are vulnerable to the effects of CC. Furthermore, geostrategic competition, wider emerging environmental threats, and natural resource competition could have implications for missions and operations. As CC-induced natural disasters increase in severity and frequency, armed forces will more frequently be called upon to provide humanitarian assistance and disaster relief. CC also challenges the Allies’ capacity to provide critical services to their populations and military forces in vital sectors, including communications, energy, transports, food and water.

NATO has been at the forefront of military technology and innovation since its foundation. In this direction, NATO’s only research center, the Centre for Maritime Research and Experimentation (CMRE), has established a new program notably dealing with CC and its impact on security and defense, with specific reference to the maritime domain (MD). This program, financed by the Sci-

ence and Technology Organization (STO) Office of the Chief Scientist (OCS) as part of the NATO 2030 initiative, has led to the creation of the new Climate Change and Security (CC&S) department within CMRE.

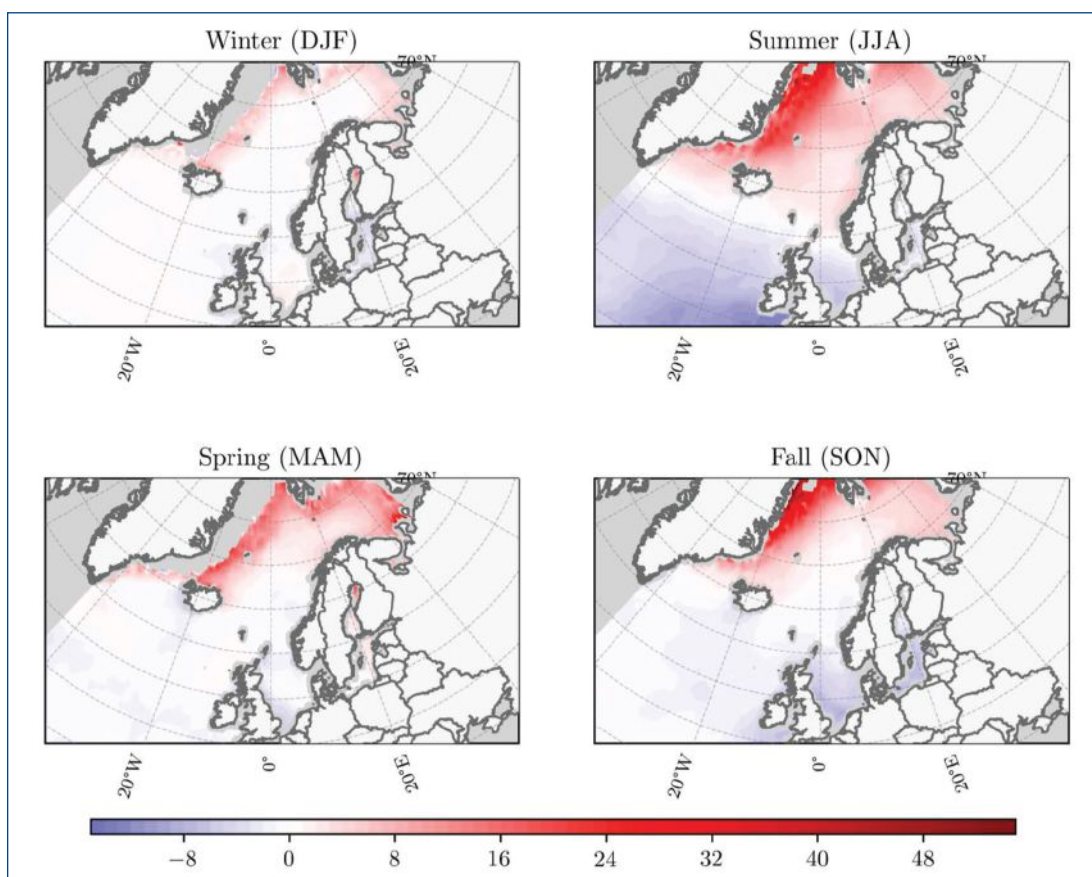
One of the goals of the NATO 2030 agenda is to maintain and enhance NATO’s technological edge, and to this end the STO is undertaking a multidimensional program of work to explore the role of emerging and disruptive technologies (EDTs) in adapting to and mitigating CC. CMRE is currently studying three technologies for possible practical applications to the defense sector, with particular focus on the CC&S themes in the maritime domain: cloud computing, artificial intelligence (AI) and quantum technologies (QTs).

Cloud Computing

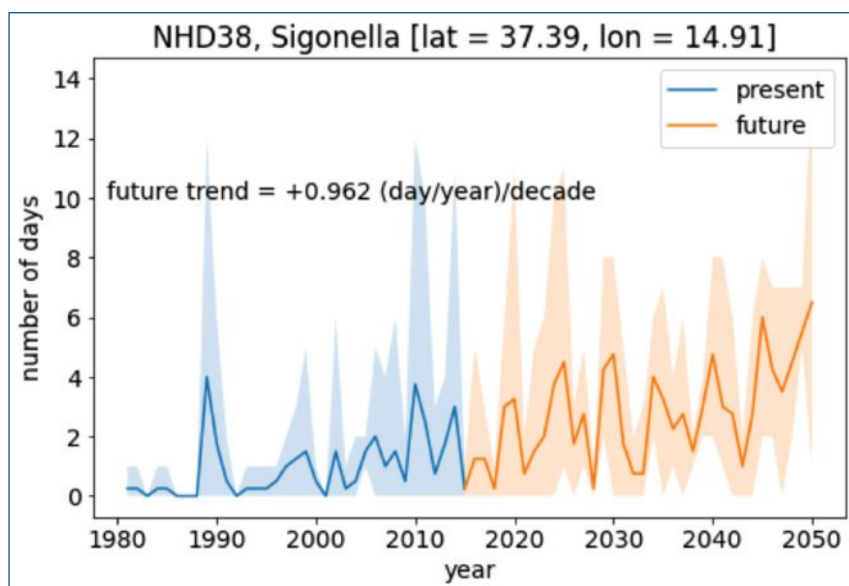
Cloud computing is a cost-efficient, scalable and easily accessible choice whenever it comes to a large amount of data being processed. A principal source of information for assessing future CC impacts derives from coupled earth-system numerical models, which simulate the complex interactions between the Earth’s ocean, atmosphere and cryosphere, in particular, the outputs provided by the Sixth Phase of the Coupled Model Intercomparison Project (CMIP6).

Working effectively with climate model outputs is challenging because of the size of data sets, as the results from a single simulation for even a single variable can be hundreds of gigabytes. To address such challenges, the scientific community has developed several platforms for scientific analysis of big data geoscience that run effectively on computers ranging from desktop to cloud-based high-performance computing (HPC).

CMRE has focused on the Pangeo Platform, deploying this flexible, scalable, open-source platform both on-premises and on the NATO Software Factory (NSF). CMRE researchers within the CC&S department installed



(Above) Seasonal difference (%) of significant wave height fields exceeding 1.25 m (Sea State 3), comparing bias-corrected modeled future climate (2071 to 2100) versus historical (1971 to 2000) results, scenario IPCC RCP8.5. Note the significant increase during summer and fall periods near the Greenland coast. (Right) Hindcast (blues) and projected (orange) number of “hot days” (air temperature > 38° C) in Sigonella Base, Italy, according to IPCC RCP8.5 scenario. Data reflect CMIP6 climate modeling, with projections starting at 2015.



the framework on their local machines and on the CMRE HPC node, hence developing customized applications analyzing and visualizing data stored both on site and remotely on NATO Software Factory (NSF). The benefits of the cloud environment for working with big data were demonstrated by reproducing a climate workflow that: searches for existing CMIP6 data available on public cloud storage, loads data from 26 different global simulations, calculates the global mean sea surface temperature, and reproduces the rise in temperature under different emission scenarios similarly to the plot shown in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), all in a few minutes.

Tests of the Pangeo Platform are continuing on the

Azure/NSF cloud environment, aiming to improve its functionalities and to assess cost and performance of the cloud approach. Plans for 2024 foresee a wider implementation of the Pangeo Platform, including the development of ad hoc analysis tools and the design of a NATO Climate Calculator for facilitating within NATO the visualization of possible CC impacts under different climate scenarios. In addition, the Pangeo framework will be able to seamlessly incorporate the new CMIP7 outputs expected to be made available in the coming months/years.

From a CC security perspective, a wider use of cloud

computing might improve planning and adaptation of a vast range of military operations and applications. For instance, processing real-time meteorological, oceanographic and climatic data/predictions for a specific area can significantly enhance assessment and prediction of: naval helicopters loading capacity (depending on air temperature and, thus, density); operability of naval platforms (depending on sea state conditions); number of “black days” (combined air temperature and relative humidity conditions harmful to the human body) for operations and training; the possible impact of sea level rise (SLR) and storm surges for naval bases and coastal infrastructures; how temperature and salinity variations can change sonar performances and underwater acoustic communications; and how future atmospheric conditions might modify naval radar detection ranges. A cloud computing approach would facilitate data analysis and sharing among Allies, and access to tai-

lored assessments and predictions could then help commanders and decision makers to take adaptive countermeasures.

Artificial Intelligence

The application of artificial intelligence in the military context is increasing, for instance, in image analysis, simulation and training, logistics, use of unmanned vehicles and for countering cyber threats. In CC-related maritime studies, AI has proven to be useful in several cases, both for data analysis and predictive modeling.

In the specific case of critical underwater infrastructure (CUI) protection, CMRE is studying the application of AI to assess the impact of extreme weather events on underwater cables and pipelines, as well as to analyze anomalous trajectories of vessels in order to predict suspicious activities near such infrastructure. The surveillance uses both data from autonomous vehicles and satellite images from

Copernicus services (as in the case of the recent Nord Stream pipeline sabotage) to enhance Maritime Situational Awareness (MSA) capabilities to create a Seabed-to-Space Situational Awareness (S3A). This maritime spatial awareness, based on analysis of an incredible amount of data, is an enabling capability to deliver information/cognitive superiority, inform decision-making processes and increase operational effectiveness.

Moreover, because information sources are heterogeneous and noisy and data flow is often intermittent or corrupted, AI algorithms can help to filter relevant information per data set and fuse them together in a process called Maritime Artificial Intelligence and Information Fusion (MAI2F). Furthermore, AI finds application as a “human enhancer” when it comes to tactical, operational and strategic planning, helping commanders in several courses of action (CoA) developments.

The development of such AI systems tailored for the analysis of meteorological, oceanographic and climate data in the maritime domain is already providing an increasingly wide variety of analyses and predictions with higher accuracy, and will do more. In addition, the increasing number of uncrewed air, surface and underwater systems often relies on AI for maneuvering or to optimize communication protocols and Physical Layer Security (PLS). The contribution from these uncrewed systems will be crucial in defining CC scenarios since they can be used for mapping and sensing the oceans at a significantly faster rate than manned platforms, enhancing our understanding of the consequences that CC will have on the maritime security sphere.

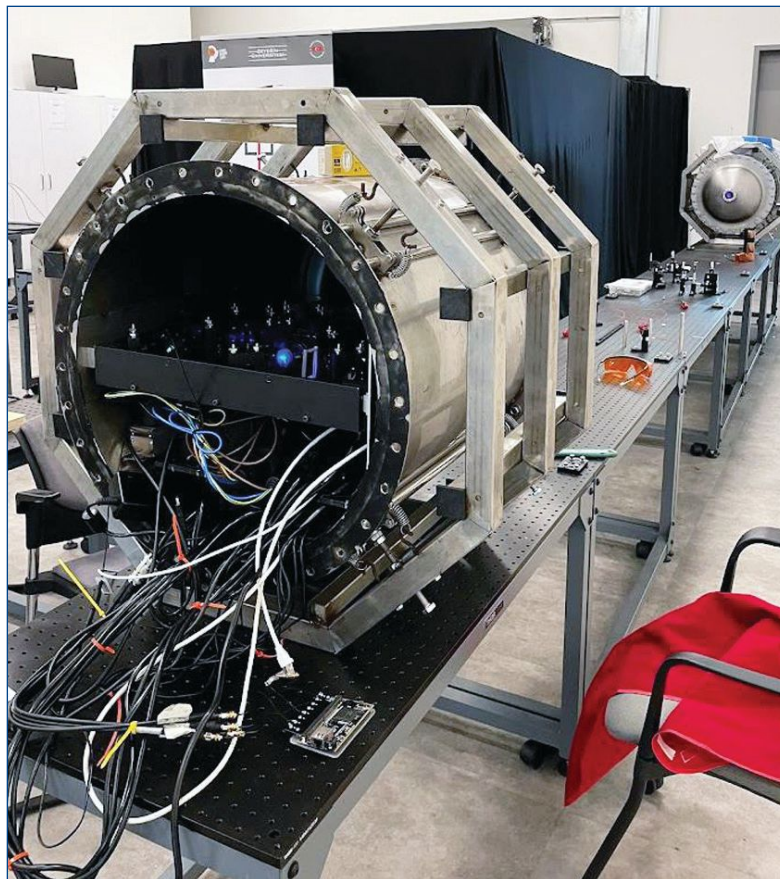
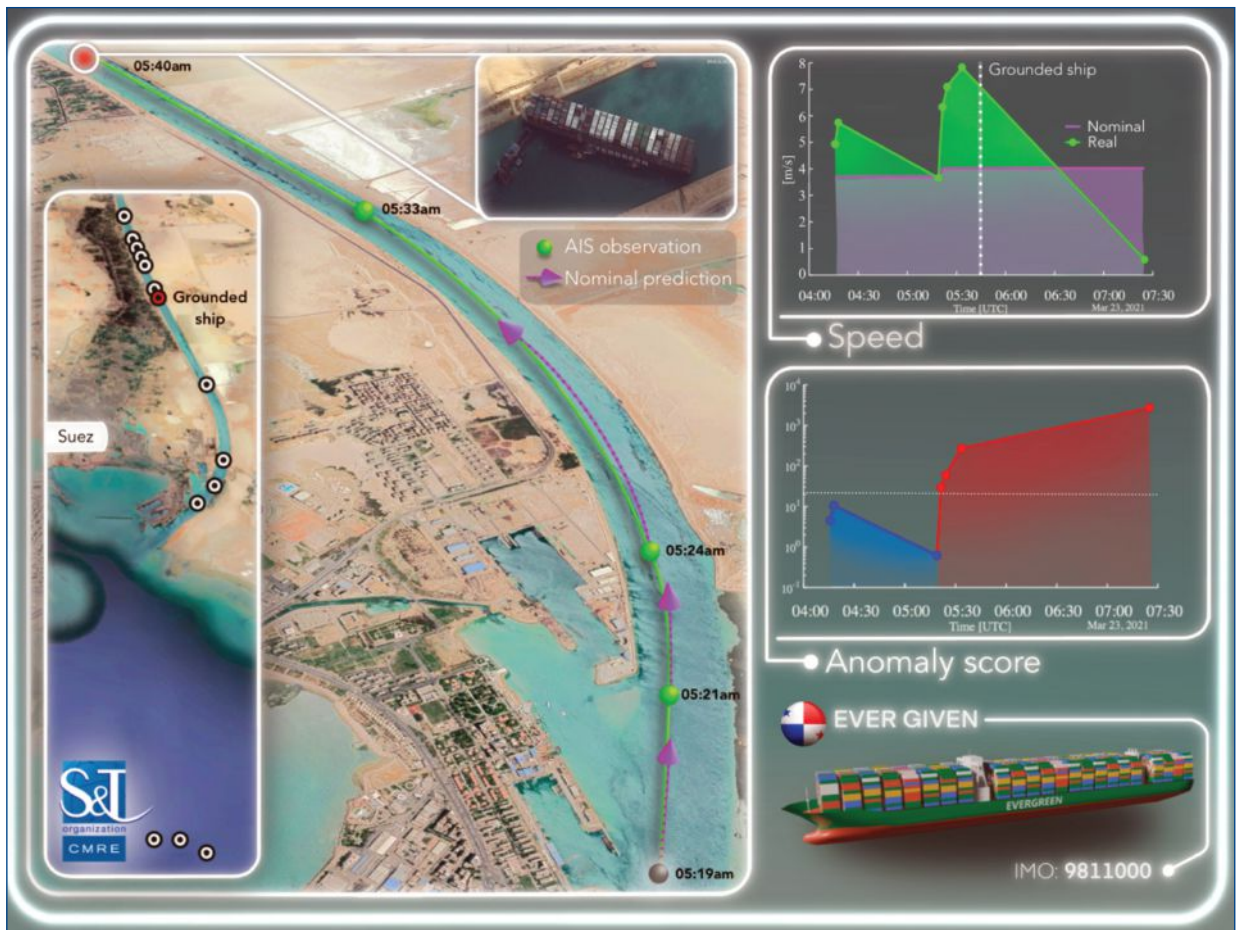
Quantum Technologies

Quantum computers are renowned for using quantum bits (qubits) instead of binary digits, exploiting the law of quantum mechanics to transfer a state from one node to another. In particular, STO and CMRE are jointly focusing on second-generation quantum tech-

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(Above) Example of AI in MSA using the Ever Given, a containership that became stuck in the Suez Canal in 2021. (Credit: Forti, d'Afflisio, Braca, Millefiori, Willett, Carniel, 2022. Next-Gen Intelligent Situational Awareness Systems for Maritime Surveillance and Autonomous Navigation Proceedings of the IEEE. <https://dx.doi.org/10.1109/JPROC.2022.3194445>) (Left) CMRE and Hyperion/Ozyegin University (Turkey) have developed a proof-of-concept prototype to perform free-space underwater QKD experiments.

nologies, which are expected to provide substantial scientific and technological benefits to the Alliance. In particular, by drafting a strategy coordinating with ongoing initiatives, CMRE is exploring the next-generation technologies and related military applications for quantum sensing, communication, computing and cryptography, collaborating with the main relevant stakeholders.

Quantum sensing (e.g., quantum magnetometers) might help to compensate for the possible future deterioration of submarine detection caused by CC impact on sonar performance in certain ocean areas. Furthermore, quantum navigation could be a reliable alternative solution in a GPS-denied

“CC is a ‘threat multiplier’ that significantly shapes the Alliance’s strategic environment, both in the Euro-Atlantic area and in its broader neighborhood.”

environment or for Special Forces operating in extreme domains (such as the Arctic, also due to CC), where/when satellite correction is not available, or underwater (“dead reckoning”).

In the future, quantum computers will enable solving superior computational problems related to complex systems, potentially providing more accurate climate scenarios. Since quantum computers will increase the capability to break traditional encryption methods, the development of a “post-quantum technology” is also needed as a countermeasure. Quantum key distribution (QKD) is providing a way for an encryption method that can be used, considering CC effects on the oceans. QKD in underwater networks is currently being experimented and validated at CMRE, exploiting the natural laws of quantum mechanics to share a secret key for Allied submarines, theoretically unhackable. A next-generation “quantum teleportation” (transferring states instead of bits) is also under study, and will be tested with repeaters and satellite to overcome the current limitation posed by fiber-optic cables.

The long-term vision in quantum communication is to create a “quantum internet” with a network of entangled quantum computers and ultrasecure communications. Prototypes of quantum Position, Navigation and Timing (PNT) devices, suitable for integration into large military platforms, can be developed and tested in real operational theaters and could be used as reliable inertial navigation systems in underwater or GPS-denied environments (e.g., below ice in Arctic regions), and therefore would bring a game-changing military capability that significantly reduces the Alliance’s reliance on space-based Global Navigation Satellite Systems (GNSS).

Conclusion

All military operations require knowledge of technology and environment. For naval forces, being prepared to operate in what will likely be the future environment is crucial to success. As Allied military forces are more often called to support their civilian counterparts for natural disasters and other CC-related extreme events, integrating the exemplified technologies can highly benefit NATO, particularly its naval forces.

While cloud computing can provide a faster and easier analytical infrastructure, AI can help both environmental monitoring and data exploitation, and quantum technologies pave the way for faster and more accurate

scenario models, as well as secure communication protocols, new sensing capabilities and improved underwater navigation. The aforementioned technologies and their application offer just a glimpse of what the Science and Technology (S&T) community is currently investigating.

Nevertheless, the key point remains the need for NATO, the international scientific academia and the industrial community to cooperate, together with national and private stakeholders. In order to avoid energy dispersion and duplication among Allies, CMRE has been active in bringing together ideas and expertise in climate-related fields. A Quantum Technology workshop was held in Turin in June 2023, and a Climate Change and Security workshop took place in Lercini in October 2023.

Bringing research from labs to real-life scenarios can take a considerable amount of time and effort that we may not be able to afford in a rapidly changing climate scenario without full cooperation. Understanding the potential benefit of EDTs, especially dual-use technologies, and making them economically and politically convenient, represents one of the main elements that the future generation of scientists and practitioners can use to operate effectively in the changing environment.

Acknowledgments

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References

For details on the models depicted in the images for this article, contact: Sandro.Carniel@cmre.nato.int. **ST**

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Dr. Sandro Carniel is an oceanographer and head of the Research Division at NATO STO CMRE, where he is directly engaged in climate and energy security themes. He was presented with the Golden Trident Award in 2022.



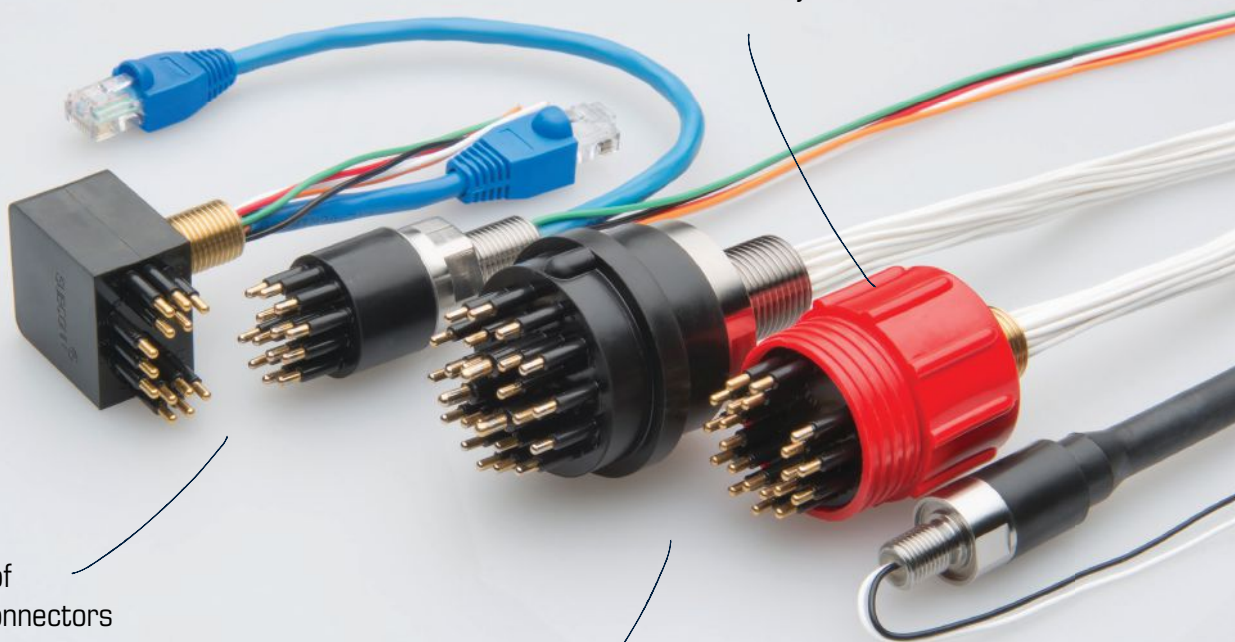


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Autonomy for Security

Using Unmanned Platforms for Commercial Marine Security Services

By Daniel Esser • Stephen Ferretti

ROVs, AUVs and, more recently, autonomous USVs have proven invaluable for a variety of survey, inspection, maintenance and repair activities in ports and harbors, near-shore and offshore. With highly flexible payloads for diverse operations, autonomous vessels used by the subsea sector for various purposes of data acquisition are now being used to improve maritime security for offshore energy producers and marine infrastructure owners.

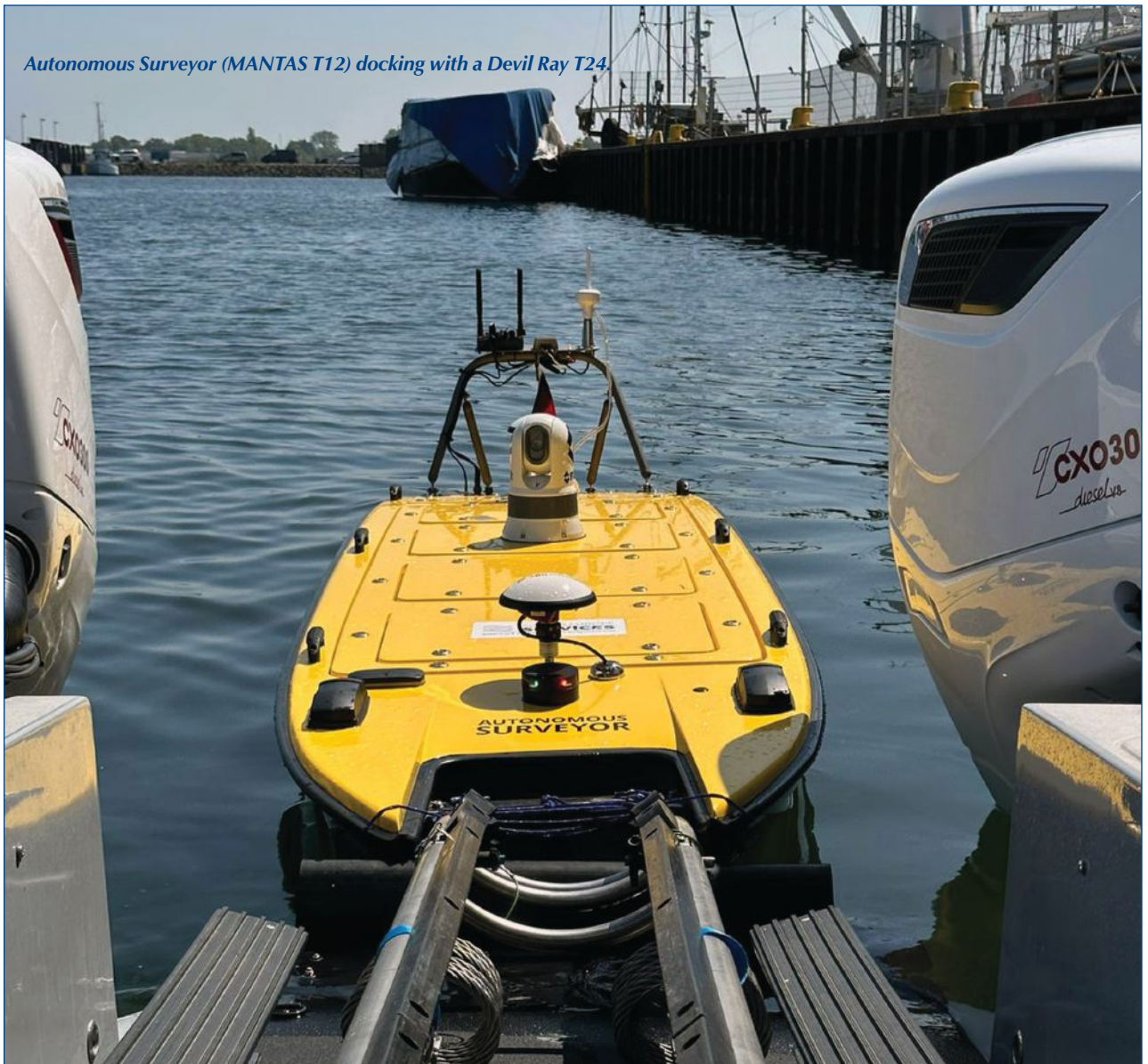
In 2022, Subsea Europe Services acquired a new autonomous USV platform, a MANTAS T12, from its Florida-based partner MARTAC Systems and christened it “Autonomous Surveyor.” The T12 is a next-generation USV offering new levels of operator control flexibility with fully autonomous, semi-autonomous and human-in-the-loop modes. Its open architecture and modular design allow rapid integration of new sensors and communication technologies to meet diverse mission requirements. These capabilities allow for dual roles as an autonomous marine survey vessel and security patrol craft.

The 12 in the vehicle designation reflects its length of 12 ft. (3.6 m). Its beam is 3 ft. (1.0 m), and it has a draft of just 7 in. (18 cm). It has a catamaran hull form and can operate at a maximum cruise speed of 20 kt., with bursts of up to 40 kt. in specif-

Autonomous Surveyor during BALTOPS 2023.



Autonomous Surveyor (MANTAS T12) docking with a Devil Ray T24.



ic configurations. Using a powerful R2Sonic multibeam echosounder, the Autonomous Surveyor's hydroacoustic package can be configured for various subsea marine survey needs. Its capabilities will continue to expand before year's end, when an innovative next-generation sonar will be offered. As well as a thermal camera, inertial navigation, GPS and sound velocity sensor, Autonomous Surveyor can be equipped with side scan sonar, a sub-bottom profiler and chemical sensors.

From Surveys to Surveillance: A Logical Step

While the Autonomous Surveyor originally found its purpose in marine data acquisition, MARTAC's experience within the defense sector, with the U.S. Navy, the U.K. Royal Navy and other NATO forces, has expanded the uses of its autonomous systems for other high-value missions and applications in security and surveillance for commercial marine assets and facilities.

Subsea Europe Services and MARTAC Systems have partnered with the belief that security will become an

increasingly important consideration for offshore wind farm operators in particular. The idea is agreed upon widely, as energy security has become a focus of attention for governments and regional bodies over the last two to three years, due in no small part to the war in Ukraine and subsequent sanctions on Russian oil and gas supplies.

It's clear that all offshore energy operations could be a potential target, as reflected by the September 2022 explosions at the Nord Stream pipelines. There are three main maritime infrastructure attack vectors: subsurface, surface and air. Of these, only air cannot be directly addressed by autonomous marine platforms. For surface and subsurface threats, autonomous craft can be applied to secure safety from recreational, commercial, militia and/or military vessels. The navigation of vessels around offshore assets represents risks, whether of negligence or malice, that must be managed as much as the underwater threat represented by divers, subsurface vehicles and underwater robotics.

(Left) Devil Ray T24. (Right) Smaller craft can easily dock with the T24.



Threats from All Quarters

Current potential military threats include Russian “spy” ships allegedly mapping North Sea infrastructure. A longer-running concern in maritime security is that of protesting environmental groups occupying offshore facilities—not just oil and gas but also offshore wind.

Terrorist attacks in general are a potential threat to offshore energy infrastructure, and then there are the unintended consequences of poor navigation or cargo lost overboard from commercial shipping. In October 2021, a craft with 25 migrants attempting to reach the U.K. drifted into a wind farm off Zeebrugge, Belgium, and the turbines were temporarily stopped for safety reasons. The cost of such stoppages can usually be counted in six or more figures.

Subsea Europe Services is addressing the risks using a combination of technology, services and support to ensure security in the maritime domain, and in June 2023 it took part for the first time alongside MARTAC in the annual BALTOPS (Baltic Operations) military exercise involving several NATO forces. BALTOPS is a combination of mine-hunting procedures and a demonstration of resolve to keep Baltic waters open to free navigation.

Subsea Europe Services’ role in the exercise involved applying the Autonomous Surveyor for mine counter-measure (MCM) work, including defining the tasks for the larger MARTAC Devil Ray T24 and the stand-by vessel, programming and performing the autonomous operations. The workflow was judged after the exercise as very efficient and time- and resource-saving compared to traditional MCM methods.

The risk to energy and communication infrastructure has resulted in action at the government level to counter the threats, but given the potential scale of the problem, it’s uncertain if navies, coast guards and marine police will be able to deliver the necessary surveillance to enable complete maritime domain awareness, while interest in tackling some of the nonmilitary threats may not exist. This makes the case for commercial marine security services using autonomous platforms powerful.

Unmanned Advantages

Manned assets are expensive and can be limited by environmental conditions, such as bad weather and human on-task limitations and manpower, which is why MARTAC classifies mission endurance in any environmental situation as a critical design objective. Autonomous vessels can be assigned to monitor assets 24/7, providing real-time feedback to a command center. A strategic deployment of various unmanned systems (USVs, UAVs, UUVs) can provide multi-modal force protection on macro and asset-specific levels against most threats.

A swarm approach—featuring multiple autonomous platforms—would be the optimum solution to improve security over a wide area. Exact requirements will vary widely, but the concept is infinitely scalable, and the cost savings and capabilities grow exponentially as further units are added to the swarm.

This includes the integration of underwater units to any given operation in the form of a unique new hovering AUV (HAUV) called the A.IKANBILIS. Developed



by Singapore-based autonomous technologies specialist Beex and operated by Subsea Europe Services, the A.IKANBILIS can work without a tether, giving it much more freedom underwater than a traditional ROV. This makes it more suitable for marine security work than ROVs. Like the

Autonomous Surveyor, A.IKANBILIS is already active in commercial data acquisition operations at wind farms, but it's potential to monitor and detect underwater threats without human interaction positions it as one of the most viable commercial subsurface technologies for marine security.

Subsea Europe Services plans to expand its fleet of autonomous vehicles to offer combined surface and subsurface capabilities to clients. Several MANTAS T12 vehicles or the slightly smaller MANTAS T8 can undertake these duties controlled from a mothership or a shore station. Even more flexible and cost-effective coverage can be achieved using larger autonomous craft such as MARTAC's Devil Ray T24 as motherships. The T24 offers the potential to automatically launch and recover smaller autonomous vehicles. This could be a MANTAS T12 as demonstrated during BALTOPS this year, an A.IKANBILIS HAUV, or even aerial drones. The flexibility and breadth of technology available allows for completely autonomous fleets with any number of diverse craft to address threats at commercial offshore facilities.

MANTAS T8 is the mid-size USV in the MANTAS class, with a maximum weight and payload carrying capacity of 86 kg and 18 kg, respectively. It is 241 cm long, 68 cm wide and 34 cm high. The T8 has a draft of 18 cm, which is the shortest among the T-series USVs, and although its cruise speed of 12 kt. is the same as the T12, it has a higher burst speed of up to 25 kt. or more.

The Devil Ray series are larger craft with sizes up to 15 m. The series was expanded this year with the in-

roduction of the 7-m-long Devil Ray T24, designed specifically for accommodating a variety of payloads that can be swapped out as necessary. The base configuration is also a catamaran hull form rated at 10 G, capable of burst speeds up to 50 kt., with a range of 600 nautical mi. The payload is 1,800 lb. (816 kg). While it can operate as a stand-alone vehicle, its potential as a mothership allows a greater area coverage in combination with the vehicles it can host.

Security Workflows

MARTAC's experience in working with the military has been leveraged in developing and optimizing new workflows for the surveillance of offshore energy facilities. For example, in the event of an attempted attack on an offshore target by drone, detect and target technology combined with the high-performance envelope of MARTAC's systems could enable detection, pursuit and overtaking of a waterborne IED at speed.

Devil Rays can also be integrated with countermeasures to neutralize a drone attack from a distance, though in general, the need for projectile or explosive weaponry is not expected in commercial security applications. Sound- and light-based intervention that interferes with a bad actor's ability to operate effectively will be the key deterrents.

A civilian maritime security offering of the type developed by Subsea Europe Services could also include vehicles from other manufacturers talking with each other and protecting at both surface and subsurface levels. The objective is to deploy multi-mode force protection to provide situational awareness and address threats. MARTAC's USVs can not only provide these capabilities above and below the surface with sensor suites, but they also have acted as a central gateway with UUVs and UAVs communicating back to a mothership or central command. The objective is to establish a mesh network that creates this capability.

Control can be initiated on multiple levels, in the field, on a mothership or in a robotics operations center. Furthermore, establishing a cloud environment for asset control and data management provides the redundancy necessary in the event of nodal failure.

Such digital platforms are already in use for marine survey and underwater inspection data acquisition, storage and analysis, and the ability to share data and insight from autonomous vessels patrolling the field above and below the surface to various approved stakeholders is the final piece of the puzzle that will put commercial-grade craft at the forefront of security at offshore wind farms. **ST**

Daniel Esser is the co-owner and director of business development of Subsea Europe Services GmbH.

Stephen Ferretti is the chief marketing officer of MARTAC Systems.

Undersea Warfare Trends

The Integration of UUVs and Seafloor Networks

By Chris Haugen

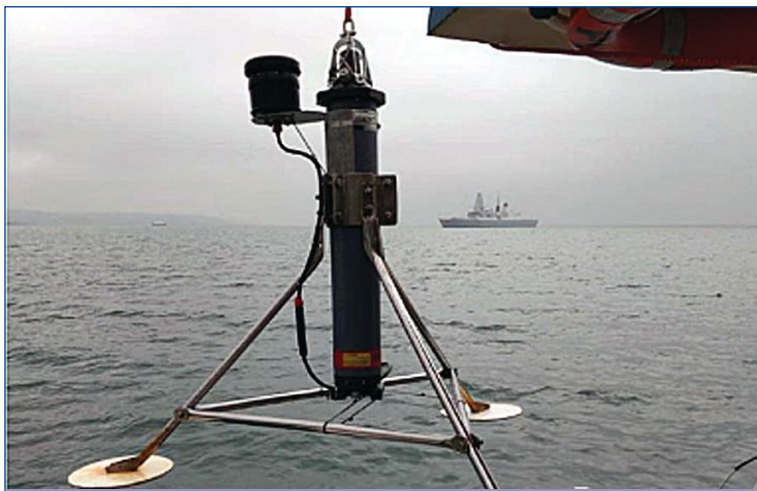
Subsurface and seabed warfare (SSW) technologies are enabling new mission sets. Increasingly challenging mission requirements are driving development of new SSW capabilities. These mutually reinforcing trends intertwine to propel both the enabling technology and the mission possibilities forward.

In its 2022 Seabed Warfare Strategy, the French Navy joined other major navies and recognized the need to be able to control the seabed, including at depths be-

low 3,000 m—depths that previously had not been as relevant for military operations. These navies identify SSW as a key component to both defensive and offensive maritime strategy. There is a wide recognition that commercial interests in the seabed, particularly offshore energy structures for the wind and oil and gas industries and transoceanic communications cables, have driven a robust technology industry providing for needed seabed capabilities. These capabilities include ROVs and UUVs,



Remotely operated mine detonation device showing the acoustically triggered initiation transponder.



Deployable Acoustic Signature Measurement Range showing an iUSBL node that will be allowed to freefall to the seafloor. It will subsequently be “boxed in” to establish its precise location.

as well as the sensors, payloads and effectors those vehicles carry to accomplish seafloor tasks from the surf zone to thousands of meters down. Naval engineering and acquisition offices are availing themselves of commercial-off-the-shelf (COTS) solutions to rapidly field capability in response to warfighter needs.

Littoral Strike Warfare

Undersea technology plays an increasingly important role in supporting littoral operations, including getting forces to and over the beach.

In the planning phase of amphibious or special forces operations, intelligence preparation of the operational environment (IPOE) can be a difference maker in narrow-margin operations. Detailed oceanography, bottom characterization, current profiling and other environmental parameters can be assessed in near real time to prevent mission-degrading surprises.

Special forces delivery systems, such as the U.S. Navy's Submarine Launch Dry Submersible (SLDS) and the Shallow Water Combat Submersible (SWCS), could have the ability to precisely navigate using a combination of highly accurate inertial navigation and Doppler velocity log (DVL) systems, supplemented by a highly accurate bathymetric and bottom feature map.

Supporting special force swimmers being put in position to swim ashore, miniature diver tracking systems provide navigation and real-time communications between divers and the delivering platform. Rendezvous between submersible and diver, which has always been a challenging evolution, can be greatly improved with the ability to track the returning divers and vector them back.

Asset Protection

Situational awareness around critical national infrastructure, high-value assets, ship visits to less secure ports both domestic and foreign, and, generally, approaches from the sea has been maintained on and above the sea surface. Intruder detection systems (IDS) provide a clear picture of threats approaching from the sea. Sentinel, an active and passive sonar system from Wavefront Systems, provides exceptionally effective intruder detection of divers out to 1,000 m and UUVs to 1,500 m.

Beyond the nearshore zone, monitoring vital seabed infrastructure, such as communications cables and pipelines, and other ocean structures, such as oil platforms or wind farms, requires an integrated system of systems. Besides a close-in system such as Sentinel, other means of detecting attacks are needed. These might include deploying marker beacons near spots of suspicious activity for rapid survey and change

assessment. High-resolution side scan sonars, such as a multiple aperture sonar also from Wavefront Systems called Solstice, with a power draw under 20 W, can be quickly deployed and enable long-endurance missions to thoroughly survey cables and detect evidence of tampering or damage. Optical imaging systems, such as the Discovery camera with real-time advanced image processing, can then be used to provide confirmation and even be used to make repairs—perhaps in a single sortie of an appropriately equipped vehicle.

Gathering forensic evidence from attacks to seabed structures is also possible. The sabotage of the Nord Stream pipelines in September 2022 demonstrates the need for this urgent capability. In addition to high-resolution images, environmental sensors can be used to assess chemical composition of residue and other artifacts.

Mine Warfare

Uncrewed systems—either UUVs or remotely operated tow vehicles behind uncrewed surface vessels—are invaluable in mine countermeasures operations. The U.S. Navy's Naval Sea Systems Command's efforts in this area have resulted in UUVs equipped with mine-detection sensors that can autonomously identify and neutralize underwater mines, minimizing the risk to human divers.

Furthermore, UUVs can be deployed in swarms to efficiently cover large areas, speeding up the mine-clearing process and ensuring safer navigation for naval vessels.

Mine clearance can be accomplished through the use of ROVs, an attachable detonation device and acoustically triggered initiation transponders. This proven concept is safe, efficient, and preserves the ROV and initiation transponder for clearance of multiple mines.

New families of smart mines are available or in development for offensive and defensive mining operations. Clandestinely delivered from UUVs or submarines, these mines will be precisely placed and programmed to best comply with existing, but limited, international law. Extra-large UUVs (XLUUVs) capable of carrying a mean-

ingful payload of mines will require highly accurate and precise navigation and positioning systems. An inertial navigation and DVL unit, such as Sonardyne's SPRINT-Nav, which is accurate within 0.01 percent of distance traveled, can be supplemented by occasional terrain mapping fixes or short excursions near the surface for a satellite fix, if that service is available.

Acoustic positioning and communication systems are needed for smart mines to pair with an ultrashort baseline (USBL) positioning system and to accept instructions and programming. Small form-factor acoustic beacons are essential for this task, providing the range and accuracy in position determination and sufficiently long-range acoustic communication for commands.

3D Tracking Ranges

Acoustic signature management is critical to maintaining submarine stealth. A deployable signature measurement range would support measurement and verification of signatures in the event there is a suspected change, keeping submarines on station and in theater.

Deployable anti-submarine warfare (ASW) tracking ranges would improve training by allowing ASW forces high-fidelity training in theater under representative conditions.

Supporting both these missions, rapidly deployable kits can be assembled from COTS gear and used to provide the position of participants with pinpoint accuracy. Recoverable inverted USBL (iUSBL) systems are released from a surface support vessel and bottom position determined; small battery-powered transponders are attached to participants' hulls; and underwater telephone systems or acoustic intercept receiver sonars are supplemented with modem software to accept position information. Such a system permits real-time position monitoring by range control for safety in an exercise area and for calibrated acoustic signature measurement. At the end of measurement or exercise operations, bottom-mounted systems are acoustically commanded to float to the surface, where they are recovered for reuse. Such a system could be packaged easily in a 40-ft. container and either permanently staged in theater or rapidly deployed as needed.

Communications

These, and other SSW mission sets, require UUV sensors and payloads and seafloor sensors and systems. Of course, these systems, increasingly remote and autonomous, must be able to somehow communicate back to decision makers when tripwires—the set of sensed conditions requiring some measure of response—are reached or to simply contribute to overall situational awareness. UUVs and seafloor sensors will generate vast amounts of data that will have to be stored until retrieved or communicated back to central nodes for aggregation. Remote effectors must be commanded to perform their tasks when appropriate.

SSW is faced with competing trade-offs between space, weight and power (SWaP); stealth; and communications. Artificial intelligence and machine learning

promise ever greater autonomy and mission capability but require power-hungry processing systems. Improved autonomy can reduce the need to communicate. Off-board processing of generated data requires communication of gigabytes of data compromising stealth in order to connect to systems of suitable bandwidth. Acoustic, optical and radio frequency systems present opportunities for data transfer but compromise stealth of the involved systems.

Companies such as Sonardyne have been instrumental in developing reliable communication systems within seafloor networks. These systems enable real-time data transmission between seafloor sensors, UUVs and surface vessels, ensuring seamless coordination and response to emerging threats.

The concept of underwater data networks is gaining traction in undersea warfare. These networks connect multiple UUVs and submarines, allowing them to share real-time data and coordinate their actions. Undersea data networks offer several advantages. One is increased stealth and persistence. Uncrewed systems can operate silently beneath the waves for extended periods, providing continuous surveillance and reconnaissance without risking human lives. This capability enhances the ability to monitor and respond to emerging threats. Another advantage of the use of UUVs in mine countermeasures and ASW is that this reduces the risk to human operators, thus enhancing safety and allowing for more effective and efficient operations in high-risk areas. Advanced sensors and AI-driven data analysis can also provide naval forces with enhanced situational awareness. This translates into faster and more informed decision making, allowing for a more proactive response to threats and contingencies. Furthermore, underwater data networks and communication systems enable improved coordination among various assets, including submarines, surface vessels and unmanned systems. This networked approach enhances overall operational effectiveness and flexibility.

Conclusion

In the evolving landscape of undersea warfare, the integration of UUVs and seafloor networks has become a foundational capability. Advances in technologies enhancing situational awareness and IPOE, expanding surveillance capabilities, improved sensor capabilities, and careful balancing of communications requirements with autonomy will continue to be needed. Looking ahead, continued collaboration and innovation with defense entities is necessary to further adapt successful COTS designs to achieve military missions. **ST**

Chris Haugen is Forcys's business development manager for North America. He was a career submarine officer in the U.S. Navy, including command of the nuclear-powered ballistic missile submarine, the USS Nebraska (SSBN-739) (Gold).



Precise Navigation

Positioning, Navigation and Timing for Underwater Vehicles, Vessels

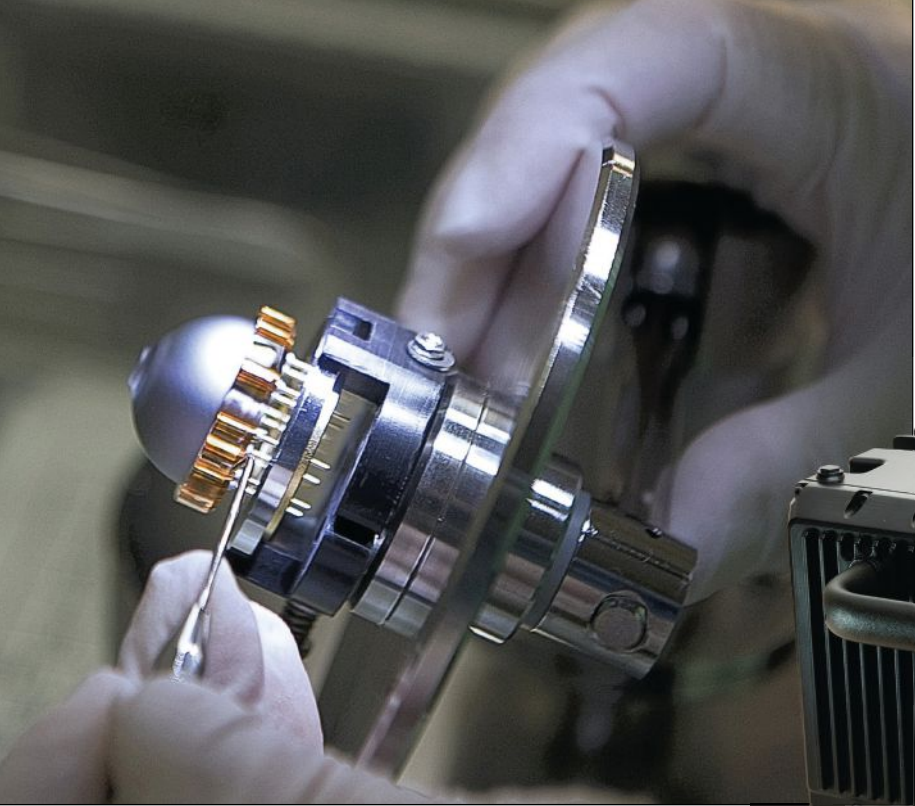
By Jean-Jacques Mounier

Imagine a short-term failure of our Global Navigation Satellite Systems (GNSS). Our motorways would be completely jammed with lost motorists, forced to return to the antique paper map. Who has one in his car today? Counting on Uber would not be such an intelligent choice, as the app simply would not work. On a larger scale and longer term, this would paralyze the whole supply chain, from our shipping industry to last-mile delivery. In the industrialized world, it would cause havoc.

In addition to longitude, latitude and altitude, GNSS provides a critical fourth dimension: time. Each GNSS satellite contains atomic clocks that provide extremely precise and reliable time frequencies for the GNSS signals. From financial networks to military operations, most activities rely on precise timing for communication, synchronization and operational efficiency.

Unfortunately, GNSS jamming and spoofing are on the rise in disputed areas. The Russian government has





(Clockwise) Safran HRG. Safran's Black-Onyx INS. Safran's miniaturized rubidium oscillator, the mRO-50, provides accurate frequency and precise time synchronization to mobile applications in GNSS-degraded or denied environments.



been deliberately and systematically interfering with GPS signals since 2016. An article in The Moscow Times that year boasted: “The Kremlin Eats GPS for Breakfast.”

Low-cost equipment, combined with open-source software and online videos, has led to a proliferation of malicious devices. Defense markets have deployed receivers capable of encrypted signals to discourage identity theft. However, nothing comprehensive has been commercialized to protect our GNSS receivers so far. Our time and position accuracy must be secured with high-integrity autonomous time and inertial references.

PNT Underwater

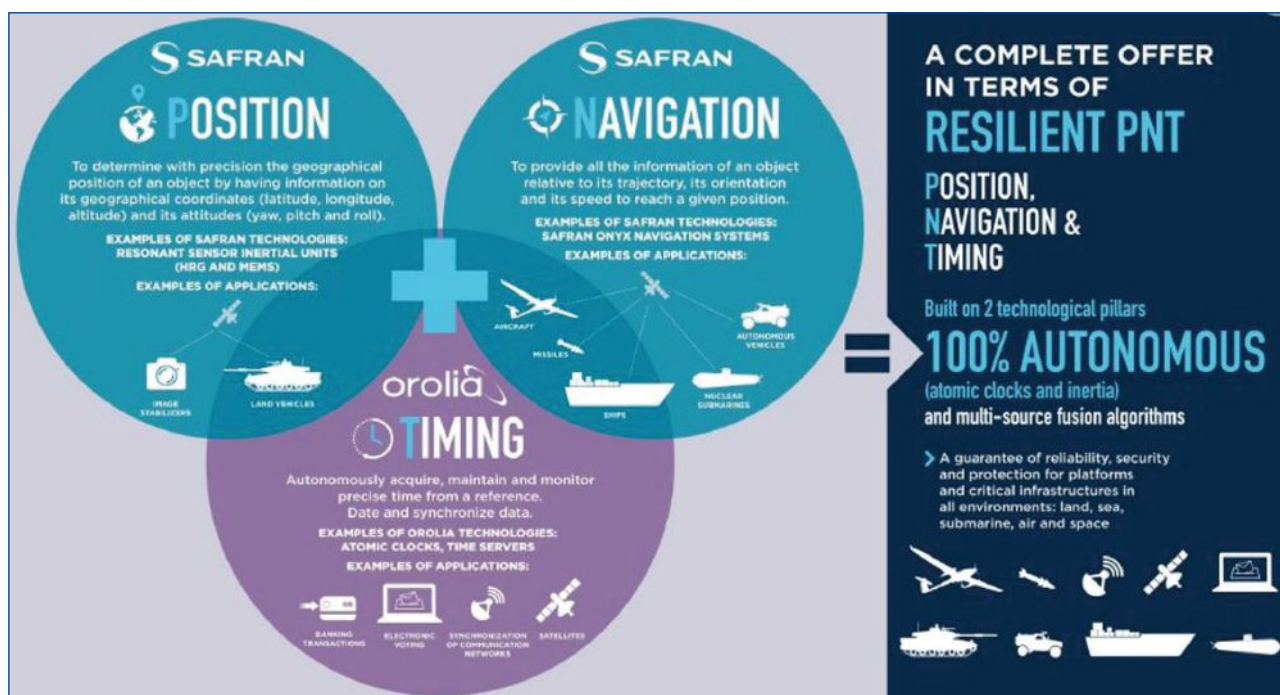
One of the most dangerous scenarios is underwater travel. As water absorbs electromagnetic radiation, locating an underwater vehicle quickly becomes a challenge. Underwater vehicles require high-performance positioning, navigation and timing (PNT) systems if they expect to remain submerged for prolonged periods. In addition, when they reach the surface, they need to pick the right signal. Of course, they can rely on their onboard sensors, such as active and passive sonars and logs or depth gauges, for basic safety. Underwater vehicles also require accurate time and position data. Safran designs PNT solutions to address these modern challenges.

Safran produces a large range of products, including commercial aircraft engines, optronic equipment, critical software, air conditioning systems, boosters, crew seats, electrical components, unmanned aerial vehicles and navigation sensors, plus engineering services. Safran Electronics & Defense's new research and development center in Eragny, France, is the leading European center in the fields of inertial navigation, precision-guided systems and tactical drones.

Safran navigation modules, such as the Black-Onyx,

are based on the principles behind Foucault's pendulum and resonance. At its core, the modules comprise a hemispherical resonating gyro (HRG) centered on a silica half-shell made of pure glass called a “resonator.” The slightest deformation of the glass generates a wave, and detecting the position of the wave enables measurement of its rotation. Black-Onyx offers an unlimited lifetime, a robust design that stands up to even the most extreme environments and an exceedingly high reliability with a low total cost of ownership.

Safran's inertial navigation systems (INS), whether for civil or military applications such as air or land vehicles or ships, are now based on the Onyx inertial navigation



core. These systems are ITAR-free, meaning they bypass the U.S. export controls of the International Traffic in Arms Regulations, and they offer a modular design.

Black-Onyx and Black-Onyx Dual Core inertial navigation systems are designed for all oceanic-class submarines. Thanks to the HRG Crystal inertial technology, this line of products offers the highest autonomous and stealthiest navigation performance ever reached on the market (less than 1 nautical mi. after several days). These INS are simple to install; weigh just 18 to 26 kg; and provide altitude, accurate roll and pitch, angular rate, latitude, longitude, depth, and horizontal and vertical linear velocities. They also allow for integration of position sensors (GNSS, electromagnetic or Doppler logs).

The Black-Onyx Dual Core delivers competitive long-term position accuracy, robustness and reliability, and Safran will continue to advance these INS by incorporating precise, high-integrity autonomous time systems, as well as technologies to combat jamming and spoofing threats. Safran has naval clients that have been using various versions of Black-Onyx successfully for several years.

In 2022, Safran Electronics & Defense acquired Orolia, a global provider of PNT equipment and technologies. As a result of this acquisition, Safran has expanded its navigation and timing portfolio of field-proven PNT technologies for precision timing, synchronization, simulation and inertial navigation solutions. Safran is now better equipped to meet the growing needs of its customers in the navigation and timing industry.

One of Safran's high-performance time and frequency solutions is VersaSync. Equipped with a high-precision time base, the time server continues to deliver accurate time. It is dependable even in the event of temporary reference signal loss. In addition, an interference detection and mitigation algorithm (IDM) can be added to detect, protect, and mitigate jamming and spoofing attacks. This solution has been developing since 2008.

These algorithms were integrated into various timing solutions to protect critical infrastructures and armed forces against jamming and spoofing threats. The IDM recognizes anomalies in GNSS signal reception, including unintentional interference and malicious attacks, as well as deactivating GNSS synchronization automatically.

Thanks to this technology, Safran is now capable of providing completely autonomous and resilient PNT solutions such as NAVKITE, which takes full advantage of Safran's proven PNT expertise to provide navigation integrity and performance whether used on land or at sea, even over extended periods and under the most demanding circumstances.

Safran has naval clients that have been using VersaSync since 2017 and the solution combined with NAVKITE since early 2023.

Conclusion

Whenever all interconnected and communicating systems require precise synchronization, Safran can be relied on to act as the chief timekeeper. In order to meet the challenges of integrity and robustness, Safran provides a comprehensive and cohesive set of resilient navigation and timing architectures and equipment. Safran offers a wide range of PNT services tailored to meet the needs of its customers in the aviation, defense, space, transportation, smart mobility and critical infrastructure markets. These include PNT system design, integration, testing and certification. Safran also provides comprehensive support services, such as field operations, maintenance and repair. The company's robust advancements in positioning, navigation and timing solutions can be a game changer for naval applications. **ST**

Jean-Jacques Mounier is the sea navigation program manager at Safran Electronics & Defense.

Extending the Life of Submarine Cables

Advanced Coherent Transmission Technique

By Geoff Bennett

From time to time, at dinner parties, I need to explain what I do, and I'm surprised how many people—even within the telecoms space, where I work—think that international internet traffic passes over satellites (great work by SpaceX marketing!). I politely point out that over 99.5 percent of intercontinental internet traffic passes through submarine cables, a statistic that was confirmed in the Telecom Mythbusters session at the SubOptic conference in Bangkok earlier this year. These cables are also responsible for over \$10 trillion in financial transactions per day, and they ensure the speed of our social media updates.

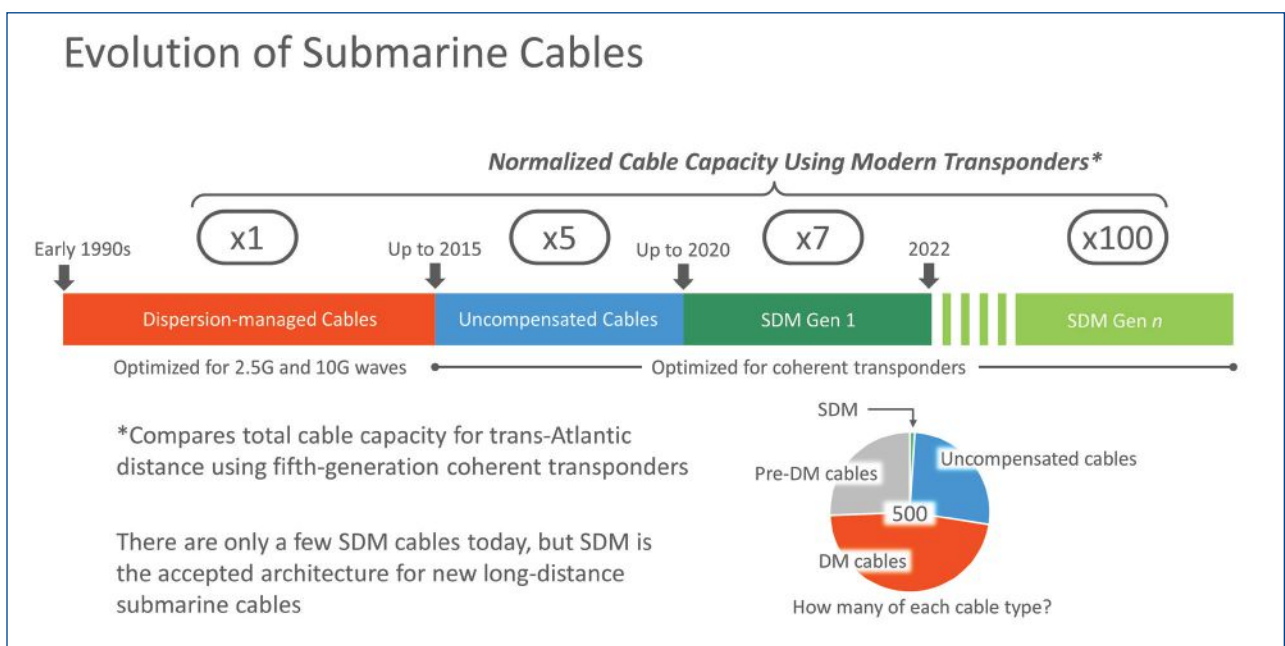
A new cable could cost more than \$100 million and take years to plan and deploy. Newer generations of cable will typically be able to carry much more capacity than older cables of about the same length.

Once a cable has been deployed, the only things we can change to increase capacity are the transponders at the ends of the cable. The rest of the system will stay sitting on the seabed for the rest of its life. So let me cover these points in more detail, starting with the fact that submarine cable technology has evolved dramatically over the past 30 years.

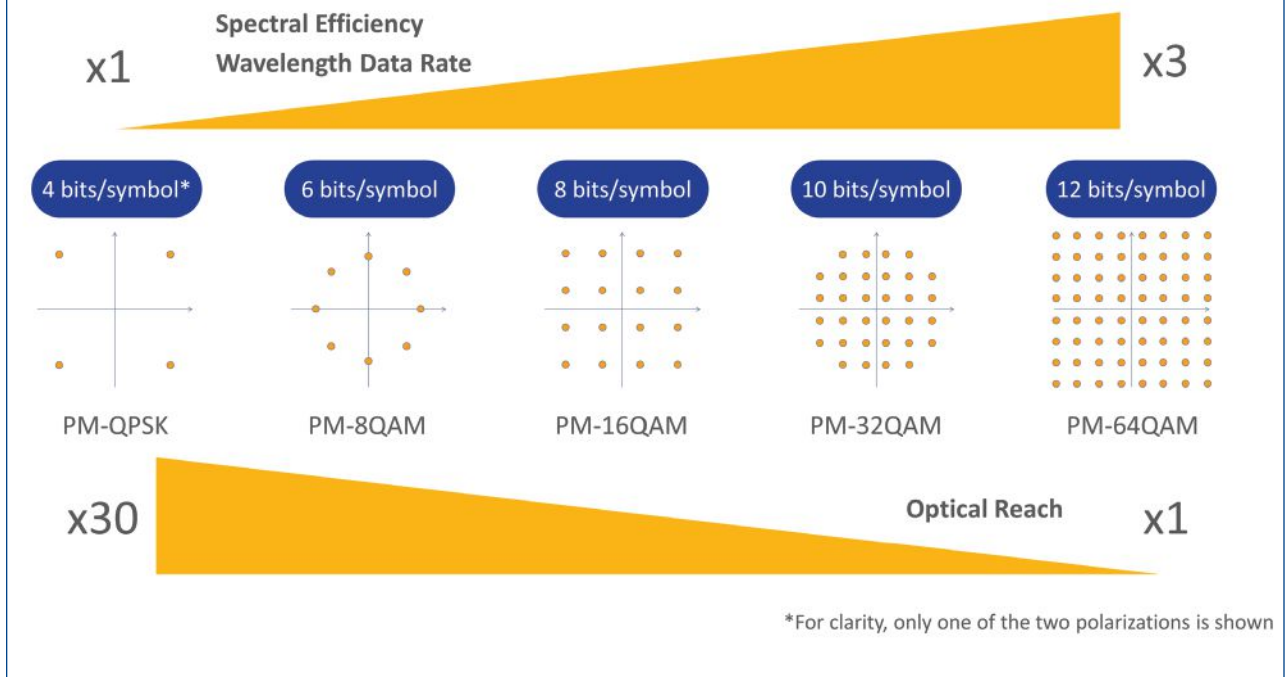
Note that when I quote cable capacity, I reference transatlantic cables as a baseline because it's possible to find examples among them of different generations that are all about the same length and provide like-for-like comparisons.

Previous Submarine Cable Generations

Long-distance submarine cables can, broadly speaking, be put into three different categories.



Higher-order Modulation



One is dispersion-managed cables designed for 2.5 Gb/s and 10 Gb/s direct-detect transmission, which were deployed from the early 1990s onward. Analog dispersion management techniques within such cables evolved over time, with at least two distinct approaches. The assumption was that no dispersion compensation was needed in the transponder, and the focus was to maximize capacity per fiber pair. The first generation of coherent transponders was deployed on this type of cable, and they delivered a massive performance boost.

However, these cables were not specifically designed for coherent transmission, resulting in certain characteristics that limit their ultimate performance, even when using the latest transponders. For this reason, I use them as a baseline of x1 in terms of performance.

A second category of long-distance submarine cables comprises uncompensated cables designed for coherent transmission, which were deployed from around 2015 onward. These cables typically operate at high repeater gain to help enable high-order modulation and high spectral efficiency. They usually use large-effective-area fibers with positive dispersion that accumulates along the whole length of the cable, and thanks to these two properties, nonlinear penalties are minimized. Dispersion is compensated for in the coherent transponder using digital signal processing (DSP). Uncompensated cables also focus on maximizing capacity per fiber pair.

The MAREA cable is an example of a long-distance submarine cable. Note that MAREA delivers the highest performance of any existing transatlantic cable in terms of fiber pair capacity, with a total cable capacity of x5 performance.

Modern transponders are so successful that they operate within a couple of decibels (dB) of the theoretical

capacity limit for these cables. For this reason, the next step in cable design moves its focus away from capacity per fiber pair and toward overall cable capacity. This new design philosophy is called space-division multiplexing (SDM).

Space-Division Multiplexing Cables

These cables represent the third category of submarine cable, and they are also designed for coherent transmission with DSP dispersion compensation and positive-dispersion fiber, but their design philosophy moves away from maximizing capacity per fiber pair in favor of maximizing the capacity of the cable as a whole. SDM repeaters operate at lower power levels, well within the linear regime, and these cables typically use more traditional and less expensive optical fiber types.

There is already an evolving roadmap for SDM, with first-generation designs deployed from 2020 and extending to transatlantic-length cables with multi-petabit capacity in the next 10 years. The Dunant cable is an example of a first-generation SDM cable, with about x7 performance.

In several submarine-networking conferences, we have seen roadmaps for future SDM evolution with capacity up to the 4-petabit level for a transatlantic cable at x100 performance. It may be possible to push this limit even more, to x200 capability, but there are many exotic and untested technologies involved in this type of cable.

Coherent Transponders: Enhancing Modulation Techniques

Coherent transponders were first commercialized around 2009 and are now in their fifth distinct generation, with transponders that can deliver up to 800 Gb/s

800 Gb/s Transmission: Baud Rate and PCS

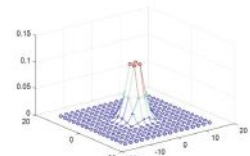
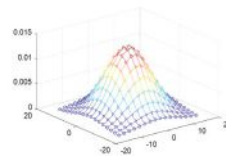
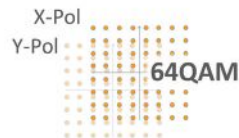
**800G
Reach**



Baud Rate



Modulation



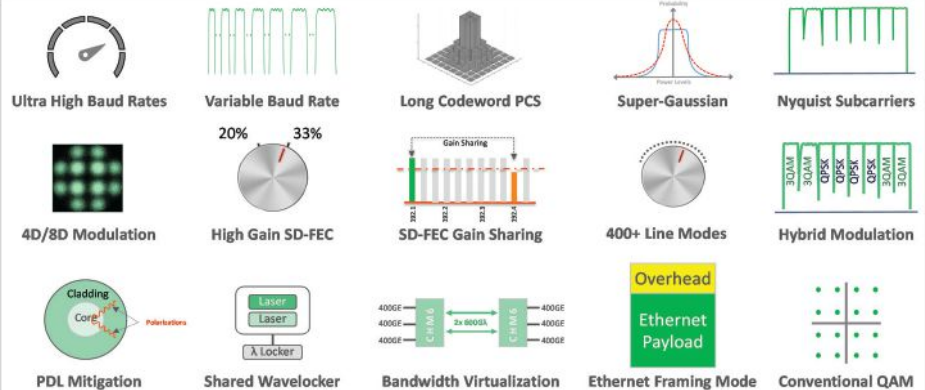
12 bits per symbol

10.5 bits per symbol

10 bits per symbol

Advanced Coherent Toolkit

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Generation
Coherent
Optical Engine**



per wavelength. There have been two clear directions of evolution: increasingly sophisticated modulation and higher baud rates.

A coherent transponder sends data using modulation symbols that hold a certain number of data bits. Modulation constellations have become increasingly sophisticated over time, and as this evolution progressed, each symbol was able to carry more bits. A PM-QPSK symbol, for example, carries 4 bits, while a PM-64QAM symbol carries 12 bits. By carrying more bits in each symbol, we increase the spectral efficiency (and thus the fiber capacity) of the system. We've seen a threefold increase in spectral efficiency over this period. Unfortunately, carrying more bits per symbol also has the effect of reducing the optical reach of the transmission, with a 30-fold reduction in reach if we compare PM-QPSK with PM-64QAM.

In the latest generation of coherent transponders, we have seen the first effective implementations of a tech-

nique called probabilistic constellation shaping (PCS), a complex idea with a fairly simple result. PCS can boost the optical performance of a modulation symbol in two ways. It offers a much more granular method to carry the bits compared to conventional constellations, so it's possible to squeeze out additional signal quality for a given wavelength data rate at a given optical reach. And by reducing the probabilities of using the highest-power modulation symbols—in other words, power increases as you move out from the origin—we can achieve better transmission performance. Conventional wisdom holds that PCS will always deliver the optimum capacity reach.

Increasing Baud Rates

The baud rate is the rate at which we send modulation symbols. For an 800 Gb/s signal that uses a full PM-64QAM constellation (12 bits per symbol), for example, we would need a minimum rate of 84 gigabaud (Gbaud). This allows not only the 800 Gb/s payload, but also the

“Over 99.5 percent of intercontinental internet traffic passes through submarine cables”

overhead of framing and forward error correction (FEC) to be transmitted. By increasing the baud rate, it can be possible to increase the optical reach of a given data rate.

Let's take for example an 84-Gbaud PM-64QAM signal with a nominal reach factor of 1. Because this uses the full 64QAM constellation with no PCS, the reach would be very short. By increasing the baud rate to 96 Gbaud, a relatively small increase, we see a fourfold increase in reach because we can “dial back” the number of bits per symbol to 10.5 using PCS. Increasing the baud rate still further to 100 Gbaud delivers a fivefold increase in reach because we've dialed back PCS still further to carry only 10 bits per symbol. Conventional wisdom holds that operating with the highest baud rate enables optimum capacity reach.

Why Defy Conventional Wisdom?

Conventional wisdom is extremely compelling in terrestrial networks, where provisioning hundreds of services over multiple routes in a meshed long-distance network must be a “production line” process with minimum manual intervention. But capacity is so precious in a submarine cable that it's worth the effort to squeeze out every last gigabit per second.

For example, if we were to design a transponder with excellent, granular PCS but perhaps just a “high” and “low” setting for baud rates, we would miss an opportunity for such optimization because we will often find that a given wavelength could support, for example, 626 Gb/s—or 642 Gb/s. We may have granularity, but this is irrelevant to the Ethernet clients that use this wavelength, who work in chunks of 100 Gb/s or 400 Gb/s. Flexible data rate Ethernet (FlexE) was supposed to address this issue, but it's not widely implemented, and even if it were, it would be tricky for subsea operators to sell a flexible service.

Turning this signal down to 600 Gb/s and then tuning the baud rate down a little from the maximum rate, we find that the spectral width of the signal will become narrower and, given enough channels across the band, we can squeeze extra channels in to use up the “stranded” capacity. We've found that we can extract up to 25 percent more capacity from a modern uncompensated or SDM cable in this way.

Similarly, there are types of cable in which PCS does not always deliver the best result, particularly cables that are older and have high nonlinear penalties. PCS loses its mojo at a spectral efficiency of PM-QPSK or lower, and we find it's better to switch it off and use non-PCS fixed modulations with special characteristics that suit these

fiber conditions. In some challenging cables, we've extracted up to 50 percent more capacity than a PCS-only implementation.

The Past and Future of Submarine Transponders

Early coherent transponders circa 2008 were designed purely for terrestrial transmission, and it was lucky that they worked so effectively on the submarine cables of that era. Over the last 15 years of coherent development, it has been essential that the same coherent DSP chips can be used by both terrestrial and submarine network markets. The cost of developing the latest DSP technology runs up to \$70 million, and this scale of investment could not be recouped if the chip set could only be used in submarine deployments.

A typical advanced coherent toolkit for a fifth-generation transponder has features that apply to both terrestrial and submarine network deployments, but a few of the features were developed either exclusively for subsea operation or can be used to deliver a significant performance boost for submarine cables. One of the earliest examples of this was for the second and subsequent generations of coherent transponder to be able to compensate for very high levels of chromatic dispersion in uncompensated cable designs.

In addition to the variable baud rates and non-PCS modulations discussed here, features such as super-Gaussian PCS, SD-FEC gain sharing and high-gain FEC modes are all valuable for certain types of submarine cables. Across a variety of cable types, these features can deliver 15 to 50 percent more capacity compared to a transponder without them.

As we look to future generations of submarine transponders, it's essential to maintain this link to terrestrial applications, but to add subsea-specific features.

Conclusion

Modern coherent transponders have a wide selection of digital tools available to help them extract maximum capacity from submarine cables. But sometimes you have to forget about conventional wisdom and think outside the box—and you need to do this at the time that the optical engine chips are designed because you can't change basic functions once they are burned into an application-specific integrated circuit. But by using these techniques, it's possible to extend the economic life of all types of submarine cables around the world. **ST**

Geoff Bennett is the director of solutions and technology at Infinera.

international

Ocean-Based CO₂ Removal Project

Strategies for the Evaluation and Assessment of Ocean based Carbon Dioxide Removal (SEAO2-CDR) is a European project that has been launched to study the feasibility of capturing CO₂ from the atmosphere and storing it in the ocean.

Led by the U.K. National Oceanography Centre (NOC) and co-ordinated by Uniresearch, the four-year project involves 13 organizations, including the World Ocean Council. The initiative will assess techniques such as increasing CO₂ absorption into seawater, enhancing algae productivity and sinking seaweed into ocean depths.

The project aims to fill gaps in OCCR understanding, evaluate its environmental and economic viability, and develop frameworks for responsible implementation, including robust monitoring strategies. It seeks to provide information for informed decisions on ocean-based carbon capture to support climate mitigation efforts.

Cable for UK-Denmark Electricity Exchange

By the end of 2023, a high-voltage direct current electricity link, Viking Link, will facilitate electricity exchange between Great Britain and Denmark. MacArtney Offshore Wind Solutions has collaborated with Energinet to develop the long-term onshore cable handling and storage solution for the Danish site.

The project involves a long-term maintenance plan with a 15-km spare cable that must always be available for prompt replacement in case of cable damage. MacArtney has supplied a comprehensive storage system with 40 years of operational reliability.

DNV Standards for Hydrogen, Ammonia

DNV has released a new service specification, DNV-SE-0654, that delineates DNV's procedures for verifying claims made by companies about the production and distribution of low-carbon hydrogen and ammonia. This new service will enable hydrogen producers to document and demonstrate compliance with applicable standards, ensuring the credibility and transparency of their claims.

It will also allow for the validation of their systems or products based on specific characteristics, such as the requirement to keep greenhouse gas emissions below a predetermined limit.

The specification encompasses advisory, verification and validation services, covering diverse pathways of hydrogen production (including conventional, electrolysis-based and innovative methods), along with associated ammonia production linked to these hydrogen pathways.

Marcura to Acquire Online Marketplace

The Marcura Group has agreed to acquire ShipServ, a maritime online procurement platform and marketplace. Upon merging, ShipServ's 126 employees will come together with Marcura's 850 to serve a combined customer

base of 800 blue-chip maritime customers and a network of 47,000 maritime suppliers globally.

NAVTOR Expands in Greece

NAVTOR, a specialist in maritime e-navigation and performance solutions, has opened its 11th office, NAVTOR Hellas. The Athens-based operation, situated at the Port of Piraeus, is an evolution of an existing, long-standing partnership with distributor Space Electronics.

UCO Adds to ROV Fleet

Underwater Contracting (UCO), the owner of the world's largest fleet of Saab UK's Seaeye Falcon ROVs, has ordered six more Falcons, boosting its fleet to 33 vehicles. This follows the award of major contracts in the aquaculture, renewable and oil and gas sectors to UCO that will see the Falcon fleet working continuously to provide a range of services in Europe, North America and Australia.

ABS Wavesight Enhances Offerings

Procureship has joined with ABS Wavesight, the ABS-affiliated maritime software-as-a-service (SaaS) company, to offer its digital procurement platform to fleet owners and operators looking to optimize and streamline operations through digitalization of maritime procurement and purchasing. The agreement will see Procureship included in ABS Wavesight's portfolio of vessel and voyage optimization tools.

New Exail Office in Norway

Exail has opened a new business office in Norway to support the company's growth in the Scandinavian region. Located in the Oslo area, the new office is led by Lars Sorfang, who is general manager for Exail AS and regional sales manager for Scandinavia.

JDP on Structural Assessment of LNG Tanks

Bureau Veritas (BV) and shipbuilder Hanwha Ocean have announced a joint development project (JDP) on the structural assessment of independent LNG fuel tanks for ultralarge ships.

Today, many vessels have independent tanks, either for the purpose of LNG/LPG transportation or for the use of LNG/LPG as a fuel. The particularity of these independent tanks is that they are not rigidly connected to the hull structure but are instead held by an important number of dedicated supports, which must be designed with consideration of nonlinear structural response during operations, including loss of contact and sliding.

Sale of Klein Marine Systems

MIND Technology Inc. has sold its Klein Marine Systems unit for cash consideration of \$11.5 million to General Oceans Inc., a subsidiary of General Oceans AS.

Pursuant to the transaction, MIND has licensed its Spectral Ai software suite to General Oceans for certain applications, particularly side scan sonar. MIND and General Oceans have also entered into a collaboration

agreement to further develop Spectral Ai and potentially other software projects.

Klein has served the offshore mapping and defense industries for over 50 years and will strengthen General Oceans' already substantial capabilities in subsea sensors, serving applications from seafloor mapping to mission-specific autonomous vehicles.

UUV Digital Twin Testing

Integer Technologies has successfully completed at-sea testing as part of its SBIR Phase Two Award—Defining and Leveraging Digital Twins in Autonomous Undersea Operations (DELTA)—with the U.S. Defense Advanced Research Projects Agency (DARPA).

Integer, along with its subcontractors at the Woods Hole Oceanographic Institution (WHOI) and Rite-Solutions Inc., has been investigating the implementation of digital twins for UUV missions. The team integrated the digital twin architecture, software and communication systems on a REMUS 100 vehicle, which were validated during at-sea tests.

Greensea Restructures

Greensea Systems Inc. has become Greensea IQ, which unites its former subsidiaries, Bayonet Ocean Vehicles and Armach Robotics, into a new business entity. This restructuring prepares the company to expand its operations into Europe, South America and Southeast

Asia, allowing the provision of closer service depots for robot deployments and more effective customer support.

Trials for Solus Extra-Large UUV

Cellula Robotics Ltd.'s Solus-XR XLUUV (extra-large UUV) has begun sea trials as part of the development of the company's long-range hydrogen fuel cell-powered autonomous underwater systems. The initial sea trials will evaluate surface performance and autonomy, offering a valuable opportunity to assess the vehicle's capabilities in the dynamic context of real-world maritime conditions. Cellula Robotics has planned demonstration missions for 2024.

Seattle Incubator for Startups

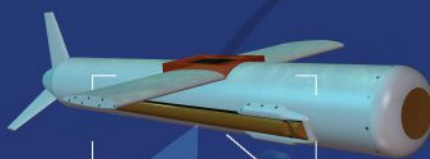
Washington Maritime Blue and the Port of Seattle have launched a new incubator program for concept and early-stage maritime, oceans, and fisheries startups and those looking to grow in the region. This one-year, free program will act as a possible feeder to the Maritime Blue Innovation Accelerator.

TDI-Brooks Builds New Workspace

Following three years of rapid growth in business and personnel, TDI-Brooks has begun construction of a 16,000-sq.-ft. technical building at TDI's headquarters in College Station, Texas. It will house office space, technical work spaces, fabrication shops and storage areas. **ST**

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100-Year Floods on the Rise

Most coastal communities will encounter 100-year floods annually by the end of the century, even under a moderate scenario where carbon dioxide emissions peak by 2040, a new study found. As early as 2050, regions worldwide could experience 100-year floods every nine to 15 years on average.

A 100-year flood is an extreme water level that has a 1 percent chance of being exceeded in any given year and is based on historical data. Despite the name, 100-year floods can strike the same area multiple years in a row or not at all within a century. But a new study found that those historical trends will no longer provide an accurate outlook for future floods.

On the coast, extreme floods can be caused by water pushed inland by storms, tides and waves, but this

study focuses on a component that contributes to flooding over a much longer time scale: sea level rise. As higher seas creep up the shore, coastal infrastructure will be closer to the water, making storms, tides and waves more likely to impact communities.

The researchers used data from more than 300 tide gauges around the world to conduct trend analyses and estimate future extreme sea levels under two carbon emission scenarios outlined by the International Panel on Climate Change: if carbon dioxide emissions continue to rise through the end of the century, and if carbon dioxide emissions reach their peak by 2040 and then decline. In both scenarios they found that sea level rise will lead to an increase in 100-year flood events in most of the locations they studied.

More than 600 million people

live in low-lying coastal regions, according to another study. That number is expected to rise. A proactive approach to land planning, urban development and coastal protective measures could help communities reduce flooding and avoid disaster, and that starts with realistic forecasts of future coastal conditions, according to the researchers.

While mean sea level is rising, the outcome won't be the same everywhere. Higher latitudes may experience a drop in sea levels as heavy ice sheets melt and the land underneath rises. In contrast, regions such as the Gulf of Mexico are experiencing rates of sea level rise that are faster than the global average because the land is gradually sinking. Coastal communities require unique solutions based on local information to match their needs, the researchers said.

OceanWise Fills Data Gaps For UK Sea Level Index

Despite ever-increasing global

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recognition of the importance of sea level data to inform decision makers on climate and environmental policies, data were insufficient to update the U.K. sea level index in both 2020 and 2021.

But data quality and reliability are now back on track, and the tide gauge network is at a high enough standard to calculate this vital statistic. The Environment Agency (EA) was able to submit mean sea level values in 2022 for the purpose of tracking sea level rise, thanks to OceanWise, which was awarded the EA contract in late 2021 to maintain and update the United Kingdom's National Tide Gauge Network (NTGN).

NTGN underpins coastal flood forecasting around the U.K. and comprises a network of 42 tide gauges at key locations. OceanWise is responsible for ensuring the real-time stream of high-quality data from the network, while maintaining legacy sensors for the long-term data record.

The purpose of the NTGN is to observe sea level throughout the U.K. in near real time, as input to monitoring and forecasting coastal surge, and to provide a long-term and strategic record for climatological and coastal engineering studies. The network currently consists of 21 sites in England, 10 in Scotland, seven in Wales, two in Northern Ireland, one in Jersey and one in the Isle of Man.

The data provided by the network is also used by academics and researchers for other scientific purposes, such as the Global Sea Level Observing System.

UK Study on Sewage in Rivers

New research by the University of Oxford has revealed that sewage discharge into rivers has a greater impact than surrounding land use on water quality and the animals and plants that live in rivers. This has strong implications for the state of U.K. rivers in light of recently weakened nutrient neutrality regulations for new housing developments.

Rivers are crucial parts of the global water cycle, contain important biodiversity and are essential for

human health (drinking water). They also function as a resource for recreation and agriculture.

The researchers investigated the effects of three different pollution sources (treated sewage discharge, agriculture and urban run-off) on different aspects of river systems. The group tested four rivers in England, both up- and downstream of sewage discharge, over three different months.

The results demonstrated that treated sewage discharge serves as the best predictor of high nutrient levels, bottom-dwelling algae and sewage fungus abundance, regardless of the type of land use (agriculture or urban) in the surrounding area.

There is an urgent need for a comprehensive action plan targeting the sewage discharge problem, the researchers said. **ST**

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Offshore Bend Stiffener System



Comprising a lead-in cone, bend stiffener connector (BSC) and dynamic bend stiffener, the system features a BSC drawn through a bellmouth located beneath a floating platform. As the BSC latching system engages with the bellmouth, the anchoring mechanism comes into action. This latch secures the mechanism during descent and maintains system stability as the anchors find their place on the tapered neck of the bellmouth. Balmoral Comtec Ltd.

Supply & Trading, to buy and sell EUAs. OceanScore GmbH.

Lifejacket for Offshore Wind

ErgoFit SOLAS redefines safety, comfort and performance for those engaged in challenging tasks on wind turbines and during offshore crew transfer operations. The comfortable "wear all day" lifejacket offers cross-compatibility with a range of fall-arrest harnesses; integrated sprayhood with airway protection and Fusion 3D technology; and contoured fit with total freedom of movement. Crewsaver.

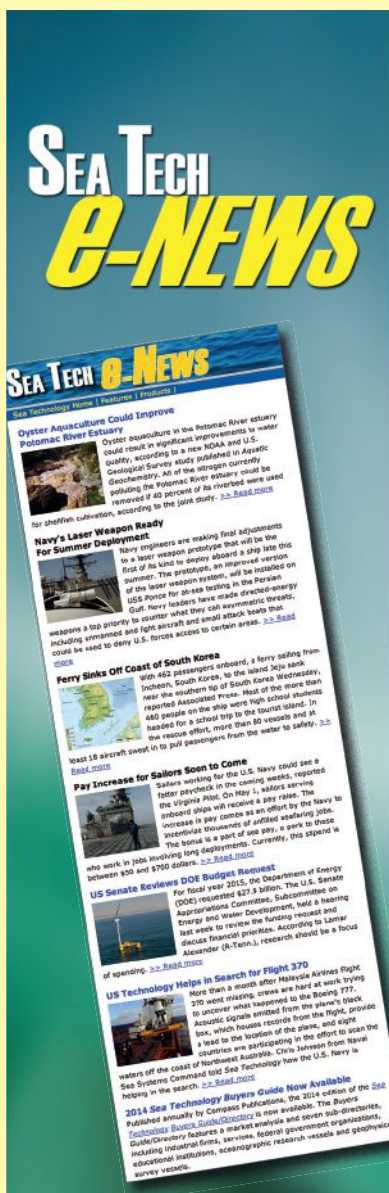
Jacking and Cradle System



As offshore wind projects become more globalized, monopiles are traveling farther distances, so heavy transport vessels need to have larger sea fastening to support monopiles during voyages. Because of this, there is less clearance when loading and unloading large monopiles using SPMTs. The jacking and cradle system can lift monopiles higher, allowing more sea transports to take place using existing support structures. The system comprises two elements: jacking spacers that sit between SPMT modules to generate greater stroke, and hydraulic, foldable saddles that cradle the monopile so it can be supported at higher points to prevent excessive ovalization. Mammoet.

Generative AI Chat

Aquila Subsea provides instant and accurate responses to a wide range of queries, empowering survey engineers and researchers to swiftly understand manuals, troubleshoot



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Seismic Data Management

MetaBlue assists E&P companies and marine seismic service providers to reduce project turnaround times by seamlessly connecting every phase of a marine seismic project. By being able to leverage efficiently all the survey data from these different project components within the MetaBlue ecosystem, project stakeholders can make holistic decisions at every stage of the survey, revolutionizing project planning, execution and completion. Sercel.

Web-Based Emissions Monitoring

ETS Manager enables ship operators to manage emissions liabilities and trade carbon allowances under the impending EU ETS regime. It automatically ingests vessel operational data, assessing the need for EU Allowances (EUAs), allocating them to owners or stakeholders, requesting and accounting for them, and tracking open positions. It incorporates the advanced trading tool EUA Trader, powered by RWE

issues and access critical information. It is the first-ever generative AI chat solution tailored specifically for the subsea survey industry, according to the company. Unique Group.

Digital Reporting



The cloud-based Streamlog Garbage Record Book and Oil Record Book are type approved by Bureau Veritas, confirming that both record books meet the IMO guidelines. By gathering all of a vessel's information in one place, the electronic record books will support compliance with new regulations and facilitate port state controls and inspections. They will also link to Opsealog's data integration and analysis platform, MarInsights, where the information can be harnessed to help inform the vessel operator on the best strategies to reduce environmental footprint and limit marine pollution. Opsealog.

Mission Bay Handling System

Designed to enable the efficient deployment and recovery, via either sides of a ship, of both manned and unmanned crafts ranging in hull type and propulsion configuration, the system applies to today's rapidly changing naval battlespace. Its key elements are: an overhead frame system, multipurpose hangar crane and various auxiliary equipment. Kongsberg Maritime.

Antisubmarine Warfare

This solution combines a rotary wing UAS with an ASW sonobuoy-dispensing capability, based on the SKELDAR V-200 uncrewed aircraft. It can track potentially hostile submarines in the open ocean or close to coastal areas. UMS SKELDAR and Ultra Maritime.

Large Uncrewed Surface Vessel

LUSV balances naval operational capability and cost-effective mass. At over 80 m long, it can operate in high sea states. This simplified supporting vessel offers the full benefits of autonomy. BMT.

Robot for Seabed Harvesting

C Bud is developed for an efficient and least-destructive harvesting process for bivalves and other bottom-living resources on the seabed. Its belt-driven main entity is controlled by an operator through a monitor via an umbilical from the surface vessel. The C Bud is equipped with video cameras, lights and positioning equipment. C Robotics AS.

PPK Software

Qinertia 4's new features include a geodesy engine "Ionoshield" mode (showing ionospheric activity); extended CORS network; and advanced GNSS data display. SBG Systems.

Dissolved Oxygen Logger

miniDOT Clear has an LCD screen for users to view data in real time. It can collect more than 500,000 samples during each deployment. The logger uses field-replaceable AA lithium batteries with a backup coin battery to allow the logger to collect accurate data during long deployments. Anti-fouling options include the WIPER and copper additions. Precision Measurement Engineering Inc.

Vessel Environmental Rating

RightShip platform's enhanced GHG 2.0 Rating features an improved methodology in line with IMO regulatory developments, such as EEXI, to support the drive for decarbonization. Vessels are compared fairly based on design potential. Operational measures will be included in the IMO's Carbon Intensity Indicator (CII) regulation, which will also be available on the RightShip platform in the future. RightShip. **ST**

A promotional graphic for Twitter. At the top, the text "FOLLOW SEA TECHNOLOGY ON..." is written in large, bold, yellow capital letters. Below this, a cartoon blue bird with large eyes is shown holding an open magazine. The magazine's cover features the text "SEA TECHNOLOGY SERVICES THE WORLD" and "SEA TECHNOLOGY". At the bottom of the graphic, the Twitter logo is displayed in blue, followed by the text "twitter.com/SeaTechnology" in large, bold, yellow capital letters. The background is a solid blue color with faint, repeating text "twitter.com/SeaTechnology".

BOEM Issues Final Guidance to Improve Offshore Wind Permit Process

The U.S. Bureau of Ocean Energy Management (BOEM) has published two final guidance documents for the submission of offshore wind project plans to improve permitting efficiency: the Notice of Intent (NOI) Checklist and the Marine Acoustic Modeling and Measurement Guidelines. These documents are part of BOEM's ongoing efforts to provide clear guidance to facilitate the responsible development of renewable energy resources on the Outer Continental Shelf (OCS).

The NOI Checklist is based on BOEM's regulations and describes how BOEM will process incomplete construction and operations plan (COP) submissions. The checklist is designed to: provide clarity to lessees; establish a pre-application and pre-NOI process with lessees and cooperating agencies that will benefit all stakeholders; and improve the efficiency of proposed offshore wind project reviews by avoiding delays to the National Environmental Policy Act (NEPA) analysis after the NOI has been published.

Alongside the NOI Checklist, BOEM has issued recommendations to lessees as they develop the acoustic and exposure models of impact pile-driving, and for

sound-field measurements, to be included with their COP.

Two New Marine Highways

The U.S. Transportation Department has designated two new Marine Highway Routes as part of the United States Marine Highway Program (MHP). The newly designated M-11 and the M-79 routes will help speed up the movement of goods, strengthen supply chains, and support local economies in Alaska, Pennsylvania and West Virginia. These designations allow any eligible applicant on these routes to apply for future U.S. Marine Highway Program grants.

The MHP supports the increased use of U.S. navigable waterways to relieve land-side congestion, provide new and efficient transportation options, and increase the productivity of the surface transportation system.

NOAA IUU Report

NOAA has released its 2023 Report to Congress on Improving International Fisheries Management, identifying seven nations and entities for illegal, unreported, and unregulated (IUU) fishing activities. Two of those nations were also cited for issues relating to forced labor, and two were identified for issues related to shark catch. This is the first time the report has used forced labor and shark catch in IUU fishing identifications.

The biennial report, required under the High Seas

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Driftnet Fishing Moratorium Protection Act, identifies nations that fail to address IUU fishing, bycatch of marine wildlife and shark management. Once identified, the United States collaborates with those nations to address their problematic fisheries issues. The 2023 report identifies Angola, Grenada, Mexico, China, Taiwan, Gambia and Vanuatu as nations and entities participating in IUU fishing.

The report starts a two-year process for the identified nations to take the necessary steps to address IUU fishing. If a nation takes appropriate actions, it will receive a positive certification in the next report. If not, it receives a negative certification, triggering a denial of U.S. port privileges, among other measures, including potential import restrictions.

The 2023 report announced certification determinations for 31 nations and entities for illegal fishing and/or bycatch of protected living marine resources from its 2021 report, including positive certifications for Costa Rica, Guyana, Senegal and Taiwan.

NSF Funds MTS Microcredentialing Program

The Marine Technology Society (MTS) has received an award from the U.S. National Science Foundation for an initiative to meet the escalating demand for skilled workers across diverse sectors in the marine industry, including research, renewable energy, fisheries, ports/shipping, national security, tourism and more. This program will create pathways to these careers that do not require advanced degrees in engineering or science. Instead, the focus will be on cultivating practical skills and technical competencies essential for success in the industry. MTS will establish a microcredentialing program to address core competencies for employment in the blue economy. Microcredentials are short, competency-based recognition that demonstrate mastery in specific areas. Unlike traditional courses, they are more concise and directly represent targeted knowledge and skills.

Upon demonstrating their competency, individuals will be awarded a digital badge, which verifies the attainment of specific competencies and can be added to resumes, LinkedIn profiles or other social media platforms as instant recognition of their personal skill set. These microcredentials can be "stacked" in a modular fashion to progressively build toward more comprehensive certifications, aligning with learners' specific career goals.

By 2025, MTS aims to offer six microcredentials, including a foundational microcredential in Underwater Gliders, ROVs, Sonar and Deck Operations, as well as intermediate microcredentials in Underwater Gliders and Sonar.

California Passes Wave, Tidal Energy Law

The California State Senate has unanimously passed a bill that directs the California Energy Commission to evaluate the feasibility, costs, and benefits of using wave energy and tidal energy across California's 840-mi. coastline. The bill was then signed into law by California's governor. It is the first legislation in the U.S. focused on the study, assessment and promotion of wave energy. **ST**

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Ndungu Pipe Contract

TechnipFMC has received an award by Azure Energy to supply flexible pipe for its Ndungu project, offshore Angola. The Ndungu project will tie into Block 15/06 West Hub, where TechnipFMC was recently awarded a substantial flexible pipe contract. Through this extension, the company was able to provide an optimized solution that enables Azure to maintain schedule and achieve efficiencies.

Spirit Energy Decom Ops

Spirit Energy is experiencing its busiest year-to-date in decommissioning with offshore campaigns across the Central North Sea (CNS), Southern North Sea (SNS) and East Irish Sea.

The most recent activity is the final phase of the campaign to remove the DP3 and DP4 installations in the Morecambe Bay development in the East Irish Sea. Completed by Allseas with its *Pioneering Spirit*, the largest construction vessel in the world, a total of 9,000 tonnes of jacket structures were removed in tandem, using the jacket lift system on the vessel, and loaded directly onto the *Iron Lady* barge to be transferred to Fife for recycling.

In the CNS, a 14-well plug-and-abandonment program across four fields (Chestnut, Birch, Larch and Sycamore) is being executed from Well-Safe Solutions' *Well-Safe Defender* vessel. Chestnut's well decommissioning has been completed, bringing to an end the 15-year life of the Chestnut field.

In the SNS, during a single mobilization, Heerema Marine Contractors successfully removed three topsides and three jackets with the SSCV *Thialf* crane vessel, and DeepOcean is set to recover subsea infrastructure from six assets later this year.

The recycling of all structures will be performed by Thompsons of Prudhoe in the Port of Blyth, making Spirit Energy the first user of the decommissioning alliance between the two companies.

Remote Metrology Project In North Sea

Harvest Technology Group Ltd. has successfully completed a milestone project in the North Sea, partnering with 3D at Depth to deliver remote metrology services for a leading global subsea services company. The entire operation was conducted successfully, with less than 1 Mbs of bandwidth, and utilized both 4G (broadband cellular network) and VSAT (two-way satellite) connectivity.

The work scope involved 3D at Depth's LiDAR laser scanning technology deployed by ROV and controlled from onshore using 3D at Depth's own remote operations technologies. This allowed 3D at Depth personnel to run the project from its Aberdeen office, reducing the requirement to mobilize personnel to the vessel.

Harvest's proprietary Node-stream technology was mobilized on board the offshore subsea construction vessel to support 3D at Depth with its subsea metrology operations, enabling real-time situational awareness, and included ROV video feeds, sonar and navigation screens.

Harvest's robust video live-stream technology allowed for cost-savings and efficiency improvements, even where limited bandwidth would previously have been prohibitive.

Oceaneering Contracts in Angola, Guyana

Oceaneering International Inc.'s Offshore Projects Group (OPG) segment has been awarded two international contracts.

Oceaneering has been named a consortium partner to support transportation and installation work on the Girassol Life Extension project. The scope of work includes air and saturation diving services, project management, engineering and procurement activities in support of the prime contractor's recovery and replacement of 12 risers. Having extensive experience in Angolan offshore developments,

Oceaneering will provide Angolan personnel for the project and manage the in-country operations of the consortium. Oceaneering is expected to provide its services in various phases, to commence in late 2023, lasting into late 2025.

Oceaneering has also been awarded a contract for work on a jumper installation project in the Stabroek block, offshore Guyana. The scope of the project adds to the company's growing body of work in the South American country in support of a key client. It consists of jumper and subsea field development installation and other associated tasks. The scope of supply is already underway and anticipated to last through the remainder of 2023.

Marine Warranty Services for Gas Field Powered by Wind

Global Maritime has been awarded marine warranty surveyor (MWS) services for the groundbreaking ONE-Dyas N05-A Gas Field project in the North Sea. The project will include the installation of the N05-A six-legged platform, export gas pipeline and subsea power cable. Services will encompass comprehensive third-party document review and on-site surveillance throughout the mobilization, transport, and installation phases of the offshore infrastructure.

The N05-A project blends the production of gas with offshore wind, with the nearby Riffgat offshore wind farm providing electricity to power the platform.

Offshore Platform Project

Through creative engineering and the use of its state-of-the-art equipment, Mammoet has achieved the safe and efficient load-out and installation of a massive offshore platform as part of the Azeri Central East (ACE) project. This is part of the next phase of development of the bp-operated Azeri-Chirag-Deepwater Gunashli (ACG) field in the Caspian Sea.

Mammoet's scope included the weighing, jack-up, load-out and float-over installation operations of the 19,600-tonne production, drilling and quarters (PDQ) platform. **ST**

Ingalls to Build More US Navy Destroyers

HII's Ingalls Shipbuilding division has been awarded a multi-year procurement contract for the construction of six *Arleigh Burke*-class (DDG-51) destroyers for the U.S. Navy. The contract includes options for additional DDG-51 ships and for engineering, design, and post-delivery efforts.

Ingalls has delivered 35 *Arleigh Burke*-class destroyers to the U.S. Navy.

Davits for US Navy Oilers

Davits supplied by Vestdavit will facilitate efficient launch and recovery of fast craft to support refueling operations at sea for the U.S. naval fleet with the award of a contract for six vessels being built by General Dynamics NASSCO in the U.S. A total of 12 high-specification PLRH-5000 davits will be installed on the *John Lewis*-class of T-AO oilers ordered by the U.S. Navy at the shipbuilder's San Diego shipyard, with two on each ship from T-AO-208 through T-AO-213 in the newbuild series.

The 745-ft.-long oilers, which will be operated by Military Sealift Command (MSC), are designed to transfer fuel to U.S. Navy carrier strike groups operating at sea, with the capacity to carry 162,000 barrels of oil.

The PLRH-5000 single-point davits will be used to handle 7-m RHIBs (rigid-hull inflatable boats) and incorporate a range of motion compensation and safety features that allow them to function effectively in challenging conditions with high sea states.

Silver Ships Delivers Special Warfare RHIBs

Silver Ships has completed the first deliveries under the Naval Sea Systems Command of seven 11-m Open Center Console (OCC) vessels and two 8-m OCC vessels as part of the Naval Special Warfare Surface Support Craft (NSW SSC) contract. The Navy has also conducted pre-delivery inspection and testing of three vessel variants included in the contract.

The NSW SSC contract entails construction of five vessel variants of the Ambar series of RHIBs. These craft can be used in inland bays and waterways, as well as deepwater over-the-horizon transits, in all operating con-

ditions and weather. The Navy SSC vessels will support the Naval Special Warfare community via ocean diver and swimmer support, medical transport, vessel towing and water airdrop training, among other missions.

Submarine Rescue System for Indonesian Navy

Submarine Manufacturing and Products Ltd. (SMP), a U.K.-based manufacturer and supplier of diving and subsea rescue equipment, will provide its new Submarine Rescue System (SRS) to the Indonesian Navy. The SRS will be hosted on a mothership designed by Houlder and delivered by its Indonesian strategic partner, BTI Defence. The three-year build contract will include the U.K. design and manufacture of the SRV-F Mk3 rescue submersible. The custom build of the mothership will take place in region, along with the associated expert training for the Indonesian Navy.

Kongsberg Waterjets for Finnish Navy

Finnish boat builder Marine Alutech has selected Kongsberg Maritime's Kamewa waterjets for 17 new landing craft it is building for the Finnish Navy.

Marine Alutech, specializing in aluminum vessel construction, first developed the Watercat M12 *Jurmo*-class landing craft in the 1990s. Now capable of speeds exceeding 35 kt., the fast and agile 14-m craft will be equipped with a pair of Kongsberg Kamewa FF375 aluminum waterjets and a compact Jet Control System. The FF375 waterjets for this project will feature a customized inlet duct to enable new craft to match the performance characteristics of the original *Jurmo*-class, introduced to the Finnish Navy more than 20 years ago. Since the first *Jurmo*-class delivery, Kongsberg's waterjets and control systems have evolved significantly. The new landing craft will feature the electronic Jet Control System, instead of the original mechanical-hydraulic system.

UK FSS Ships Feature Sustainable Design

Team Resolute, a consortium of Navantia UK, BMT and Harland & Wolff, has unveiled the design for the Fleet Solid Support (FSS) ship as part of the U.K. Ministry of Defence's manufacture contract for three FSS ships for the Royal Fleet Auxiliary (RFA). It features energy-saving and emission-reducing technologies and future fuels that will contribute to carbon reduction. **ST**



contracts

ABB, Zurich, Switzerland, has received an order to supply the Azipod DI propulsion system for the new compact icebreaker of China's Institute of Deep-sea Science and Engineering. The ship is expected to be delivered in 2025 for operations in the Arctic and Antarctic Ocean. Guangzhou Shipyard International.

FibreMax, Joure, Netherlands, will combine its specialized fiber tendon technology with a fully restrained platform wind foundation monopile design to extend operating depth up to 100 m. Entrion Wind.

WinGD, Winterthur, Switzerland, will cooperate on future fuel vessel applications with ammonia-fueled engines. This will include preparing X-DF-A for integration with wider ammonia fuel systems and auxiliary machinery across a range of vessel designs, including oil tankers, container ships and ammonia carriers. Samsung Heavy Industries.

DNV, Høvik, Norway, has signed a memorandum of understanding with a Singapore-based ship owner and operator that builds on an earlier agreement, with a renewed focus on environmental, social and governance (ESG) topics, such as sustainable, future-proof vessel designs and decarbonization strategies. Pacific Carriers Ltd.

WINDEA Offshore GmbH & Co. KG, Hamburg, Germany, has entered a sales partnership to provide the European offshore wind market with hydrographic survey and underwater inspection technology and services. Subsea Europe Service GmbH.

Wärtsilä, Helsinki, Finland, will supply an integrated hybrid propulsion system for two new hybrid RoRo vessels being built at the China Merchants Jinling shipyard (Weihai) Co. Ltd. for a Swedish shipping company. They will be the world's first methanol-fueled hybrid RoRo

vessels and will operate in the Stena Line Irish Sea system. Stena RoRo.

Satlink, Madrid, Spain, will provide technical support for its SeaTube electronic monitoring systems on board longline fishing vessels to monitor and manage local fishing activities. Satlink will also update the local fisheries management center. Ministry of Fisheries and Marine Resources, Solomon Islands.

EIVA, Skanderborg, Denmark, will deliver a containerized remotely operated towed vehicle (ROTV) displaying data in NaviSuite software. U.K. Ministry of Defence.

Fraunhofer IWES, Bremerhaven, Germany, has been contracted to carry out a preliminary meteorological investigation in the North Sea as part of the area development plan. This will further accelerate offshore expansion in Germany. Federal Maritime and Hydrographic Agency of Germany. **ST**

meetings

DECEMBER

December 4-6—AAPA LATAM Convention of Ports, Barranquilla, Colombia. <https://aapa.getregistered.net/latam-convention-of-ports>.

December 4-6—Marine Renewables Canada Conference, Ottawa, Canada. <https://marinerenewables.ca/event/marine-renewables-canada-2023-conference-december-4-6-in-ottawa>.

December 4-7—Egypt Defence Expo, Cairo, Egypt. www.egyptdefenceexpo.com.

2024

JANUARY

January 24-25—Coastal Futures, London, U.K. cms@coastms.co.uk and www.coastal-futures.net.

January 30-February 1—EUROMARITIME, Marseille, France. www.euromaritime.fr.

FEBRUARY

February 5-7—Floating Wind Solutions, Houston, Texas. <https://floatingsolutions.com>.

February 11-13—Geo Week, Denver, Colorado. www.geo-week.com.

February 26-29—Blue Innovation Symposium, Middletown, Rhode Island. <https://blueinnovationsymposium.com>.

MARCH

March 12-14—Oceanology International, London, U.K. <https://www.oceanologyinternational.com>.

APRIL

April 9-11—Undersea Defence Technology, London, U.K. www.udt-global.com.

April 14-18—OCEANS 2024 Singapore, Singapore. <https://singapore24.oceansconference.org>.

MAY

May 6-9—Offshore Technology Conference, Houston, Texas. 2024. otcnet.org.

May 20-23—MTS Buoy Workshop, Sequim, Washington. www.mtsociety.org/buoy-workshop.

JUNE

June 10—Speed@Seawork, Cowes, U.K. <https://seawork.com/about-speed>.

June 11-13—Seawork, Southampton, U.K. www.seawork.com.

NOVEMBER

November 4-7—EURONAVAL, Paris-Nord Villepinte, France. www.euronaval.fr.

November 7-10—Europort, Rotterdam, Netherlands. www.europort.nl.

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

Largest Battery Electric Ship

Wärtsilä will power the biggest battery electric ship ever built with its battery electric propulsion system and waterjets. The vessel is a new ferry being built by Incat Tasmania and has been ordered by Incat's long-term South American customer, Buquebús. With an overall length of 130 m, the ferry will be the largest ever vessel of its type. It will also be the world's first zero-emission, lightweight catamaran. Delivery of the Wärtsilä equipment is scheduled for the latter part of 2024, and the vessel will be delivered in 2025. It will operate between Argentina and Uruguay.

Makai Software for OMS Group's Cable Vessels

Makai Ocean Engineering Inc. has commissioned Makai Software aboard five of OMS Group's cable installation and repair vessels. OMG Group is now utilizing Makai's software on all its cable installation and repair operations. Leveraging functionalities such as advanced modeling, real-time control and data logging allows for more precise control throughout the cable installation and repair process, especially in deepwater areas.

Phase Two of Autonomous Ship Project in Japan

Tel Aviv-based maritime technology company Orca AI will continue its successful collaboration with NYK Group subsidiary MTI and partners, leveraging its automated watchkeeper in the second development stage of the MEGURI2040 project administered by the Nippon Foundation.

MTI, alongside sister entity Japan Marine Science Inc., is spearheading the Designing the Future of Fully Autonomous Ships Plus (DFFAS+) consortium comprising 51 Japan-based companies that will work together on the next phase of MEGURI2040.

Maritime trade volumes are predicted to triple by 2050, but a skilled crew shortage is growing globally. Specifically, a diminishing, aging population in Japan has made it difficult to find skilled personnel for coastal shipping. This lack of experienced crews has created an acute need to mitigate the risk of human errors in navigation, which could potentially result in maritime accidents. The Nippon Foundation's MEGURI2040 project has envisioned the fully autonomous navigation program as a way to address these social issues, and the project was launched in 2020 with the aim to reach a full-scale commercialization of fully autonomous ship technology by 2025.

The first phase of MEGURI2040 culminated in May 2022 with the successful autonomous trial voyage of the 749-gt NYK short-sea containership *Suzaku* in congested waters off Japan's east coast. Equipped with Orca AI's automated watchkeeper to replace the human lookout, the vessel achieved 40 hr. of navigation with complete

autonomy, or around 98 percent of the voyage between Tokyo Bay and the port of Tsumatsusaka in Ise Bay. Data from the integrated display were livestreamed to the fleet operations center in Tokyo. The ship performed 107 collision avoidance maneuvers and avoided up to 500 other vessels en route.

MEGURI2040 Phase Two will demonstrate ship-shore operations using four different vessel types: a new containership with a fully autonomous operation system, an existing container ship, Ro-Ro vessel, and remote island route ship with partial autonomous operations, as well as two fleet operation centers.

Boxfish Changes Name

Boxfish Research has been renamed Boxfish Robotics to reflect the company's evolving focus and product line. The original name, Boxfish Research, was rooted in scientific exploration. Boxfish Robotics' applications now encompass submerged asset inspection, offshore energy, marine science, expedition research vessels, aquaculture, biosecurity and cinematography.

Edge-Computing USV Control

SEA-KIT International has unveiled its vessel control system (VCS) featuring new autopilot and drive modules built into the company's existing, purpose-built remote helm station, GSAVI. This brings the company closer to developing the first type-approved VCS for USVs. **ST**

Li-Ion Ocean Power



The advertisement features a blue background with a red header. It displays several product images: a large yellow battery pack labeled '6x1 MWh Energy Storage System' with an 'API 137 certified' badge; a white 'Charging Units' box; a row of cylindrical 'Li-Ion Batteries'; and a bundle of 'XXL AUV Li-Ion Batteries' with a green 'UN 38.3' certification logo. Below the images, the text reads 'Li-Ion PowerPack™ - Underwater Power Solutions'. Further down, it states 'Highly reliable, efficient and safe Li-Ion batteries AC+DC Made for harsh offshore and subsea conditions such as offshore energy, scientific and AUV or ROV equipment'. A 'Learn more' button is present. At the bottom, contact information for SubCtech GmbH is provided, along with 'UN 38.3' and 'ISO 9001' certification logos and the SubCtech logo.

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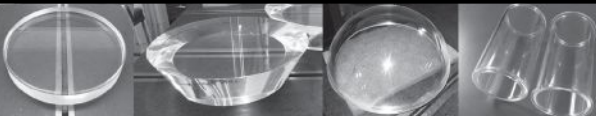
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It's Too Soon—and Too Risky—to Allow Seabed Mining on High Seas—Julian Jackson

Julian Jackson heads The Pew Charitable Trusts' work on deep seabed mining at the International Seabed Authority and leads engagement in Europe on the recently adopted UN Treaty on biodiversity beyond national jurisdiction. Jackson was previously a civil servant with the U.K. government, working on international agriculture and biodiversity policies. He is passionate about climate change and biodiversity loss.



The deep sea is inhabited by a multitude of unique and remarkable life forms that collectively play an important role in the wider health of our ocean and planet. Experts' understanding of this realm is ever expanding, with estimates that hundreds of thousands of species remain to be discovered in the deep ocean. For example, scientists recently discovered a new ecosystem of extremophiles, organisms that thrive in extreme environments, beneath the hydrothermal vents of an underwater volcano on the East Pacific Ridge off Central America. Meanwhile, earlier this year, research by London's Natural History Museum showed there are likely thousands of undiscovered species in the Clarion-Clipperton Zone, a vast, deep area of the Pacific Ocean between Hawaii and Mexico.

Nonetheless, a small group of companies and governments hopes to gain approval to engage in deep-sea mining, which could pose a major threat to marine life. They are seeking this from the International Seabed Authority (ISA), which the United Nations Convention on the Law of the Sea (UNCLOS) created to, among other things, negotiate regulations for deep-sea mining and oversee mining of deep-sea minerals in international waters.

In 2021, the ISA was forced to accelerate negotiations on the regulations when the Republic of Na-

uru triggered a rule in UNCLOS that stipulates that if regulations are not completed within two years, the ISA must consider any pending mining applications—a move that could allow unregulated mining. In response, a groundswell of governments, indigenous groups, scientists, conservation organizations and downstream mineral consumers, including electric vehicle and smartphone makers, have called for a moratorium on deep-sea mining because it could destroy critical ocean habitat, kill known and unknown species, and disrupt deep-sea ecosystems and the services they provide to humankind. Many stakeholders view mining as running counter to multilateral efforts to halt biodiversity loss and combat the impacts of climate change, such as the global framework adopted last year by the Convention on Biological Diversity and the new treaty to protect high seas marine life agreed on at the UN in June.

Fisheries management organizations and seafood retailers are also increasingly worried about the potential impact of sediment plumes from mining on commercially important fish species, and the cable-laying industry is pushing for greater transparency to ensure that vital global communications are not destroyed nor future infrastructure prevented.

This summer, the two-year time frame that Nauru triggered expired, yet the ISA is far from completing regulations. At its July meeting, a host of outstanding issues remained, including how to protect the marine environment, how to handle site inspections, compliance and enforcement, liability, institutional accountability and transparency, and even how much money to charge miners for the extraction of deep-sea minerals. Because of gaps in the science, some of these regulations, such as environmental thresholds, might not be ready to finalize for

decades. Although mining proponents claim that minerals beneath the seabed—such as cobalt, nickel and copper—are needed to help the world transition to cleaner energy and can be extracted sustainably, new science continues to come forward calling into question whether such extractive activities could ever be done without causing significant and irreversible harm to the ocean. Furthermore, new technologies are reducing reliance on these metals, while more and more electric vehicle makers and other tech companies are publicly forswearing use of minerals from the deep sea until the impacts of mining are sufficiently understood. Additionally, the many outstanding science and regulatory gaps make it doubtful that deep-sea mining could make any meaningful contribution in the coming decade to global commitments for carbon emission reduction.

Despite looming scientific and regulatory uncertainties, the threat of unregulated mining persists. At its July meeting, the ISA failed to make a decision to eliminate this threat despite widespread support from countries, while Nauru stated its intention to sponsor an application for a mining contract next year.

Hurrying to open a new extractive frontier before regulations are in place and scientific research has been done to understand the implications is nothing but reckless. To avoid significant and irreversible harm to the marine environment, the ISA should implement a moratorium until it agrees on robust regulations supported by solid science. It also must show that it can serve as an effective regulator of an extractive industry operating hundreds or thousands of miles offshore. Allowing mining activities without more science and robust protections could have dire consequences for deep-sea life, with little social benefit. It's simply not worth the risk. **ST**

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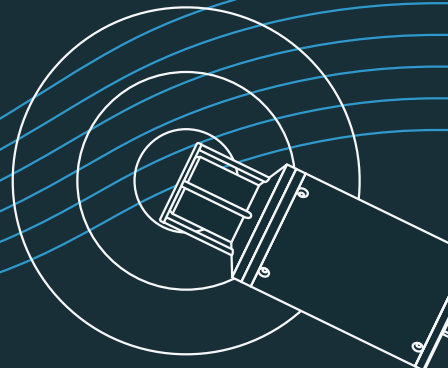
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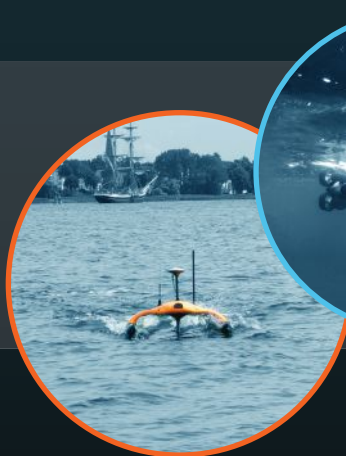
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