MARINE TECHNOLOGY REPORTER

January/February 2025
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Shape of Things to Come

Subsea Vehicles

Autonomous Navigation
Gaining More Agility

Securing the Deep
Infrastructure Protection

Subsea Defense
Calling the Crawlers

Batteries Interview
Nat Spencer, COO, Kraken

Volume 68 Number 1

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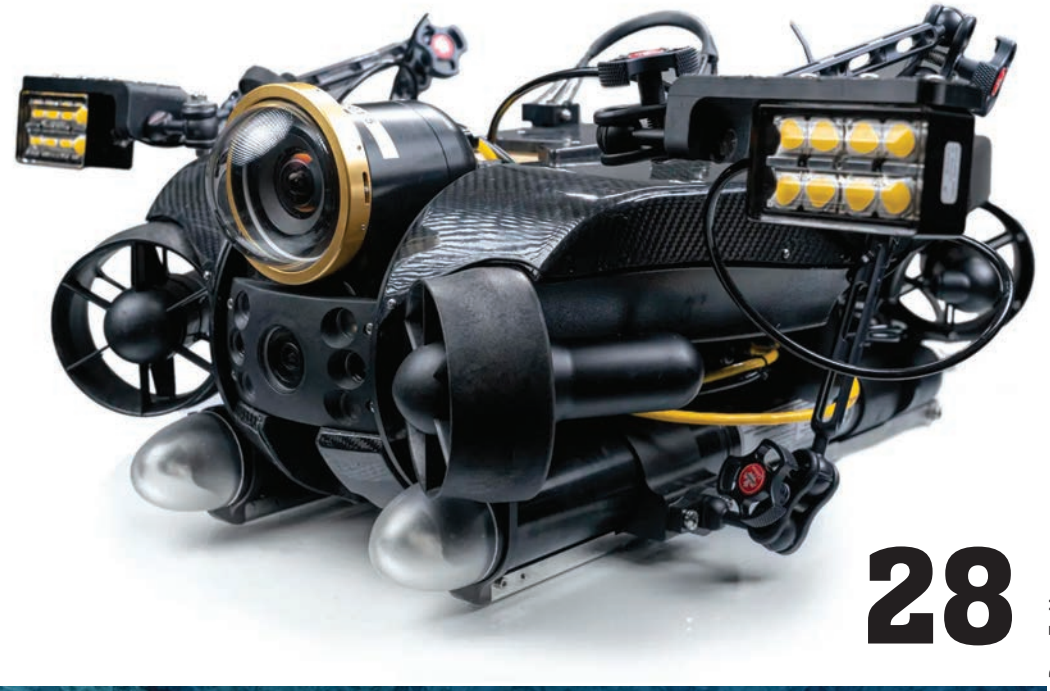

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Sunfish AUV

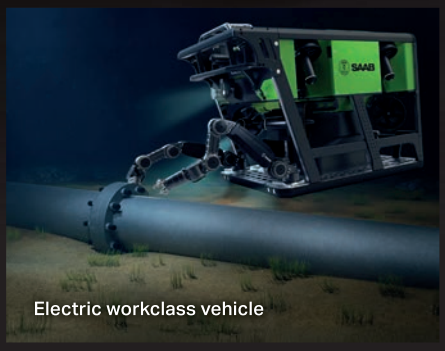
On the Cover

Greensea IQ's Bayonet family of tracked amphibious underwater ground vehicles (AUGVs). Image courtesy Greensea IQ

SAAB

Seaeye SR20

Empowering eco-responsibility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Editorial

Justin Zaure

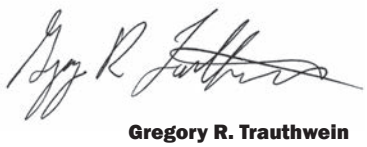
Subsea security. I know we've only completed 1/12th of the year to date, but if you're looking for two words that will define 2025, trust that those two words are '**subsea security**.'

As the world around us continues to spiral into a world of increasingly complex, escalated and connected geo-political conflicts, more than ever the value and vulnerability of subsea infrastructure comes to the fore, particularly for countries ringing the Baltic Sea. Asymetric threats – whether it take the form of swarms of relatively cheap, armed drones or the form of a commercial ship with an anchor and the intent to wreak havoc – will continue to drive innovation in the name of monitoring, identifying and thwarting these threats on and under the world's waterways.

This month, our subsea security expert **David Strachan** breaks down, starting on page 8, the implications of the U.S. Navy's early 2025 release of SBIR 25.1, which among several subsea warfare topics was one for a novel kind of unmanned underwater vehicle (UUV) – a maritime expeditionary response crawler, a specialized UUV designed to operate on the ocean floor using legs, tracks, or wheels. Specifically, the Navy is seeking a small, compact crawler weighing no more than 150 pounds that is capable of conducting sustained operations for six hours at depths of 600 meters or more, a push that underscores the Navy's increasing commitment to subsea and seabed warfare (SSW).

Next, **Alisa Rainer** writes at length on the world's growing reliance of subsea infrastructure – and the risks that grow in tandem – in her report *Securing the Deep: Business Opportunities in Subsea Defense,* starting on page 36.

The impact of increased defense spending is touching all sectors of subsea, and in our conversation with Kraken this month, COO **Nat Spencer** puts it neatly in perspective when discussing the company's SeaPower batteries: *"The defense sector is pushing the boundaries of what's possible. They're asking, 'How do we go further? How do we increase capability? How much energy can we fit into a given space?,"* particularly as the size and number of AUVs continue to rise.



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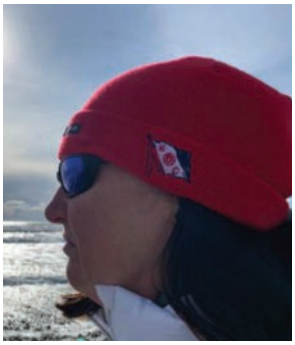
Moniz



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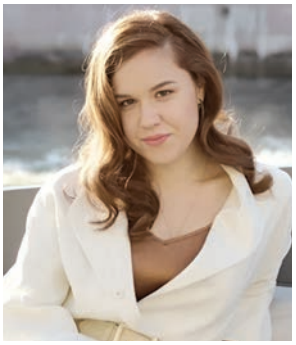

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Gallaudet

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Hardy

Kevin Hardy is President of Global Ocean Design, creating components and subsystems for unmanned vehicles, following a career at Scripps Institution of Oceanography/UCSD. He holds patents in the field of ocean landers. He is on the academic advisory board of Instituto Milenio de Oceanografía at the Universidad de Concepción, Chile. Hardy received an honorary Doctor of Science degree from Shanghai Ocean University in 2018. He proposed making thick wall glass spheres to Nautilus Marine Service/Vitrovex (Germany) that opened the hadal depths to routine exploration. He writes for the *Journal of Diving History* and the *MTR*.

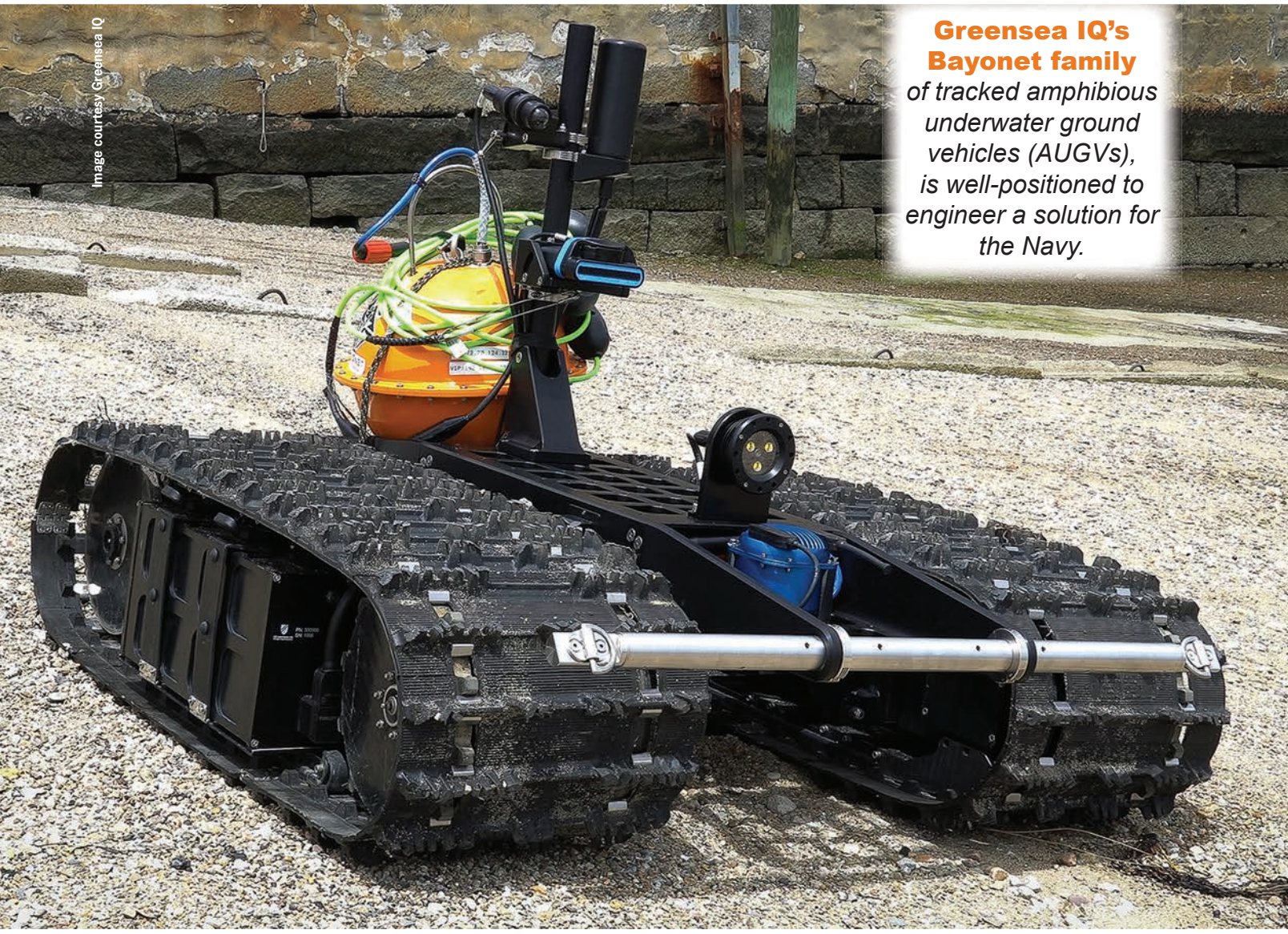


Image courtesy Greensea IQ

Greensea IQ's Bayonet family *of tracked amphibious underwater ground vehicles (AUGVs), is well-positioned to engineer a solution for the Navy.*

USN IS CALLING ALL CRAWLERS

By David Strachan, Strikepod Systems

On January 8, 2025, the U.S. Navy released SBIR 25.1, and among several subsea warfare topics was one for a novel kind of unmanned underwater vehicle (UUV) – a maritime expeditionary response crawler, a specialized UUV designed to operate on the ocean floor using legs, tracks, or wheels. Specifically, the Navy is seeking a small, compact crawler weighing no more than 150 pounds that is capable of conducting sustained operations for six hours at depths of 600 meters or more. The development and deployment of such a vehicle underscores the Navy's increasing commitment to subsea and seabed warfare (SSW), and to ensuring readiness for the range of threats and contingencies that could arise during future undersea conflict.

Crawlers bridge the gap between traditional UUVs and remotely operated vehicles (ROVs), and are ideal for tasks that require precision, stability, and sustained seabed operations, such as inspecting and maintaining underwater infrastructure, monitoring subsea ecosystems and environmental conditions, mapping and analyzing seabed mineral deposits, or assisting in site surveys for oil and gas exploration. In a defense role, they can be used in mine clearance, explosive ordnance disposal, payload delivery, and conducting surveillance of subsea infrastructure for threats or tampering.

The idea of underwater vehicles crawling along the ocean floor is perhaps unusual, but has been under development for nearly a century. During the waning days of World War II, German engineers developed Seeteufel, a prototype tracked amphibious midget submarine designed to launch and recover from the beach under its own power. During the Cold War, the U.S. Navy's nuclear-powered research submarine NR-1, equipped with a set of bottoming wheels, engaged in covert seabed surveillance, mapping, and object recovery missions, many of which remain classified to this day. And during the 1980s, Swedish intelligence uncovered evidence of tracked seabed vehicles operating within Swedish territorial waters. The origin of these tracks remains a mystery to this day, but it is widely suspected that they were left by innovative Soviet submersibles mapping critical infrastructure, gathering intelligence, and testing Swedish defenses. These early innovations laid the groundwork for the seabed crawlers of today, which leverage advances in marine robotics and underwater technologies to meet contemporary operational needs.

Moving into the unmanned era, ocean crawlers have been

subject to the usual challenges and limitations of operating in the undersea environment – communication, navigation, and endurance. As such, they have been largely limited to seabed operations in the coastal shallows and surf zone. But the Navy is now seeking a deep-water vehicle that can both crawl and swim. According to the SBIR solicitation, it must be capable of transiting on the surface to a preprogrammed waypoint for at least two nautical miles.

It should then be capable of autonomously submerging to the seabed and deploying a tethered buoy to be used by operators for semi-autonomous control.

This would enable standoff mine countermeasures in advance of an amphibious landing, possibly covert mine neutralization or render-safe operations which could provide invading forces with operational surprise and enable them to seize the initiative. Other missions could be possible too, such as prepositioning weapons, supplies, or even swarms of weaponized crawlers to provide suppressive fire in support of amphibious forces.

But while the solicitation suggests that expeditionary mine countermeasures (MCM) would be the primary mission for a Navy crawler, it is interesting that the vehicle must be capable of conducting operations at depths of over 600 meters, which is well beyond the maximum effective depth of bottom mines or moored contact mines. Deep water MCM could be on the vehicle's list of mission sets (moored rising and anti-submarine encapsulated torpedo mines can be deployed at such depths), but it is likely that the Navy may have an altogether different mission set in mind: offensive seabed warfare. Although conceivably the vehicle could be used to monitor and defend critical underwater infrastructure, it is more likely that the vehicle would be deployed at standoff range, sink to the seabed, deploy its buoy, and, via an RF communication link to human operators, employ manipulator arms to place explosives, tap or sever cables, or deploy surveillance sensors. The vehicle's compact size would enable it to be deployed via the stern ramp of a small special operations boat, such as the Naval Special Warfare Combatant Craft Medium (CCM), or even a small unmanned surface vehicle (USV) that has been modified to accommodate roll-on roll-off payloads. Alternatively, crawlers could be deployed at standoff range from the well deck of an amphibious ship, such as the San Antonio-class LPD, or from the moon pool of a Pathfinder-class (T-AGS) survey ship. Depending on its size and weight, it potentially could be man portable and deployed over the side of small craft as well.

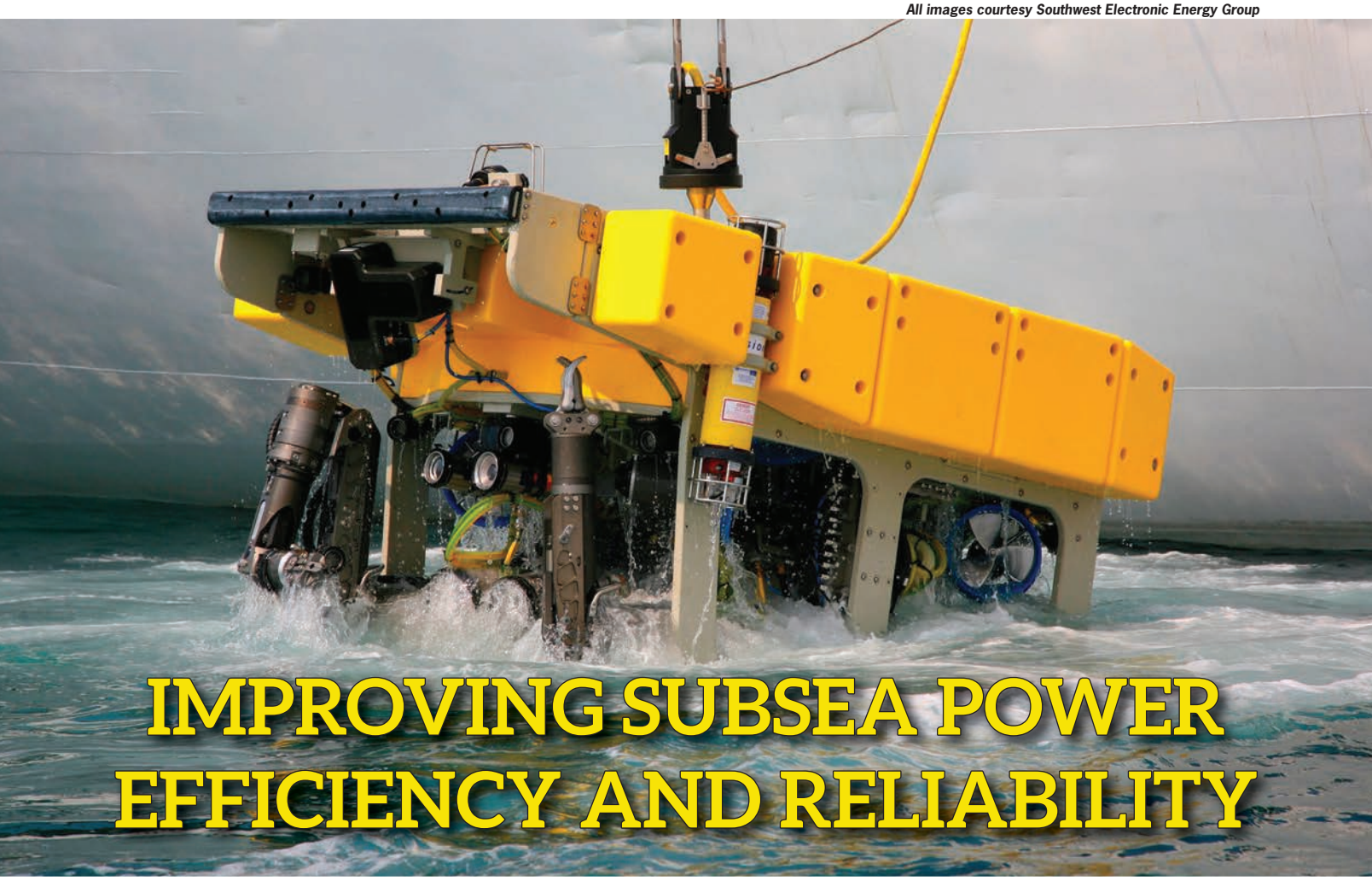
With a base weight limit of 150 pounds, and a payload limit of 100 pounds (including additional batteries), the vehicle will be limited in the quantity and types of sensors and effectors it can accommodate, and any additional payload weight will increase energy consumption, reducing both range and endurance. The six-hour operational window will also be a limiting factor, but this reflects the inherent constraints and specialized, task-oriented focus of seabed crawlers. Unlike UUVs operating in open water, crawlers must contend with drag and friction forces along the seabed, making energy management even more critical. The trade-offs between endurance, payload capacity, and mobility will be significant, though innovative buoyancy systems may help mitigate some of these challenges, as could emerging technologies such as AI-optimized energy management or seabed charging stations.

Although no current commercial-off-the-shelf products check all of the Navy's boxes, one subsea robotics company, Greensea IQ, maker of the Bayonet family of tracked amphibious underwater ground vehicles (AUGVs), could be well positioned to engineer a solution. Bayonets have an endurance of six hours, an operational depth of 100 meters, and can be remotely operated using a tethered RF buoy. They are also fully integrated with OPENSEA, Greensea IQ's open architecture software framework which is already used to drive a range of explosive ordnance disposal (EOD) and special operations forces (SOF) systems, including ROVs and diver navigation systems.

As the strategic and operational importance of the ocean floor continues to grow, seabed crawlers will have a role to play not only in monitoring and neutralizing threats, but in taking the subsea fight to the adversary. Whether supporting mine countermeasures, defending critical infrastructure, or engaging in offensive actions against adversary assets, these compact and versatile vehicles will be valuable tools in meeting the unique security challenges of the future subsea domain.

About the Author
David R. Strachan is a defense analyst and founder of Strikepod Systems, a research and strategic advisory focusing on autonomous undersea systems.

All images courtesy Southwest Electronic Energy Group



IMPROVING SUBSEA POWER EFFICIENCY AND RELIABILITY

How battery technology can complement umbilicals

Umbilicals are a lifeline for subsea systems, delivering power, communication, and hydraulic support to equipment operating in deep-sea environments. Essential for applications like oil and gas extraction and underwater robotics, these multi-functional cables ensure long-term connectivity in some of the world's most challenging conditions. However, their deployment brings significant challenges, including high costs and maintenance demands. Subsea batteries are emerging as a complementary solution, offering enhanced power efficiency and reduced reliance on traditional umbilical set-ups, explains Leon Adams, VP of Sales and Marketing at Southwest Electronic Energy Group, an Ultralife company.

Designed to ensure seamless operation in demanding underwater environments, umbilicals connect subsea infrastructure to surface vessel systems and onshore facilities. These robust cables power remotely operated vehicles (ROVs), transmit data for real-time monitoring, and supply hydraulic fluids and chemicals to control valves and actuators. This versatility makes them indispensable for critical subsea applications, from oil and gas extraction to deep-sea research.

One of the key characteristics of umbilicals is their reliability. They are designed to endure extreme underwater conditions and provide consistent power and communication at great depths. They can transmit energy over long distances, making them ideal for projects far from shore or centralized power sources.

However, as projects move deeper and into more remote waters, the length and size of umbilicals required to meet power and communication demands increases exponentially — as do operational costs.

The Challenge of Umbilicals

Despite their strengths, umbilicals have limitations, which can bring significant challenges to subsea applications. The cost of materials, installation, and ongoing maintenance is a significant barrier, especially for projects operating in remote or ultra-deep waters. Deploying these heavy cables requires specialised vessels and equipment, increasing the project's expense.

Meanwhile, the harsh underwater environment — including high pressure, corrosive saltwater, and fluctuating temperatures — can cause wear and tear, increasing the likelihood of equipment failing. Additionally, umbilicals often lack the flexibility needed for dynamic or modular systems, limiting their suitability for autonomous, deeper, or more remote operations.

In oilfield operations, umbilicals must deliver hydraulic fluids, chemicals, and power to equipment stretched across vast underwater landscapes. During these projects, umbilicals can be vulnerable to clogs or conductor breaks and power limitations, particularly when handling significant movement stress or peak electrical demands. Also, as umbilicals get longer for deeper or more remote locations, since electrical resistance increases proportional to the length of a conductor, the gauge thickness of the power conductors in the longer umbilicals must increase to compensate for the increased length and deliver the same power to the endpoint of the longer umbilical. This makes the entire umbilical thicker, heavier, more expensive, and harder for operations to handle.

Introducing Subsea Batteries

Although batteries cannot replace umbilicals entirely, they can support local subsea power supply and transmission. For

ULT186 -
Subsea batteries ready for testing

electrical power, umbilicals act as an extension cord, requiring a constant connection to an above-water power source. However, subsea batteries can provide an autonomous and local energy supply in the deep subsea. They reduce the need for longer and heavier umbilicals, cutting costs associated with materials, installation, and maintenance. Batteries are also configuration-flexible; modular designs of different sizes and capacities meet the evolving operational needs of remote monitoring, subsea robotics, and other applications.

Batteries can also act as a fail-safe power source during umbilical failures, ensuring uninterrupted operations. For autonomous underwater vehicles (AUVs), batteries enable untethered capability, allowing them to operate independently. Unlike umbilicals, where costs increase exponentially with depth, pressure-tolerant subsea battery power costs remain constant, making batteries a more economical option for deep-sea applications. Advanced technologies like the Sea-Safe® subsea battery modules, which are pressure-tolerant to depths of 6,000 meters, exemplify this capability.

Combining the Two

Umbilicals and batteries both play important roles, so combining the two can optimize energy management in subsea applications. Subsea batteries provide localized power to remote systems, reducing dependency on long umbilicals. Serving as a supplementary power source, subsea batteries can also enhance system reliability, ensuring seamless operations in isolated or unmanned environments.

Hybrid systems that combine the strengths of umbilicals and batteries can benefit from optimal energy performance and efficiency. Batteries can take on peak demand scenarios, al-

leviating strain on umbilicals, and act as backup power, ensuring consistent power delivery. This redundancy is crucial in mission-critical applications like oil and gas extraction or environmental monitoring. Together, these technologies deliver cost savings, improved efficiency, and enhanced system reliability. In the case of ROVs, batteries can eliminate the need for larger umbilicals for deeper deployment, since an existing umbilical gauge can charge onboard batteries without needing a burst of energy. Then, the onboard batteries handle the dynamic power bursts needed by the ROV actuators or thrusters.

Getting it Right

Specialist subsea battery manufacturers like Southwest Electronic Energy (SWE) can provide comprehensive battery sizing and cost estimates tailored to the depth and power requirements of subsea operations. This process begins with an assessment of the voltage levels, power load profiles, and duration needed to operate the subsea equipment. Based on this analysis, SWE can provide a clear breakdown of the costs for the required battery system.

For brownfield sites where existing umbilical infrastructure is already in use, it is important not to overtax the current system when expanding operations. In these cases, it is recommended to support the system with batteries capable of handling the additional power during peak demand periods. Then, the batteries can be charged via. the existing umbilical using low-power supply during nominal demand periods to avoid straining the system. The gradual charging process enables the battery to store energy over time, ensuring it is ready to deliver high-power output when needed.

The specific requirements for a battery-umbilical system depend on the application. For example, subsea activities involving chemical dispersal may require enhanced energy storage to support consistent and controlled outputs. Additionally, any changes to the infrastructure — such as adding new equipment or modifying existing systems — must be factored into the overall design and cost. While these considerations can add complexity, they ensure the solution is robust and fit-for-purpose.

Subsea batteries can transform how we power underwater equipment by introducing flexibility, modularity, efficiency, and reliability across various subsea applications. While they cannot replace umbilicals entirely, they are indispensable, addressing many of the challenges associated with traditional systems, especially as subsea operations expand in distance, depth, or autonomy.

DECLINING ANTARCTIC SEA ICE GENERATING MORE OCEAN HEAT LOSS, STORMS

Courtesy Dr. Andrew Meijers

Declining Antarctic sea ice cover is generating unprecedented ocean heat loss to the atmosphere and more storms, according to a new study led by the UK's National Oceanography Center (NOC).

The study, published in the journal Nature, focused on the record low Antarctic winter sea ice cover in 2023 and provides the first clear picture of the impacts of the disappearing sea ice.

Using data from the atmospheric layer just above the ocean surface, it found a doubling of heat loss to the atmosphere, matched by higher numbers of storms around much of the high latitude Southern Ocean.

The study also warns of potentially far-reaching impacts on the deeper ocean circulation, due to the heat loss making Antarctic surface waters denser than previously seen.

Lead author Professor Simon Josey says the results point to an urgent need to use state-of-the-art ocean and climate simulations, such as those currently undertaken by NOC, to better understand the broader impacts of Antarctic sea ice loss, which could ultimately extend to the Northern Hemisphere.

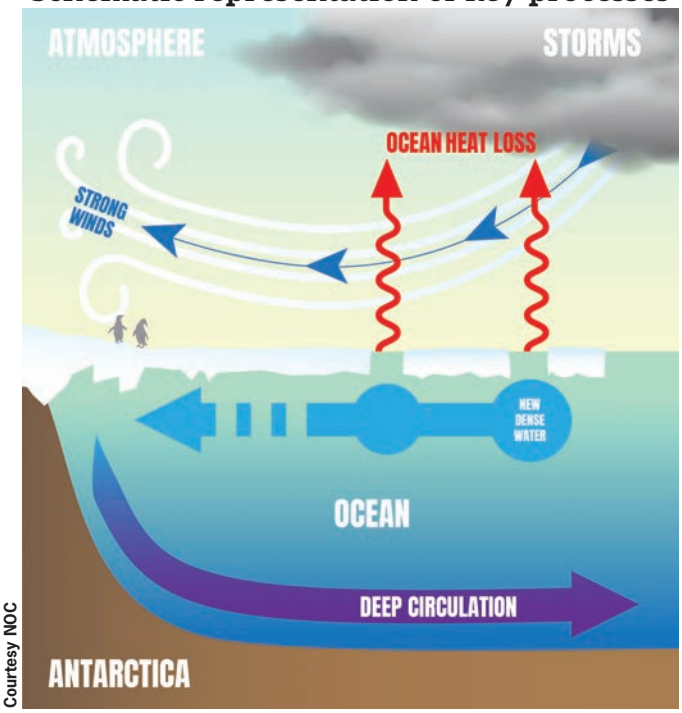
"It is too early to state whether 2023 and it's record-breaking sea-ice decline marks the onset of a fundamental shift in the amount of Antarctic sea ice," says Professor Josey, an expert on ocean-atmosphere interaction at NOC, which is a leader in ocean and climate research.

"However, our study does reveal the extreme conditions to be expected in future years of low ice regrowth, with 2024 looking like it is continuing the sharp change seen in 2023."

"Based on our study, years of low sea ice like this will continue to have more storms and greater changes to ocean properties that could impact the wider ocean circulation. Repeated low ice cover conditions in subsequent winters will strengthen these impacts and may result in profound changes further afield, including the Tropics and Northern Hemisphere."

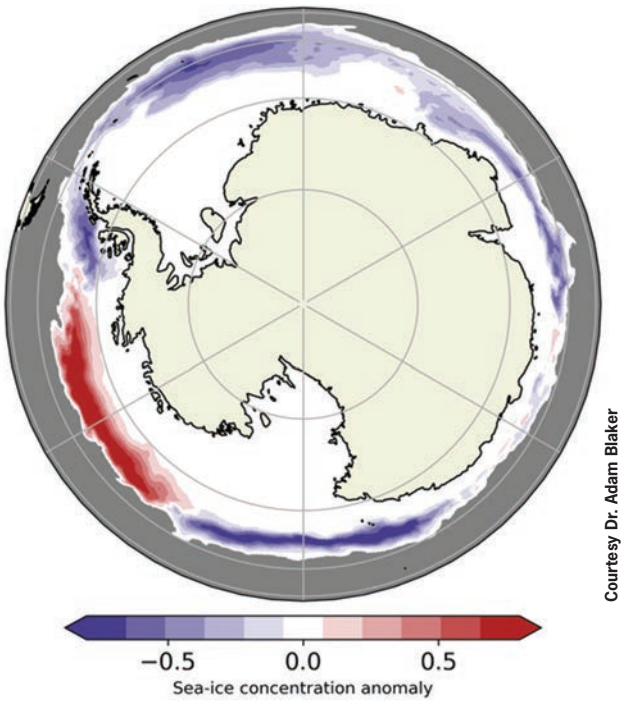
Sea ice cover provides a winter blanket over the high latitude Southern Ocean, which stops it from cooling through exposure to the atmosphere. With the blanket removed, heat is lost into

Schematic representation of key processes



Courtesy NOC

Declining Antarctic Sea-ice from the NOC Near Present Day NEMO ocean model simulation. Colors show the difference of June to July 2023 from June to July 1991-2020, blue shows less ice around much of Antarctica.



Courtesy Dr. Adam Blaker

the atmosphere and surface waters become cooler and denser.

Sea ice cover around Antarctica hit a record low in 2023, with ice reductions in strong loss regions 50 to 80 % below the 1991 to 2020 winter average. Ocean heat loss to the atmosphere at some locations has more than doubled and an increase in storms has been observed around much of the high latitude Southern Ocean by up to seven days a month.

Previous analysis of the long-term impacts of declining Antarctic sea ice by co-author Dr Holly Ayres, formerly at the University of Reading and now at NOC, shows that enhanced ocean heat loss can also affect the climate as far away as the Tropics and the Northern Hemisphere.

She says, "My work analyzed a climate model experiment where the amount of ice was artificially reduced. However, I didn't expect to see a real-world ice decline as large as that observed in 2023 with such strong consequences for the ocean heat loss."

The study also found that the disappearing sea ice is allowing the ocean surface waters to change their properties particularly density. Professor Josey notes, "The massive increase in ocean heat loss to the atmosphere is increasing the density of water at the sea surface to values not previously seen in the newly ice-free regions."

Co-author Dr. Andrew Meijers, from the British Antarctic Survey, explains further, "The location of this new denser surface water is relatively far from the sites at the Antarctic shelf where the densest and deepest waters of the global ocean are formed.

"However, this cooling and subsequent sinking of waters previously covered by sea ice has the potential to release deeper warm waters that would normally be kept away from ice by an insulating surface layer. In turn this has the potential for increasing sea ice melt in future years".

"Further analysis is urgently needed to understand these processes and their complex feedbacks, and determine how the massive decline of winter sea ice in 2023, and again this year, will impact the Southern Ocean circulation. This is key to understanding the climatically critical ocean uptake of atmospheric heat and carbon, and the rate of melt of the Antarctic continent."

"We now need a more detailed understanding of the strengthening ocean heat loss in the regions of declining Antarctic sea ice and its wider impacts," adds Professor Josey.

"This is vital to understand how the increased number of storms are linked to the extra heat supply into the atmosphere and for determining long term societal risks, including potential changes to weather conditions in the decades ahead in locations far removed from Antarctica."

"Critically, we need to use our ocean and climate simulations to understand how the major increase in heat loss and increased surface water density impacts the wider ocean circulation."

Read the full article in Nature:
https://www.nature.com/articles/s41586-024-08368-y

U.S. Dredging Outlook 2025

Courtesy Curtin Maritime

The U.S. dredging industry's future is bright, with more than $3B invested in a fleet of new vessels and capabilities and a new Administration that is pro-business, pro-industry and pro-America. A long list of major port deepening projects, in step with routine maintenance dredging and the provision of new buffers against larger, more frequent storms, promises to keep this U.S. dredging industry gainfully employed for years to come. ***Bill Doyle, CEO of Dredging Contractors of America (DCA),*** *offers insights on what's to come in 2025 and beyond.*

By Greg Trauthwein

In the midst of 2022, the U.S. dredging business in a Covid-induced tailspin, premised on the Army Corps of Engineer's inability to get the normal load of jobs out to private industry, a situation that lasted into the start of 2023.

"The rebound started in May of 2023 and has run all the way through 2024," said Bill Doyle, CEO, DCA, a rebound driven by government work as well as energy companies that privately own their terminals and docks "and wanted to attach it to a federal channel."

By all accounts, it appears the good times in U.S. dredging are poised to continue, driven by major ports demands to deepen navigation channels (most notably in New York/New Jersey, which recently unveiled its 50-year plan; as well as the Port of Wilmington; Port of Corpus Christie; Port of Baltimore and Louisiana, too) to handle increasingly large ships, as well as the never-ending balance of maintenance dredging in the name of safe navigation, and last but certainly not least, the coastal restoration and beach nourishment that is helping to fortify the security of some of the country's largest cities in the face of rising tides.

THE FLEET

When 'innovative, emission-efficient maritime tonnage' is the topic, dredgers more than likely are not an industry executive's first thought. If true, that's all changing now, as the industry cumulatively has delivered and continues to order high-tech, low-emission dredgers of all varieties to join the fleet.

"We're always seeing the dredge industry improve and innovate – that's part of the competition between the this heavily saturated market in the United States," says Doyle, adding, "A relatively new entrant, Curtin Maritime, has really taken off in the clamshell market over the past five years."

Martin Curtin, the founder of Curtin Maritime, literally came up from the deck plates, working on tugboats, then owning them, then expanding to the point of building and repairing his own. Along the way, Curtin has taken clamshell dredges to the next level, as shown by the clamshell dredge DB Avalon built in 2022: a hybrid-powered dredge vessel and is considered the lowest carbon footprint clamshell dredge of its class, outfitted with energy-efficient Tier 4 QSK60 Cummins generators. Avalon's hybrid power source allows for generators two-thirds the size of a conventional dredge vessel, reducing CO2 emissions by 30%, using a proven Selective Catalytic Reduction (SCT) technology with a flow-through exhaust after-treatment system, using diesel exhaust fluid (DEF), to deliver ultra-low emissions.

In addition, four banks of 20 battery modules each, are controlled by the latest software that optimizes charge and discharge cycles by harnessing regenerative power from normal digging operations and re-charging the batteries, further reducing fuel consumption and greenhouse gas emissions. The DB Avalon has taken on multiple dredging projects in the Houston Ship Channel, San Juan Harbor in Puerto Rico and is now working in the Chesapeake Bay on the Baltimore approach channels.

Looking at the industry wholistically, the U.S. dredging industry is in the midst of a $3 billion recapitalization with a focus on enhancing the capacity and efficiency of the fleet to meet the growing demands of federal and private sector projects.

"I think the order level is appropriate," said Doyle, noting that "I'm the guy that has to manage competitors! DCA is an organization of companies that fiercely compete with each other." More modern, cable dredgers on the market mean

"With President Trump coming in, we're excited: *He's pro-business, he's pro-industrial, he's pro-Build American. If you look at [U.S.] dredging and the Jones Act industry; it's American-owned, American-built, with American citizens onboard those ships. So we fit right into what [President Trump is] trying to do."*

– Bill Doyle, CEO, DCA,
on the incoming Trump Administration

Courtesy DCA

Watch the full interview with Bill Doyle, CEO, Dredging Contractors of America, including his insights on:

- European efforts to break through the Jones Act dredging market; and
- The impact of larger, more powerful and destructive storms on the dredging industry.

more competition, so this small fraternity of tight knit yet competitive forces must keep an eye on the overall ball to ensure the balance between dredgers working and dredgers under construction maintain some sort of balance, regardless if it's a cutterhead suction dredge, a hopper dredge or a clamshell dredge.

"What we're going to see somewhere in the first or second quarter is the largest hopper dredge ever built in the United States. It's coming online," said Doyle. "That's the Frederick Paup by Manson Construction being built down in Brownsville, Texas. They're going through the dock trials right now, and it's a beautiful ship, a 15,000-cu. yd. vessel that will be able to do some beach work like you've never seen before."

POLITICAL WILL

As of this writing, January 20, 2005 – the U.S. Inauguration Day – was drawing closer, with President Donald Trumps administration set to re-enter the White House. Politics and political will have a direct impact on many if not all industries, and dredging is no exception.

"We're excited about the Trump administration coming in," said Doyle. "All of my dredgers, all of them, see this as: 'we've got a president coming in that is not anti-Jones Act, plus he has made statements that he wants a robust shipbuilding industry."

In addition, the Trump Administration will be aided by a Republican Congress.

"You've got Mike Johnson (R-LA) as the Speaker of the House, and that's huge. The folks in Louisiana, Mississippi and Texas live and die by dredging. They need dredging. They understand dredging. They understand the shipbuilding industry. So it's a big help for us to know what's coming, to know we're going to be supported."

Doyle said the industry, in turn, must uphold its end of the bargain and maintain an efficient, effective and competitive industry, noting that last year alone the Army Corps of Engineers awarded contracts to 56 different companies, helping to keep prices lower and competition high.

"With President Trump coming in, we're excited," said Doyle. "We know that we have to do our work with him to keep our issues at the forefront and to show the positive story of dredging and the Jones Act. He's pro-business, he's pro-industrial, he's pro-Build American. If you look at [U.S.] dredging and the Jones Act industry, it's American-owned, American-built, with American citizens onboard those ships. So we fit right into what [President Trump is] trying to do."

Order Book: Jones Act Dredging Private Fleet $3Billion and Growing

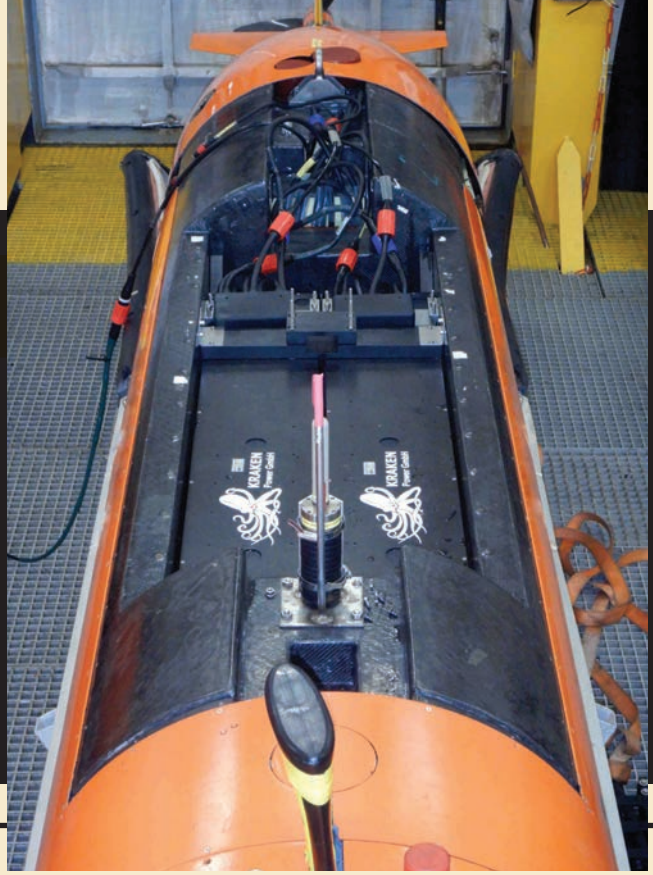
Company	Dredge Name	Dredge Type	Capacity	Shipyard	Status
Manson Construction	Frederick Paup	Hopper	15,000 CY	Keppel AmFELS (TX)	Expected delivery (2024)
Cashman Dredging	Mighty Quinn	Hopper (T & B)	4,000 CY	Feeney's Shipyard (NY)	In service (April 2023)
Great Lakes Dredge & Dock	Amelia Island	Hopper	6,500 CY	Conrad (LA)	Expected delivery (2025)
Great Lakes Dredge & Dock	Galveston Island	Hopper	6,500 CY	Conrad (LA)	Delivered/In service (2024)
Weeks Marine	RB Weeks	Hopper	8,550 CY	Eastern (FL)	In service (May 2023)
Callan Marine	General Bradley	Cutter Suction	28-inch	Halimar (LA)	In service (April 2022)
Callan Marine	General Arnold	Cutter Suction	32-inch	C&C (LA)	Delivered/In service (2024)
Callan Marine	General Marshall	Cutter Suction	18-inch	DSC (LA)	In service (April 2023)
The Dutra Group	ES-15	Split Hull Dump Scow	6,000 CY	Corn Island (IN)	In service (2019)
The Dutra Group	MS-16	Split Hull Dump Scow	6,000 CY	Portland (OR)	In service (2022)
The Dutra Group	CB Harry S	Liebherr 8300.2 Clamshell	35 CY Cable Arm	Conrad Amelia (LA)	In service (2022)
The Dutra Group	TBD	Hopper	10,464 CY	TBD (USA)	In final development
Orion Group	Lavaca	Cutter Suction	20-inch	Southwest Shipyard, TX	In service 2022
Callan Marine	Admiral Nimitz	Hopper	16,000 CY	TBD	Construction Tender released (June 2022)
Muddy Water Dredging, LP	Vaneta Marie	Cutter Suction	24-inch	DSC, Reserve, Louisiana	In service (April 2024)
Mike Hooks	Lorraine Hooks	Cutter Suction	27-inch	Mobile Pulley Works (AL)	n service (June 2023)
Curtin Maritime	TBD	Clam/Crane Barge/Scow		Lad Services /Corn Island	Delivery Expected (Q4 2024)
Curtin Maritime	DB Avalon	Clamshell	HL 242,000 lbs.	Curtin	In service (2022)
Curtin Maritime	Crown Point	Dump Scow	6,000 CY	Gunderson (Portland, OR)	In service (2022)
Curtin Maritime	Inspiration Point	Dump Scow	6,000 CY	Gunderson (Portland, OR)	In service (2022)
Curtin Maritime	Sand Point	Dump Scow	6,000 Y	Gunderson (Portland, OR)	In service (2022)
Marinex Construction	Wadmalaw	Cutter Suction	30-inch	Detyens Ship Yard (SC)	Nex service (2021)
Cashman Dredging	TBD	Split Hull Dump Scow	7,500 CY	TBD	Expected delivery (2025)
Callan Marine	Gen. MacArthur	Cutter Suction	32-inch	C&C (LA)	In service (2020)
Weeks Marine	JS Chatry	Cutter Suction	30-inch	C&C (LA)	In service (2019)
Great Lakes Dredge & Dock	Ellis Island	Hopper	14,800 C	Eastern (FL)	In service (2018)
Weeks Marine	Magdalen	Hopper	8,500 CY	Eastern (FL)	In service (2018)
Manson Construction	Robert M. White	Cutter Suction	30-inch	Halimar (LA)	In service (2018)

*C&C Shipyard is currently building two 28" Cutter Suction Dredges (CSD) on spec for sale or lease
** Industry has made additional capital investments in cranes, tugs, barges, scows, tender boats, survey vessels, boosters, pipeline, pontoons, etc.

Courtesy DCA

Powering UUVs

In the fast-evolving world of marine technology, **battery innovation** *plays a crucial role in advancing underwater vehicles and offshore operations. At the forefront of this transformation is Kraken, a company that has rapidly expanded its presence in subsea technology. To gain insight into Kraken's journey and breakthroughs in battery technology, we spoke with* **Nat Spencer, COO, Kraken**.



Courtesy Kraken

For Nat Spencer, the path to Kraken wasn't a conventional one. His career began in law before pivoting into business and ultimately leading him into the marine and energy sectors. "I've had a bit of a varied journey," he shares. "I started out as a lawyer, worked in oil and gas services, then moved to Oceaneering, where I focused on business development and corporate growth, particularly in renewable energy."

His transition into Kraken came through PanGeo Subsea, a company specializing in subsea survey services, which Kraken acquired in 2021. "Initially, I joined PanGeo to help expand into the U.S. market, leveraging my experience in renewables. Over time, I moved into operations, overseeing the services business. When Kraken acquired PanGeo, I took on an even larger role, eventually becoming COO in 2023."

Today, Spencer oversees Kraken's multiple business lines, which include sonar systems, software-as-a-service (SaaS) solutions, batteries, and offshore survey services. "We've grown tremendously," he says. "We've expanded from around 80 employees to 300 and are continuing to scale. Our operations span 20 countries, with key offices in Newfoundland, Halifax, Aberdeen, Bremen, and Rio, along with production facilities in Germany and Newfoundland."

The Evolution of SeaPower Batteries

One of Kraken's fastest-growing divisions is its SeaPower battery line, which has been making waves in the defense and commercial sectors. According to Spencer, the market for underwater battery technology has fundamentally shifted. "For years, the industry wasn't producing enough batteries at scale to expose and address technical challenges. Companies would manufacture small batches—maybe 15 or 20 batteries a year—but that has changed drastically."

Now, Kraken is fulfilling orders in the hundreds. "The scale has grown immensely. What used to be an exciting 20-battery order has now turned into requests for 200, 300, or even 400 units at a time."

The secret to Kraken's battery success lies in its pressure-tolerant technology. Unlike traditional subsea batteries, which rely on heavy pressure housings, Kraken's batteries use silicone encapsulation that allows them to withstand deep-sea pressures without additional protective casings. "The result is a significantly lighter, more energy-dense battery," Spencer explains. "Compared to competitors, our batteries offer 20% to 50% greater energy efficiency, depending on the application."

This increased energy density translates into two key advantages:

- Extended Range – Underwater vehicles (UUVs and AUVs) can travel further distances without needing to recharge.
- Higher Power Capability – Operators can run more sensors and instruments simultaneously without sacrificing battery life.

Spencer sums it up simply: "If you want your vehicle to travel an extra 1,000 kilometers or operate multiple sensors at once, our batteries make that possible without compromising performance."

"The scale has grown immensely. What used to be an exciting 20-battery order has now turned into requests for 200, 300, or even 400 units at a time."

Nat Spencer, COO, Kraken

Courtesy Kraken

Why Kraken's Batteries Stand Out

So, what makes SeaPower batteries the choice for UUV applications? Spencer is clear: "It all comes down to energy density. We are 20% to 46% more effective than our competitors in storing and delivering power. That's the primary reason customers choose us."

The compact size of Kraken's batteries also provides a critical edge. "In any underwater vehicle, space is at a premium. Our batteries are either the same size or smaller than traditional models, but they hold significantly more power," Spencer explains. "They're also lighter because they don't require oil compensation or extra pressure housing. This results in a three-fold advantage: more power, smaller size, and reduced weight."

For subsea operators, this means vehicles can stay underwater longer, carry more advanced payloads, and reduce operational costs.

Defense and the Future of Battery R&D

While Kraken's technology has broad applications, Spencer acknowledges that military and defense markets are the primary drivers of innovation in subsea battery technology. "The defense sector is pushing the boundaries of what's possible," he says. "They're asking, 'How do we go further? How do we increase capability? How much energy can we fit into a given space?'"

This demand has also led to a rapid increase in vehicle size. "We used to think of commercial AUVs as large when they were 30 feet long," Spencer notes. "Now, the next-generation underwater vehicles are the size of a city bus."

With these advancements, Kraken is focusing its R&D on three major areas:

- **Increasing Energy Storage** – Packing even more power into confined spaces.
- **Enhancing On-Vehicle Processing** – Allowing UUVs to process and analyze data before transmitting it back to operators.
- **Advancing Offshore Recharging** – Developing ways for vehicles to refuel at sea, extending missions indefinitely.

"Many of these ideas weren't considered necessary in the commercial market until now," Spencer admits. "But with larger, more powerful AUVs hitting the water, maximizing battery performance is more critical than ever."

The Road Ahead for Kraken

As Kraken continues to expand, Spencer remains focused on balancing innovation with operational efficiency. "We're proud of our pragmatic approach—we work closely with our clients to understand their needs and develop practical, high-performance solutions."

Looking ahead, Kraken is set to scale even further, with increased production and a growing global footprint. "As subsea operations become more complex, the demand for high-efficiency, high-capacity batteries will only increase," Spencer predicts. "We're excited to be leading that charge."

From its early days as a niche battery supplier to its current status as a key player in subsea power solutions, Kraken is proving that the future of underwater technology is all about going further, lasting longer, and performing better—one powerful battery at a time.

Nuclear Submarine NR-1

Life is Actually Like This.

Courtesy U.S. Army/Released

Discussing the possibilities of nuclear propulsion in the maritime sector at a holiday cocktail party, this author 'struck the mother lode' of insight and historical perspective.

By Rik van Hemmen

Nuclear energy, and, particularly for me, nuclear ship propulsion, continues to be a tantalizing solution to CO2 reduction.

We know nuclear energy works, but from that point on there appear to be more questions than answers. The questions range from economic viability to waste disposal concerns. I am not a nuclear engineer, but in general engineering systems terms, I have followed nuclear power for decades. That is not hard to do, since the pace of nuclear innovation has been slow to say the least. In essence, I only have to wake up every decade or so, take a quick look, and go back to sleep.

That is broadly true, but in the details it is not. For example, I will admit that nuclear waste hype hoodwinked me, and I worried about that until we became involved in a nuclear plant decommissioning a few years ago. There I discovered that the plant's nuclear waste was peacefully sitting in what was essentially a swimming pool, just waiting for it to be sufficiently decayed for storage in low level waste disposal like Yucca mountain (or reprocessed, but that is yet another confusing story).

Yucca mountain got covered in misinformation and did not happen. Overall, costs went through the roof, and nuclear power became a red headed stepchild.

And whenever nuclear power was discussed, the discussion focused on the worst examples (and I will admit there are some really bad examples of past errors in the development of nuclear power). This means that nuclear power is considered to be too manpower intensive, too expensive to operate, has too many security concerns and is inherently unsafe.

The last time I woke up to get an update on nuclear power I discovered that there are real and realistic efforts to finally move nuclear power to a more realistic, safe, secure and economic position. And quite frankly, the new reactor designs really look attractive from a ship propulsion point of view.

But when the discussion turns to ship propulsion, inevitably the inefficiency of the NS Savannah, or the high security needs of US Navy vessels is raised.

It is important to rely on past experience to figure out how to solve problems, but I am suggesting that we are looking at the wrong examples and I want to add another example to the general discussion. This example, the NR-1 submersible, has intrigued me for decades. The vessel was designed and constructed through Admiral Rickover's political machinations and launched in 1969. She served longer than Admiral Rickover and was not decommissioned and scrapped until 2008.

The NR-1 was actually more correctly a small US Navy nuclear submarine than a submersible. She displaced about 400 tons, was about 150 feet long with a pressure hull less than 12 feet in diameter and a crew of about 11.

It had a mini version of the classic US Navy pressurized water reactor, but it only ran a turbo generator. The entire vessel was electric drive and she had tons of neat gadgets that were used for her still often classified activities.

She could operate independently for weeks, and dive much deeper than US Navy subs.

There is very little detailed literature available on her design and that is a shame.

With shipboard nuclear we often think in terms of very big and fancy, but NR-1 has proven that nuclear can work quite well on a small scale too. I am not advocating that all vessels down to 150 feet in length should be nuclear, but if big works, and small works; intermediate will work too.

What, to me, was most striking is that the NR-1 was a 24/7 vessel that had such a tiny crew. No doubt the crew was ultra qualified, but with three watches there could be no more than one reactor engineer per watch. There is very little public information on the NR-1 and I always felt I had insufficient information to advance the argument that small nuclear is beautiful, and I never could put my finger on more specific information.

At our last holiday reception, I was in the middle of a nuclear power discussion with a small group of fellow engineers, and raised the subject of the NR-1 when a person in an adjacent social circle turned around.

It was Alan Weigel, a long-time friend and client, known to me as an ex-nuclear submariner, but presently an admiralty attorney.

And here was a genuine Annie Hall, Marshall McLuhan moment. I am referring to the great scene in the movie where Woodie Allen ends the scene by breaking the fourth wall and saying: "If only life were like this."

Well friends, life sometimes is like this. Alan said: "NR-1? I sailed on the NR-1."

Thanks to food and drink with friends, and the arrogance of raising half developed arguments among engineers, I had struck the mother lode.

Alan gave us the full dope on the NR-1 and confirmed that nuclear propulsion does not have to be fancy. If well designed, it is simply another propulsion mode. The NR-1 was an amazing vessel, but its nuclear propulsion was simply another piece in a well designed whole. And its design was very much a minimalist design, not the just the propulsion/power plant; also its accommodations, which were truly minimal. Although even there Alan noted that the microwave chicken nuggets were excellent.

Based on his input, the discussion shifted from: "well maybe it won't work" to what new reactor designs are being worked on to make commercial nuclear propulsion finally a reality. It was a microcosm of the conversation that needs to take place at the national, and even international, level.

A few months ago, I was aboard the NS Savannah and took a picture of the bar. Now I am wondering if nuclear propulsion would have advanced much faster if that bar had continued to operate. Never underestimate the power of random technical conversations in "proper" social settings.

'STANDING WATCH' IN OFFSHORE WIND FARMS WITH AUVS, AI

DFKI

The AUV DeepLeng navigates autonomously in a frozen lake during field tests in Sweden.

Sustainable monitoring of the marine environment is crucial for the environmentally responsible operation of offshore wind farms and the protection of biodiversity. In the SeaMe project, RWE is collaborating with leading research partners to develop innovative technologies for comprehensive ecosystem monitoring. The goal is to replace costly, invasive, and CO2-intensive methods. The German Research Center for Artificial Intelligence (DFKI) is contributing by equipping an autonomous underwater vehicle with oceanographic sensors and artificial intelligence technologies to enable safe navigation and precise data collection.

With the SeaMe project (Sustainable Ecosystem Approach in Monitoring the Marine Environment), RWE aims to gain a comprehensive understanding of the interactions between offshore wind farms and the local ecosystem. To this end, a sound scientific approach is combined with innovative and more environmentally friendly monitoring technologies based on Artificial Intelligence (AI). Using aerial drones, autonomous underwater vehicles and environmental DNA analysis, the goal is to develop sustainable methods that reduce CO2 emissions while minimizing the impact on marine life.

The simultaneous collection of physical and biological data allows for a comprehensive assessment of the marine ecosystem. This includes often overlooked components such as phytoplankton (microscopic algae) and zooplankton (e.g. krill), which play a crucial role in the marine food chain.

Developing AUV DeepLeng

In SeaMe, the DFKI Robotics Innovation Center is further developing the autonomous underwater vehicle (AUV) "DeepLeng" to optimize it for monitoring offshore environments. To achieve this, the researchers in Bremen are equipping the AUV with a multimodal oceanographic sensor system capable of precisely measuring physical parameters such as water temperature, salinity, and oxygen content. These data are essential for sound ecological analyses, providing valuable insights into the living conditions within the waters of wind farms.

In addition, researchers are developing an AI-based video monitoring system that will enable the AUV to detect fish and marine mammals. This technology uses machine learning and image processing, allowing the robot to continuously improve its ability to identify marine life. AI-based image analysis aims to replace invasive and CO2-intensive methods such as trawling, and provide accurate, continuous in-situ monitoring of marine life without disturbing their habitats.

Enhancing Capabilities

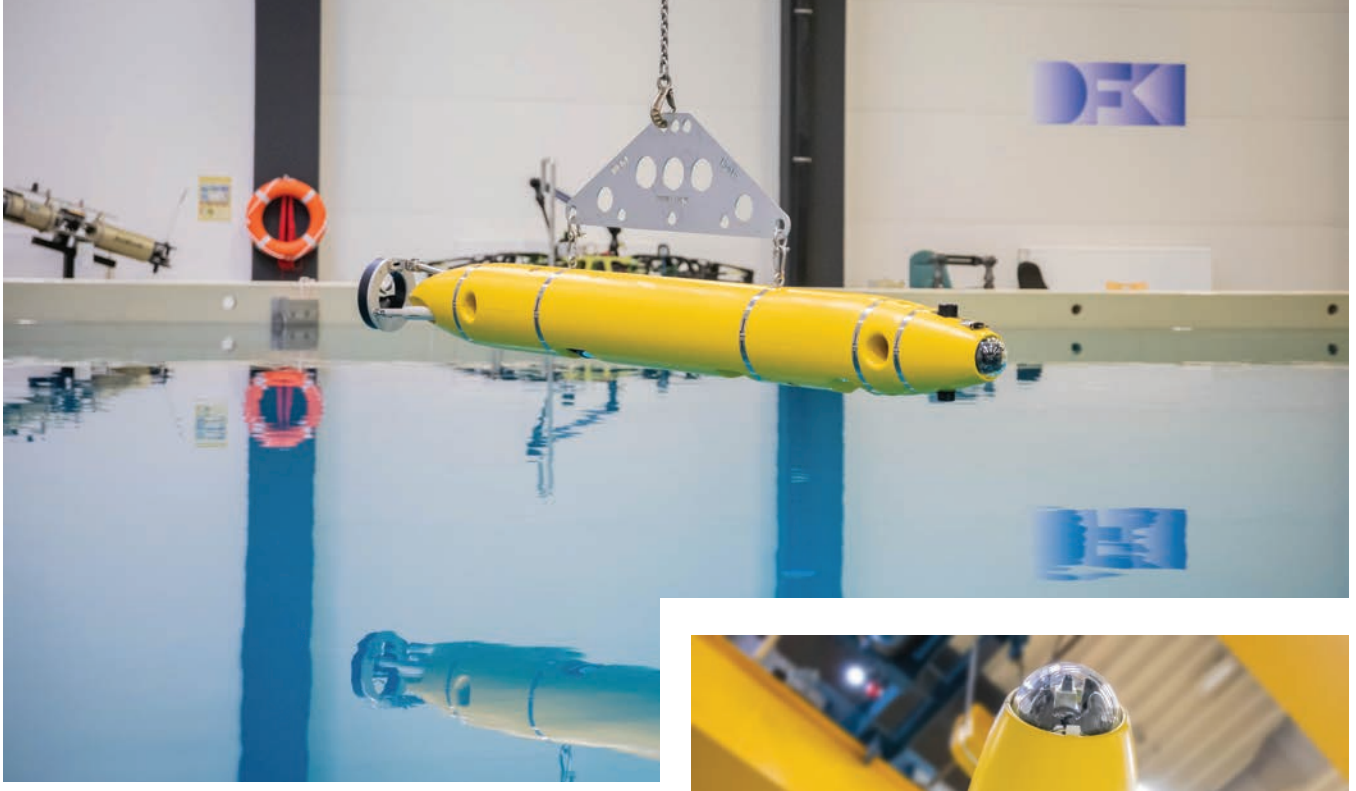
Another focus of DFKI's work is preparing the system specifically for offshore use. To achieve this, its capabilities are being expanded, and existing functions optimized to withstand demanding operating conditions. This includes improving communication systems, implementing enhanced safety measures such as emergency surfacing capabilities, and increasing overall system robustness.

Navigation in the open ocean is particularly challenging as conditions vary and the AUV has to react to unforeseen events. To address this, the researchers are developing intelligent algorithms that enable the robot to maneuver safely through the water, detect and avoid obstacles, and maintain mission objectives.

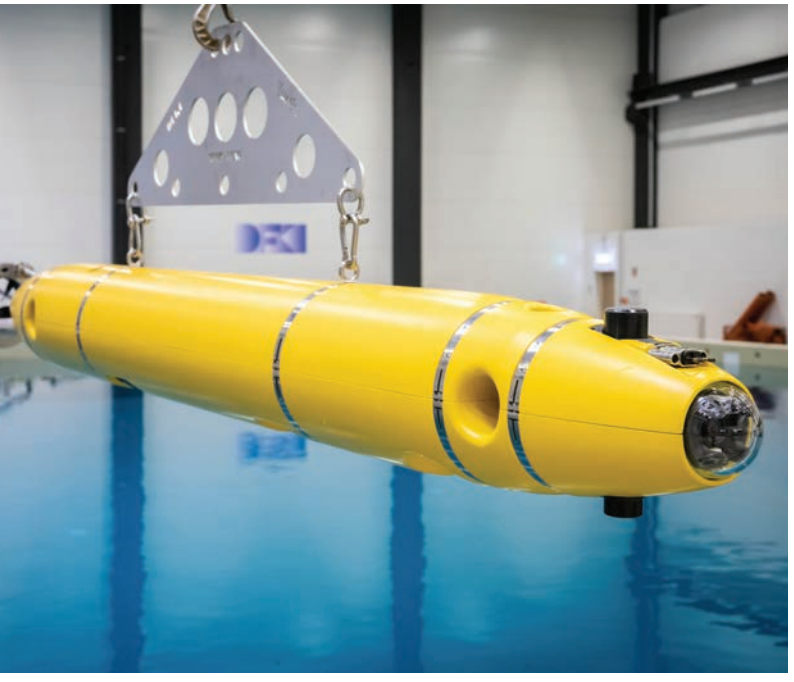
Extensive Lab Tests, Field Trials

In addition to extensive laboratory tests conducted in the 1,300-square-meter Maritime Exploration Hall at DFKI in Bremen, which is unique in Europe, field tests are planned at the Test Center for Maritime Technologies on Helgoland to assess the AUV's seaworthiness and safety functions.

In the second phase of the project, an extensive test cam-



The AUV DeepLeng in the Maritime Exploration Hall at the DFKI in Bremen.



DFKI, Annemarie Popp

paign consisting of numerous individual tests under real-world conditions will take place at RWE's Kaskasi offshore wind farm, approximately 35 kilometers north of Helgoland. With a capacity of 342 megawatts, the wind farm can supply around 400,000 households with electricity. The tests will be supported by an RWE operations team, overseeing the integration of the technologies developed by the research partners into the offshore environment.

The research partners in SeaMe

The SeaMe project, led and financed by RWE, was launched in the summer of 2024 and is scheduled to run for three years. In addition to DFKI, the research partners include the Helmholtz Institute for Functional Marine Biodiversity at the University of Oldenburg (HIFMB), the Alfred Wegener Institute Helmholtz Center for Polar and Marine Research (AWI), BioConsult SH, and the Danish company DHI A/S.

State UV the Art

Underwater vehicles deliver unique and versatile solutions for maritime needs

By Celia Konowe

As much as humans may be drawn to explore the depths of the ocean, only so much can be done without the help of underwater vehicles (UVs), traversing dangerous environments and withstanding extreme conditions to seek out the unknown. Those that are remotely or autonomously operated can push the envelope even further, collecting data, imagery and even samples without relying on direct human control. Canadian companies Cellula Robotics and Deep Trekker, based in British Columbia and Ontario, respectively, are at the forefront of UV technology, with new solutions to lead the industry.

Cellula Robotics

Cellula Robotics' class of autonomous underwater vehicles (AUVs) includes two distinct types, Envoy and Porter. Envoy is similar to other survey-class AUVs in that it is almost cylindrical, allowing easier payload integration, explained Chief Commercial Officer Richard Mills. It can also be operated from ship or onshore. Porter has a square cross-section, designed for carrying a payload to be deployed from the AUV, and is intended to be used from shore. Both are powered by hydrogen fuel cells, allowing for longer distance coverage than with traditional lithium batteries. Envoy and Porter both share the same software architecture, added Mills, and can be equipped with sensor payloads, such as geophysical survey sensors, multibeam echosounders, sub-bottom profilers, cameras and lasers.

Porter's size also allows it to carry a large fuel supply, increasing operational ranges to up to 5000 km. This equates to about 45 days of at-sea endurance, while vehicles with a similar battery size achieve 15 to 20. One unique feature, Mills pointed out, is Porter's ability to come to a complete stop in the water column and hold station. It's equipped with vertical and horizontal thrusters, which allows it to turn within its own body length. "To my knowledge," said Mills, "that level of control in such a large AUV is unique."

Cellula Robotics recently was awarded Maritime Autonomous Ship Surface (MASS) compliance in Canada, which allows the operation of a large, uncrewed vehicle at or close to the surface safely. This achievement continues the development of AUVs within that country's strong subsea and robotics industry.

Deep Trekker

Deep Trekker offers a range of remotely operated vehicles (ROVs) including the PHOTON which is small, agile and designed for quick deployment and confined spaces. The PIVOT, a midsized vehicle, offers a mix of portability and power for operation in lakes, rivers, reservoirs and coastal areas. The REVOLUTION is Deep Trekker's most powerful ROV, said Account Executive Mackenzie Normandeau, and ideal for deepwater surveys, offshore energy and infrastructure maintenance.

The REVOLUTION stands out thanks to it rotating camera head, which allows operators to maintain a fixed position while adjusting their field of view. "This feature is especially useful with an attached sonar," she noted, "making it the only ROV on the market with an adjustable forward-facing sonar." Other notable features include six thrusters and hybrid propulsion that provide lateral movement and stable station-keeping, modular design to support various instruments, customizations, and du-

The Envoy AUV, formerly known as SOLUS LR.

The Porter AUV

Images © Cellula Robotics

Images © Deep Trekker

rability and portability with a depth rating to 305 meters.

Furthering their commitment to the industry, Deep Trekker is leading an $8.1 million AI ROV Ship Modeling and Detection Project in collaboration with Canada's Ocean Supercluster, Qii.AI, the Department of National Defense, Kongsberg Discovery Canada and ABS Global Canada. "The initiative integrates AI with high-resolution ROVs equipped with 4K cameras, multibeam sonar and advanced sensors to enhance ship hull inspections with real-time data processing," Normandeau explained. "Qii.AI's software analyzes sonar and video footage to detect corrosion, biofouling and structural defects, consolidating results into an interactive dashboard with 3D models and annotated imagery." In addition to improving accuracy, reducing inspection time, and enhancing safety and environmental protection, this collaboration highlights Canada's continuing role in AI-driven ocean technologies.

Additionally, a collaboration with Voyis Cameras enhances Deep Trekker's ROVs with imaging technology for tasks like infrastructure inspections, environmental monitoring and underwater archaeology. 3D modeling capability allows for accurate spatial mapping and improved decision-making.

Autonomy for Humanity

The UV industry, as with many sectors of maritime technology, is poised for significant evolution in the coming years. "The biggest and most active market segment is defense," said Mills. Driven by unstable geopolitical situations around the globe, UV applications like the survey and inspection of critical undersea infrastructure are of growing importance. "UVs will be essential to the future of the global and Canadian maritime sectors, enabling safer, more efficient underwater operations across industries, and supporting data collection, infrastructure inspections, resource management and security," added Normandeau. Other industries, such as offshore energy and fisheries and aquaculture will also benefit. For Canada specifically, UVs are vital in ice-covered and deep-sea environments, where human access is limited.

Driven by increasing demand for cost-efficient and persistent operations in offshore energy, defense, aquaculture and environmental monitoring, the UV market is also shifting towards

increased autonomy. This move presents Deep Trekker with opportunities to expand into new sectors, explained Normandeau, such as Arctic surveillance and deep-sea infrastructure inspection. She added, "Strengthening AI integration and remote operation features will be critical for staying ahead in a market that prioritizes efficiency, safety and sustainability."

There also remains so much to learn about the world's oceans, Mills pointed out. Despite more than 70% of the planet being covered in water, only about a quarter has been mapped. "We are discovering new life forms almost every week, and still don't understand how ocean currents affect the temperature and weather at the surface," he said. "I see this as a key opportunity to scale data gathering through the widespread use of uncrewed and autonomous technologies."

In the face of an evolving industry, UVs provide a unique and growing opportunity to explore the hard-to-reach, survey vital infrastructure and collect crucial data. Cellula Robotics and Deep Trekker are two Canadian companies poised to meet global needs, bringing new advancements and collaborations to the forefront.

Sandia National Laboratories' four-channel, silicon photonic single-sideband modulator chip, measuring eight millimeters on each side, sits inside packaging that incorporates optical fibers, wire bonds and ceramic pins.

Photo by Craig Fritz

Agility Boost

New navigation technology is supporting greater vehicle agility and advanced mission planning.

By Wendy Laursen

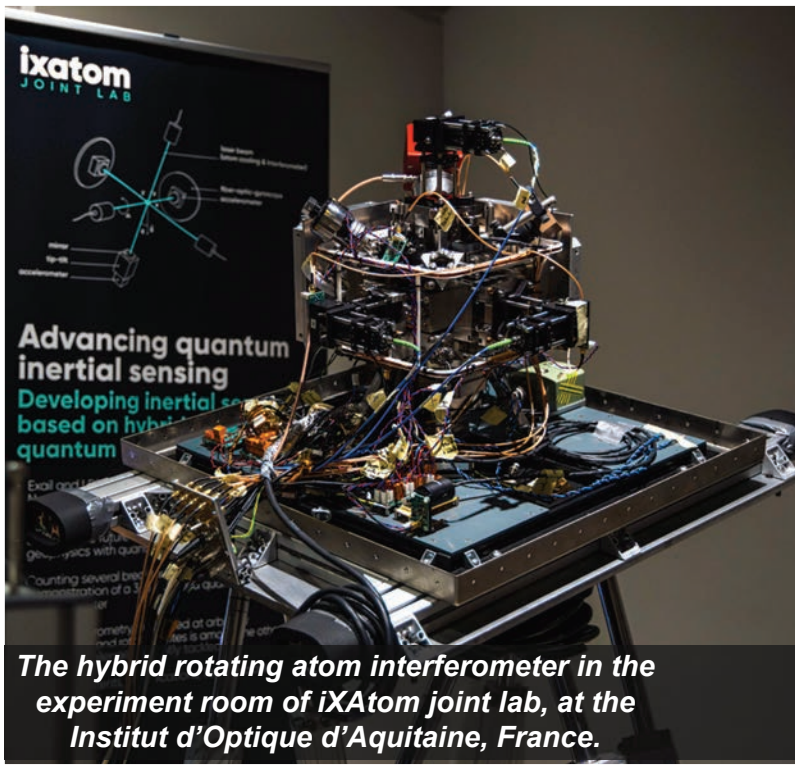
Exail has been experimenting with clouds of rubidium atoms. Trapped and cooled they offer the potential to boost the navigational accuracy of AUVs that are required twist and turn at speed in complex environments. The company's new sensor, developed with LP2N, combines cold-atom technology with fiber-optic gyroscope technology, enabling navigation at high rotation rates (up to 14o per second) and arbitrary orientations.

Researchers at Sandia National Laboratories have also been working with rubidium atoms and have made significant progress in reducing sensor size, weight and power needs whilst boosting accuracy. "By harnessing the principles of quantum mechanics, these advanced sensors provide unparalleled accuracy in measuring acceleration and angular velocity, enabling precise navigation even in GPS-denied areas," says Sandia scientist Jongmin Lee.

These developments are still confined to the laboratory, but advances are also being made with conventional technology. SBG Systems has developed a new tactical-grade low noise cluster-based inertial measurement unit that can provide accurate navigation to swarms of subsea drones in highly dynamic environments. The Pulse 40 IMU's Micro Electro-Mechanical Systems (MEMS) gyroscope and other sensors are designed to ensure precise heading for several hours following initial surface navigation with GNSS. MEMS technology can offer a lower cost and lower power alternative to fiber optic gyroscopes while still providing navigational information over six degrees of freedom.

Movella launched a new inertial sensor, Xsens Sirius, that delivers real-time 3D data for the precise navigation or stabilization of AUVs and ROVs. A key feature is its advanced signal pipeline with analog filtering, ensuring high vibration resistance for precise measurements even in the most extreme vibration environments. It also supports high-fidelity data capture and georeferencing for subsea bathymetry.

The latest model of Advanced Navigation's Hydrus AUV comes with an AI chip that enables users to include their own models to, for example, autonomously identify specific objects and then undertake a pre-set mission when they find them. This functionality was recently used to obtain 4K georeferenced imagery of a shipwreck in deep waters where such searches are typically cost prohibitive. Hydrus was able to reduce the surveying cost by up to 75% compared to a ROV operation, enabling the team to conduct more frequent and extensive surveying of the wreck in a shorter time period. The compact design of the Hydrus, weighing around 7kg, eliminates the need for large vessels, complex launch systems and professional dive teams.



The hybrid rotating atom interferometer in the experiment room of iXAtom joint lab, at the Institut d'Optique d'Aquitaine, France.

Image credit: Exail, G. Lemaintec

Greensea IQ's new IQNS edge processing and inertial navigation system has been paired with the company's defense-focused EOD Edge software package.

Image courtesy Greensea IQ

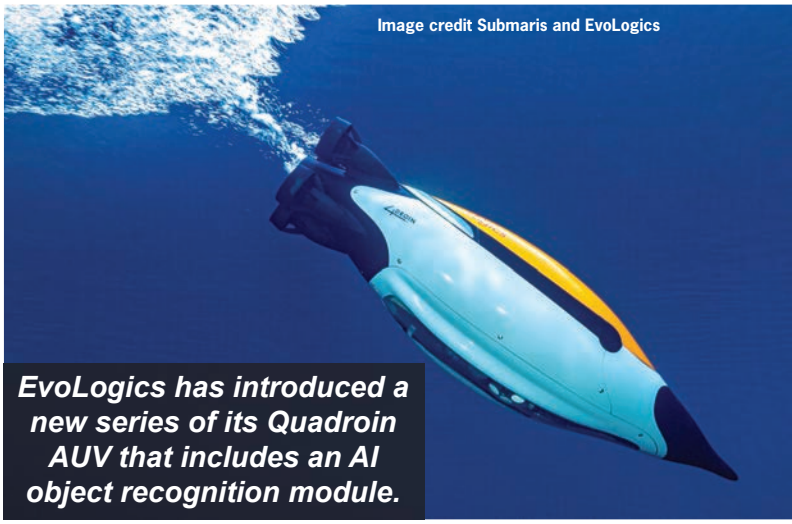


Image credit Submaris and EvoLogics

EvoLogics has introduced a new series of its Quadroin AUV that includes an AI object recognition module.

Its miniaturization extends to its georeferencing capability. Where other surface systems require the triangulation of three acoustic positioning systems (USBLs), Advanced Navigation has packed them into a single unit. Adding to the sensor fusion designed into the inertial navigation system, it means greater navigational accuracy, says senior software engineer Dr Alec McGregor.

Water Linked, a company that was part of the NATO DIANA accelerator program, has developed a 3D sonar system, 3D-15, that provides imagery in low-visibility environments in real time – something 2D sonar cannot achieve without combining data from multiple scans. "Each acoustic 'ping' generates a complete 3D image without the need for scanning, motion compensation or post-processing," says Johnny Broeders, Marketing Specialist. "When moving around, an AUV, ROV, USV, boat or diver can immediately create a single 90x40 degree clear 3D point cloud of what is seen underwater. This is especially useful in underwater terrains where you can't pick up anything with a camera. With our API you can then merge the sonar data with position information and third-party software to create an extensive map of the underwater area. The sonar output also has the potential to increase autonomous navigation capabilities underwater and is a big step in achieving full spatial awareness."

EvoLogics has introduced a new series of its Quadroin AUV that includes an AI object recognition module based on input from forward-looking side-scan sonar and two full-HD underwater cameras. Francisco Bustamante, Director Sales and Operations, says: "New processing capabilities have increased to the point that the vehicle's options can now include real-time object collision avoidance that recognizes the objects and navigates around them. And while before a vehicle would collect data which could be reviewed only after the mission had been completed, onboard AI processing can nowadays detect in real-time objects of interest and reduce the amount of required data transmitted to the point that the operator is notified in real-time about the findings."

Greensea IQ's new IQNS edge processing and inertial navigation system has been paired with the company's defense-focused EOD Edge software package to provide enhanced autonomy and platform stability for applications such as automatic target recognition. It has been field tested on a VideoRay Defender ROV, and David Pearson, Technical Solutions Architect, says the software can perform advanced onboard analytics that enables the IQNS to process data from the forward-looking sonar to detect and classify features in real-time. For example, it can identify and track potential obstacles and map them to aid navigation.

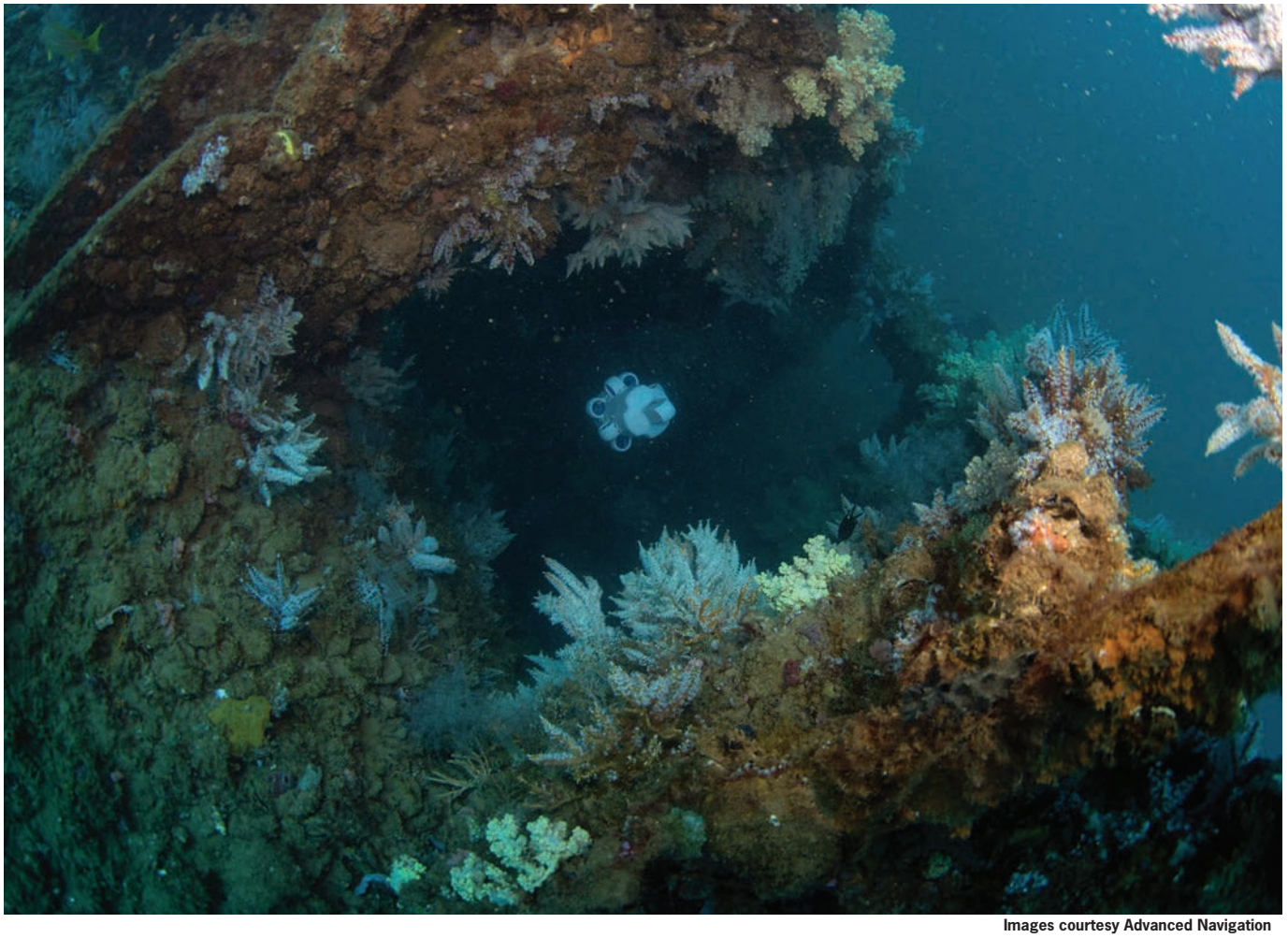
"We're also looking ahead to future applications of edge processing. For instance, we're developing generative AI tools that dynamically prioritize tasks and adapt missions in real-time based on environmental changes or new operator goals." Additionally, the company is looking to use edge AI to support operations with vehicle-mounted manipulators for precise intervention tasks, such as object retrieval or repairs.

Dr Alexander Philips Head of Marine Autonomous and Robotic Systems (MARS) at the National Oceanography Centre, sees machine learning as bringing more efficient mission planning, moving away from pre-defining waypoints to goal-based planning and high-level objectives. "There are a couple of ways we can put more advanced algorithms into operations. We can put algorithms on board the vehicle, for example if you want the vehicle to react to what it is measuring and the sensors that it has on board. That's within the confines of what's on board the vehicle.

"But we could also do what we're calling server-side autonomy. This is looking at a much bigger set of external data sets, such as weather and ocean forecast data, ship AIS data and even satellite data, to inform where your vehicle needs to go. The algorithms do their work onshore and send the information that's needed to the AUV.

"In the future, combining these approaches could be really powerful."

The latest model of Advanced Navigation's Hydrus AUV comes with an AI chip.

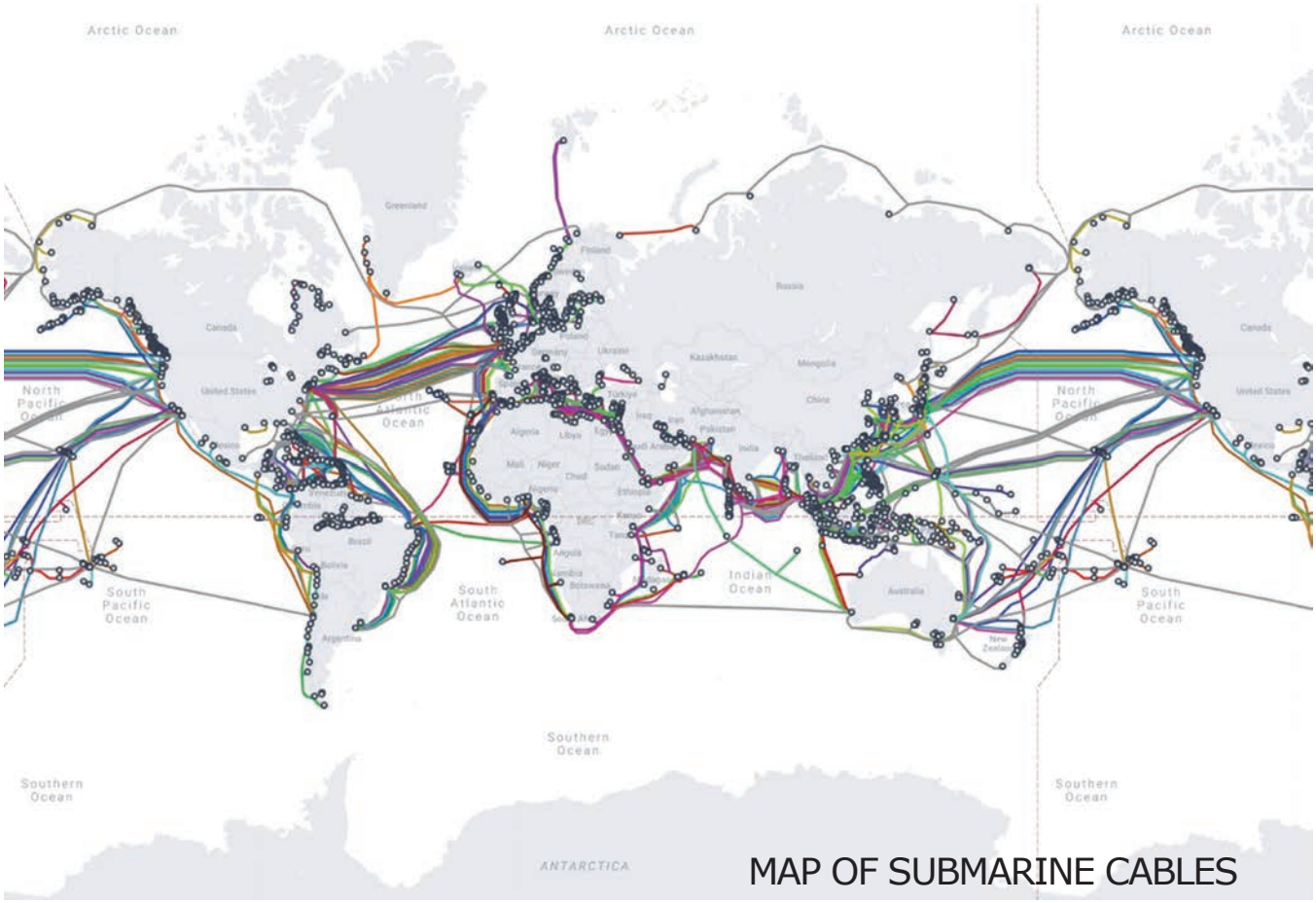


Images courtesy Advanced Navigation

SECURING THE DEEP: BUSINESS OPPORTUNITIES IN SUBSEA DEFENSE

As global reliance on subsea infrastructure grows, so do the risks. Discover how safeguarding undersea assets opens new frontiers for innovation and investment.

By Alisa Reiner



MAP OF SUBMARINE CABLES

Credit: TeleGeography

Importance of Subsea Infrastructure

Subsea infrastructure plays a critical role in maintaining the operational continuity of the modern society and the global economy. This vast network includes subsea data and communication cables, pipelines for energy transportation, electricity cables, and resource extraction systems. What's important is that these components are increasingly vulnerable to damage, whether due to natural phenomena or intentional human interference.

In the realm of communications, submarine cables are indispensable:

- *They carry between 97% to 99% of global internet traffic, underpinning everything from everyday civilian internet usage to critical financial transactions and military communications (Defense News, 2020; TeleGeography, 2024).*
- *Cable traffic represents about $10 trillion in daily financial transactions. (Defense News, 2020)*
- *With over 570 submarine data and communication cables currently in use, stretching across more than 14 million kilometers and connecting over 1,300 landing stations globally, these cables form the backbone of our global connectivity (Military Law Review, 2021; TeleGeography, 2024).*
- *As of June 2024, this number has grown to include more than 600 active and planned submarine cables, emphasizing their continued expansion and importance (TeleGeography, 2024).*

Beyond communication, the seabed also supports extensive energy infrastructure, including gas pipelines and electricity cables. For example, the North Sea alone hosts approximately 3,000 kilometers of gas pipelines alongside numerous cables1. As climate change accelerates the shift to renewable energy, the importance of undersea infrastructure has significantly increased. While some traditional oil and gas pipelines may decline in number, there are initiatives to repurpose these structures for new applications, such as transporting hydrogen or enabling carbon capture and storage. Additionally, electricity cables interconnect power markets, allowing for electricity transfer to balance supply and demand across regions and between islands and the mainland, thus supporting the integration of variable renewable energy sources. The growth of offshore wind power, for instance, requires more seabed electricity cables to connect new wind farms to the grid.

Aside from civilian uses, underwater cables are vital for military operations. Most military communications, including those necessary for operating remote drones in distant theaters, are transmitted through the transatlantic and transpacific

Subsea infrastructure, including pipelines and cabling carrying electricity and communications, is relatively easy to sever, but takes months and millions to effectively repair.

U.S. Navy photo by Mass Communication Specialist 1st Class Brian M. Brooks/RELEASED

Knifefish is a medium-class mine countermeasure UUV designed for deployment off the Littoral Combat Ship.

cable networks. These cables also facilitate secure military-encrypted and diplomatic communications, underscoring their strategic importance (Wilson Center, Polar Institute, 2024).

In today's competitive and threat-laden environment, the vulnerabilities of our expanding subsea data and energy transportation systems—responsible for transferring molecules and electrons—are increasingly exposed. This highlights the critical importance of subsea defense.

Vulnerabilities and Attack Vectors

Subsea infrastructure, while critical, is fraught with vulnerabilities that pose significant risks to global security and economic stability.

Physical Vulnerabilities

Subsea security and seabed warfare have become prominent issues in the context of gray zone operations and sub-threshold warfare against critical underwater infrastructure (CUI). For hostile state actors, disrupting CUI is an attractive strategy due to its low-cost, high-impact potential, driven by critical dependencies and the cascading effects disruptions can have (Wilson Center, Polar Institute, 2024). Among CUI, fiber optic data and communication cables are particularly susceptible to disruption. The Arctic region exemplifies this vulnerability due to its geographic and natural chokepoints, like the Svalbard, Greenland–Iceland–UK (GIUK), and Greenland–Iceland–Norway (GIN) gaps and the Bering Strait, where cable resilience is minimal. This lack of redundancy, along with increasing geopolitical importance of the Arctic, makes cables in the region prime targets for seabed warfare (Wilson Center, Polar Institute, 2024).

While, in most places, cables are widespread across the ocean floor, reducing bottleneck risks, their landing stations can become focal points for potential attacks due to their geographical concentration (Kavanagh, 2023). Coordinated attacks on critical nodes could cause cascading failures, significantly affecting systems and escalating costs, with broader economic and societal repercussions (Rand, 2024).

Practically speaking, in deeper waters, cables lie unprotected on the seabed, making them less vulnerable to anchoring or trawling but more susceptible to deliberate sabotage. Additionally, the public availability of detailed maps displaying

cable locations increases their exposure to malicious acts (TeleGeography).

Attack Vectors

One of the key vulnerabilities of subsea infrastructure lies in its geographical isolation. The lack of an immediate human presence at these sites makes physical threats, such as attacks on fiber optic and copper cables, relatively easy to execute (Turing Institute, CETAS). This remoteness also results in longer response times for security services, further compounding the risk.

The rise of autonomous underwater vehicles (AUVs) and drones has introduced a new dimension of threats. These technologies can be exploited for hostile surveillance or direct attacks. Additionally, as drone-based operations and maintenance (O&M) become more common, the risk of hacking or malware implantation during production grows. Such vulnerabilities could allow malicious actors to manipulate drones once they are operational (The Diplomat, 2023). These advancements not only enhance the capabilities of state actors but also extend sophisticated tools to terrorist organizations and criminal networks, broadening the scope of potential threats.

The subsea cable industry also faces critical supply chain risks. China's rapid emergence as a leading subsea cable supplier, driven by its Digital Silk Road initiative, has positioned it to capture a significant share of the global fiber-optic market. Companies like HMN Technologies, which supplied up to 18% of subsea cables between in 2019-2023, play a major role in expanding global cable infrastructure (Reuters, 2023a). However, this dominance raises national security concerns, particularly among NATO members (CSIS, 2024). Firmware and software used in cable landing stations could be compromised before installation, with adversaries potentially embedding bugs or surveillance devices in hardware. Once breached, attackers could manipulate cable controls or disrupt operations.

While a single attack on subsea infrastructure might cause limited disruption, coordinated assaults could trigger devastating cascading effects—potentially serving as precursors to larger military actions or coercive strategies. Protecting this critical infrastructure is essential, requiring robust surveillance measures and international collaboration to address these growing vulnerabilities.

Recent Examples of Threats

In recent years, several incidents have highlighted the vulnerabilities of subsea infrastructure. In 2023, Taiwanese authorities accused Chinese vessels of cutting submarine cables that are critical for internet connectivity to Taiwan's Matsu Islands (CSIS, 2024). The incident left 14,000 residents in digital isolation for six weeks.

In the Baltic Sea, a telecom cable linking Sweden and Estonia was damaged alongside a Finnish-Estonian pipeline and cable in October 2023, with investigations pointing to Russian and Chinese vessels as potential saboteurs (Reuters, 2023b). Further incidents in November 2024 saw communication cables between Sweden and Lithuania, and Germany and Finland severed, raising suspicions of sabotage (Guardian, 2024).

Globally, the South China Sea and the Red Sea have been identified as chokepoints for undersea cables. In March 2024, several major cables in the Red Sea were cut, impacting 25% of data traffic between Asia and Europe (Rand, 2024).

These threats are not just isolated incidents but may form part of broader strategic maneuvers. At the onset of potential hostilities, cable disruptions can serve as tactical enablers, preparing the battlespace for larger military operations. Such disruptions often occur alongside coordinated activities, marking the "first salvo" in broader conflict strategies (Wilson Center, Polar Institute, 2024).

Threats to Subsea Infrastructure

Subsea infrastructure is increasingly threatened by activities that fall within the realm of plausibly deniable, subthreshold operations. These threats are

often carried out by state and non-state actors using dedicated units, structures, and subsurface capabilities.

There are two primary categories of seabed warfare activities that adversaries might conduct against underwater cables: intelligence gathering and physical destruction.

■ **Intelligence Gathering**

This involves mapping and monitoring seabed infrastructure, primarily conducted by civilian vessels and uncrewed underwater vehicles equipped with remote-sensing capabilities (Wilson Center, Polar Institute, 2024). Such operations allow actors to prepare for potential acts of sabotage and gain awareness of the cable layout. The physical tapping of cables to intercept communications, although technically challenging, is another form of intelligence gathering.

■ **Physical Destruction**

This more direct form of attack involves severing cables or using undersea explosives like torpedoes or maritime improvised explosive devices (MIEDs) to damage or destroy them (Wilson Center, Polar Institute, 2024). Such actions can be disguised as accidental, using "ghost ships" to conduct anchoring and dredging activities.

Defense of Subsea Infrastructure

Given its critical role, the protection of subsea infrastructure presents numerous business opportunities, spanning challenges across sea, land, and cyberspace and in various sectors, including cables, landing stations, and repair ships. Entrepreneurs should recognize the critical role of these infrastructures and prioritize their defense as a vital component of national security, opening avenues for innovation and investment.

International and Regional Partnerships

In December 2023, a multinational effort named SeaSEC was initiated by the Netherlands, Denmark, Germany, Finland, Norway, and Sweden. This program seeks to develop advanced methods for monitoring underwater infrastructure in the North and Baltic Seas, focusing on pipelines, wind turbine platforms, and internet cables1.

In April 2024, countries bordering the North Sea—including Belgium, Germany, Norway, Denmark, the Netherlands, and the UK—agreed to work together on enhancing security for subsea energy and telecommunications infrastructure. This was quickly followed by a similar agreement among eight Baltic Sea nations to protect offshore energy assets.

On a broader level, there is an ongoing debate on whether CUI should be recognized as an operational domain of warfare (Wilson Center, Polar Institute, 2024). This could potentially lead to CUI being declared an official operational domain, enabling more comprehensive legal and military protection strategies.

As of now, the European Union (EU)'s Critical Entities Directive requires member states to enact protective measures for critical infrastructure, reflecting a coordinated effort across Europe (Rand, 2024). The collaboration between the EU and NATO also aims at improving the resilience of critical infrastructure. The EU-NATO Task Force has recommended further cooperation in monitoring and safeguarding maritime assets, resulting in initiatives such as the NATO Critical Undersea Infrastructure Coordination Cell in Brussels and a Maritime Centre for Security in London (Rand, 2024).

Public-Private Collaborations

By working with private companies, governments can better identify and protect critical elements of these systems. For example, RAND suggests establishing an international undersea infrastructure protection corps to combine public and private resources in safeguarding subsea assets (Rand, 2024).

In Germany, various stakeholders, including the German Navy, Federal Police, and Federal Maritime and Hydrographic Agency, are contributing their expertise to ensure the success of initiatives aimed at protecting subsea infrastructure. North.io, a German company focusing on organization and management of geospatial data with the help of AI, leads the effort2.

Germany's Argus project, supported by the Federal Ministry of Digital and Transport, further aims to utilize big data and AI technologies to protect critical underwater infrastructure. This 3.5 million initiative involves collaboration with the GEOMAR Helmholtz Centre and focuses on developing autonomous systems for enhanced monitoring1.

Technological Solutions

The protection of subsea infrastructure relies heavily on advanced technological innovations that enhance detection, inspection, and response capabilities. The sheer volume of data generated by the automatic generation system (AIS) signals, port calls, and ship-to-ship meetings presents a challenge in filtering out critical threats from the noise (Windward, 2024a). In addition, malicious actors may manipulate data to obscure their activities. Detecting such deceptive practices and decoding data becomes necessary to ensure reliable maritime domain awareness.

Detection and Inspection Technologies

Remotely operated vehicles (ROVs) and AUVs are essential tools for identifying unauthorized objects like surveillance devices or explosives that might be attached to subsea infrastructure. These vehicles are supported by customized launch and recovery systems, which ensure their safe and effective deployment (Royal IHC). They also employ sensors to detect potential threats, enhancing situational awareness.

For monitoring underwater installations such as cables and pipelines, ROVs, AUVs, and towed systems are equipped with advanced launch and recovery systems (LARS), enabling precise control during operations (Royal IHC). These inspection systems are complemented by hydrographic surveying tools,

which use sonar for accurate seabed images to plan and execute detailed operational strategies.

The offshore energy sector offers valuable synergies, as demonstrated by the UK defense ministry's acquisition of the Topaz Tangaroa, a former subsea construction vessel (OEDigital, 2023). After military modifications, this 98-meter vessel will protect subsea cables and oil and gas pipelines. It will function as a "mother ship," deploying remote and autonomous systems for underwater surveillance and seabed warfare.

Big Data and AI Innovations

The Germany Argus project will utilize the TrueOcean platform to analyze large volumes of underwater sensor data, providing a comprehensive situational picture that enhances threat detection and response capabilities2. By integrating underwater data, Argus improves risk identification, cross-references anomalies with critical infrastructure locations, and reduces response times. The project is also developing systems for automated monitoring and strategic decision-making in infrastructure security.

Data-Driven Proactive and Reactive Measures

By analyzing extensive maritime activity records, machine learning algorithms help identify potential threats and inform the strategic placement of infrastructure3. This proactive measure involves avoiding high-traffic maritime corridors to minimize risks, thus ensuring the safety of critical assets.

Advanced real-time tracking systems provide a comprehensive view of vessel movements, distinguishing between normal and potentially threatening behaviors3. Predictive behavioral analysis helps move beyond well-known threats to uncover new and emerging risks or the unseen threats. By building detailed vessel profiles and applying risk models, this approach identifies vessels more likely to engage in illicit activities and ensures that only relevant alerts are issued, facilitating timely and appropriate responses to potential threats. (Windward, 2024b).

Further, innovative tools for incident management and reporting enable incident replay and analysis, aiding in understanding events like near-misses or groundings3. This not only assists in liability and insurance claims but also enhances future safety measures.

Strategic Diversification

One of the key preventative strategies involves rerouting planned subsea cable systems away from hostile territories and vulnerable areas. This approach minimizes the risks associated with geopolitical tensions and reduces the potential for infrastructure vulnerabilities.

Further, to mitigate risks associated with overreliance on specific suppliers, there is an emphasis on diversifying trusted suppliers for technology and operations as well as ensuring that cable maintenance is performed by reliable vendors.

In addition, through enhancing network redundancies and interconnectivity, the subsea infrastructure becomes more resilient to disruptions. This involves creating multiple pathways for data and energy flows, allowing for alternative routes in case of an outage or attack. To note, however, is that interconnectors might increase vulnerability since they create more points of attack.

Several new projects in the North Sea and Baltic Sea are exemplary in integrating clean energy, redundancy, and interconnectivity. The TritonLink, for instance, plans to connect high-voltage grids in Belgium and Denmark via two energy islands in the North Sea, thereby supporting the EU's transition to renewable energ2. Similarly, the Bornholm Energy Island (BEI) project between Denmark and Germany aims to integrate at least 3 GW of offshore wind power into the grid by the early 2030s. Another project, the Elwind initiative, seeks to enhance cross-border electricity connectivity between Estonia and Latvia.

In April 2024, the Viking Link project, celebrated as the world's largest interconnector, officially launched, creating a vital energy link between the UK and Denmark to enhance energy security and grid stability2. Similarly, ambitious projects like the $3.2 billion Eastern Green Link 1 (EGL1) and the $5 billion Eastern Green Link 2 (EGL2) are set to strengthen electricity transmission across regions. Adding to these efforts, the proposed 6 GW North Atlantic Transmission One–Link (NATO-L) aims to establish a high-voltage direct current (HVDC) connection between North America and Western Europe, providing Europe with a more secure and carbon-free power supply.

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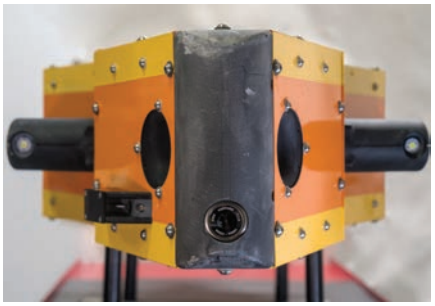
■ **Sunfish**



■ **Octans 9 Gyrocompass**

■ **Tritech Gemini 1200id**

■ **KIOST buys Klein 5900 SSS**

■ **Omicron Connectors**

■ **SMD, Beam Team**

■ **Sunfish**

The Sunfish AUV is an achievement in autonomous robotics in the exploration of submerged cave systems. A collaboration with DeepWater Exploration introduced the Sunfish team to the exploreHD Heavy camera, which uses a USB 2.0 signal. Although initially skeptical due to unfamiliarity of a subsea camera using USB, the team's decision to integrate it not only addressed the connectivity issues but also dramatically improved the AUV's capabilities. The camera's integration streamlined operations, cutting down on both costs and time while providing exceptional image quality in low-light environments.

■ **Octans 9 Gyrocompass**

Exail launched its new Octans 9 Attitude and Heading Reference System (AHRS), the latest model in its navigation solutions range. Building on the previous generations, Octans 9 offers several upgrades to enhance operational performance across applications such as dynamic positioning, vessel navigation, and offshore platform stabilization. Leveraging Exail's Fiber Optic Gyroscope (FOG) technology, Octans 9 provides precise measurements with a heading accuracy of 0.1° secant latitude and heave measurement accuracy of 5%.

■ **Tritech Gemini 1200id**

The Gemini 1200id is built on the same platform as the Gemini 720is sonar. It features a wide 120° horizontal field of view when operating at both 720 kHz and 1200 kHz acoustic frequencies and offers improved attenuation of waterborne electrical noise for optimal imaging performance. An integrated speed-of-sound sensor ensures that targets are displayed to a high degree of positional accuracy. CHIRP processing provides improved target separation over longer ranges.

■ **KIOST buys Klein 5900 SSS**

The Korea Institute of Ocean Science & Technology (KIOST) accepted delivery of the Klein Marine System's 5900 ultra-high-resolution sonar, planning to use the high-speed side-scan for its seafloor topography surveys. Klein Marine System's 5900 sonar is the flagship in its family of multi-beam side scan sonar systems. The system is a configurable multi-functional platform that allows high-speed surveys up to 12 knots with 100% bottom coverage. Its non-magnetic tow body is hydro-dynamically designed to provide a stable towing for increased acoustic performance, natural depression capabilities and overall robustness.

■ **Omicron Connectors**

Teledyne Impulse-PDM supplied its Omicron optical fiber connectors to BBC Studios for use in its underwater natural history series, set to air in 2026. Filming required custom-built camera technology designed to capture extraordinary marine footage from the depths of the Arctic, facilitated by the Rev Ocean's Aurora ROV. To capture underwater content, BBC Studios and Marine Imagine Technologies designed a deep ocean-rated camera system integrated with a telemetry bottle, the central hub for communications on the submersible. However, during the Arctic expedition, the crew encountered challenges connecting the camera system to the ROV's telemetry bottle due to a missing optical fiber connector. BBC Studios reached out from their expedition for support and Teledyne Impulse-PDM rapidly supplied the Omicron 5030/5070 optical connectors which deliver high-performance fiber connectivity.

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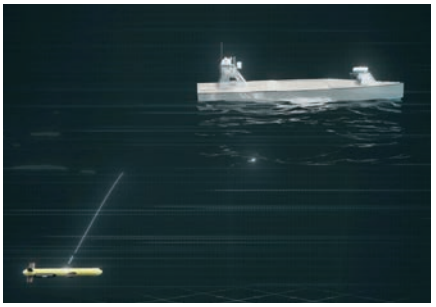
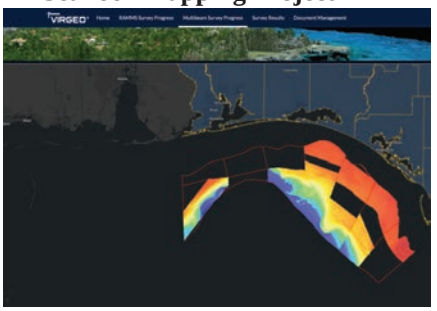
■ **OSIL Buoy Charts New Waters**

■ **EIVA, Tuco Team**



■ **Seafloor Mapping Project**



■ **SMD, Beam Team**

Underwater technology and services company, SMD, and deep technology company, Beam, are mobilizing autonomous vehicles in harsh offshore environments using Beam's Pathfinder software. Having purchased SMD's Quantum EV, Beam plans to mount its innovative subsea perception system, SubSLAM - running its Pathfinder software - to the vehicle, enabling AI-driven autonomous piloting in deeper, harsher waters.

By combining SubSLAM's localization, AI and mapping technology with Quantum EV's exceptional high-current performance, is aimed at improving the efficiency of offshore wind farm maintenance.

Simon Adams, Program Director at Beam, said: "By moving towards autonomous vehicles for inspection and maintenance missions, we cut operational costs and improve overall efficiency. These inspections also require less manpower, which is critical in an industry facing a workforce shortage."

■ **OSIL Buoy Charts New Waters**

Ocean Scientific International Ltd. (OSIL) manufactured a pioneering oceanographic data buoy system, the first of its kind in the Central American Pacific coast. The buoy system will be used as a floating laboratory platform and has been installed in the Parque Nacional Coiba in Panama for the Estación Científica Coiba (COIBA AIP) to assist with the study and conservation of marine diversity and monitoring climate change. Coiba Island is part of the marine corridor of the tropical eastern Pacific, and regularly sees large congregations of different migratory marine species. The buoy will continuously monitor parameters that are crucial to critical migratory events. The 1.2m system is equipped with two multiparameter sondes (one at the surface and another at a depth of 10m) that measure up to 20 environmental parameters including temperature, salinity, sound velocity, dissolved oxygen, pH and Chlorophyll a, and a current profiler.

■ **EIVA, Tuco Team**

A new partnership between EIVA and Tuco Marine will provide integrated autonomous systems for inspecting subsea assets, such as cables transporting renewable energy. EIVA, a developer of software and equipment for surveying below the water's surface and Tuco Marine, producers of unmanned surface vessels (USVs) have announced they are now working together to provide an integrated system solution. The ProZero 8m Naval Intelligence USV by Tuco Marine sails to an area of interest and launches the remotely operated towed vehicle (ROTV) ViperFish by EIVA. ViperFish is a sensor platform for high-resolution seabed imaging, as well as mapping depth and magnetic signals to monitor subsea assets. The quality of data delivered with this system also benefits from positioning and imaging sensor technologies thanks to partnerships within the Covelya Group. EIVA's sister companies in this group include sensor providers Sonardyne and Wavefront Systems, as well as Forcys.

■ **Seafloor Mapping Project**

Fugro is expanding its role in the Florida Seafloor Mapping Initiative (FSMI), a multi-year effort by the Florida Department of Environmental Protection (DEP) to map the state's seafloor for improved coastal resilience, infrastructure planning, and environmental protection. Building on its previous award of 14,000 square kilometers of airborne lidar data for the FSMI, Fugro is now conducting vessel-based surveys across 42,000 square kilometers offshore Florida. This new data acquisition campaign covers five of the six Florida DEP program regions, including the entire Atlantic Coast, the Florida Keys, and portions of the Gulf Coast. Initially launched in Q4 2024 with a single survey vessel, the project has rapidly scaled to a multi-vessel operation. Field activities are being managed using Fugro's innovative VirGeo platform, which provides real-time project tracking and quality control information to both Fugro and Florida DEP.

■ **NWBMS X Multibeam Sonar**

NORBIT Subsea introduced the WBMS X, the latest addition to its multibeam sonar family. This compact system is designed with flexibility, built to tackle the most complex survey challenges. To that, the WBMS X can be customized to fit any operational environment. WBMS X standard bundles come with integrated Applanix or SBG

■ **NWBMS X Multibeam Sonar**

GNSS/INS, but you may choose a non-integrated version for applications such as ROV. Need extra beams for data density? Upgrade to 1024 True Beams. Need even more data density? Add Dual Swath. Need active stabilization for dynamic conditions? Add Pitch and Yaw Stabilization.

■ **Green Marine Team with NOC to Deploy Gliders**

Green Marine UK has deployed underwater gliders in the North Sea to support a data-collecting exercise led by the UK's National Oceanography Center (NOC) and the Met Office. Operating for 6-month intervals, the specialist gliders will survey ocean depths approaching 200m for a three-year period.

■ **MiniSpector's Mini-ROV System**

MCS Group's 10 MiniSpector Mini-ROV systems completed subsea inspection and survey projects across Southeast Asia, the Middle East, and North Africa in 2024. In 2024, the MiniSpector fleet carried out platform-based inspections on 19 platforms, deployed directly from platform facilities in Malaysia, Egypt, and Qatar, with inspections in Qatar focusing on flare platforms without requiring shutdowns. Among its achievements, MiniSpector completed a 40-day high-pressure water jet cleaning project in the Red Sea for a major Middle Eastern client.

■ **ESI Buys Hydrosurv REAV-28**

HydroSurv recently sold a REAV-28 USV package to Engitec Systems International (ESI), marking the company's first sale in the Eastern Mediterranean region. ESI, a Cyprus-based specialist in marine and offshore engineering solutions, will deploy the vessel for environmental monitoring and research applications.

The zero-emission, battery electric REAV-28 will initially support ESI's REDRESS project, focusing on ecosystem restoration and environmental monitoring in coastal and offshore waters. The versatile platform will be equipped with an advanced sensor array to monitor critical water quality parameters, including temperature, salinity, dissolved oxygen and turbidity.

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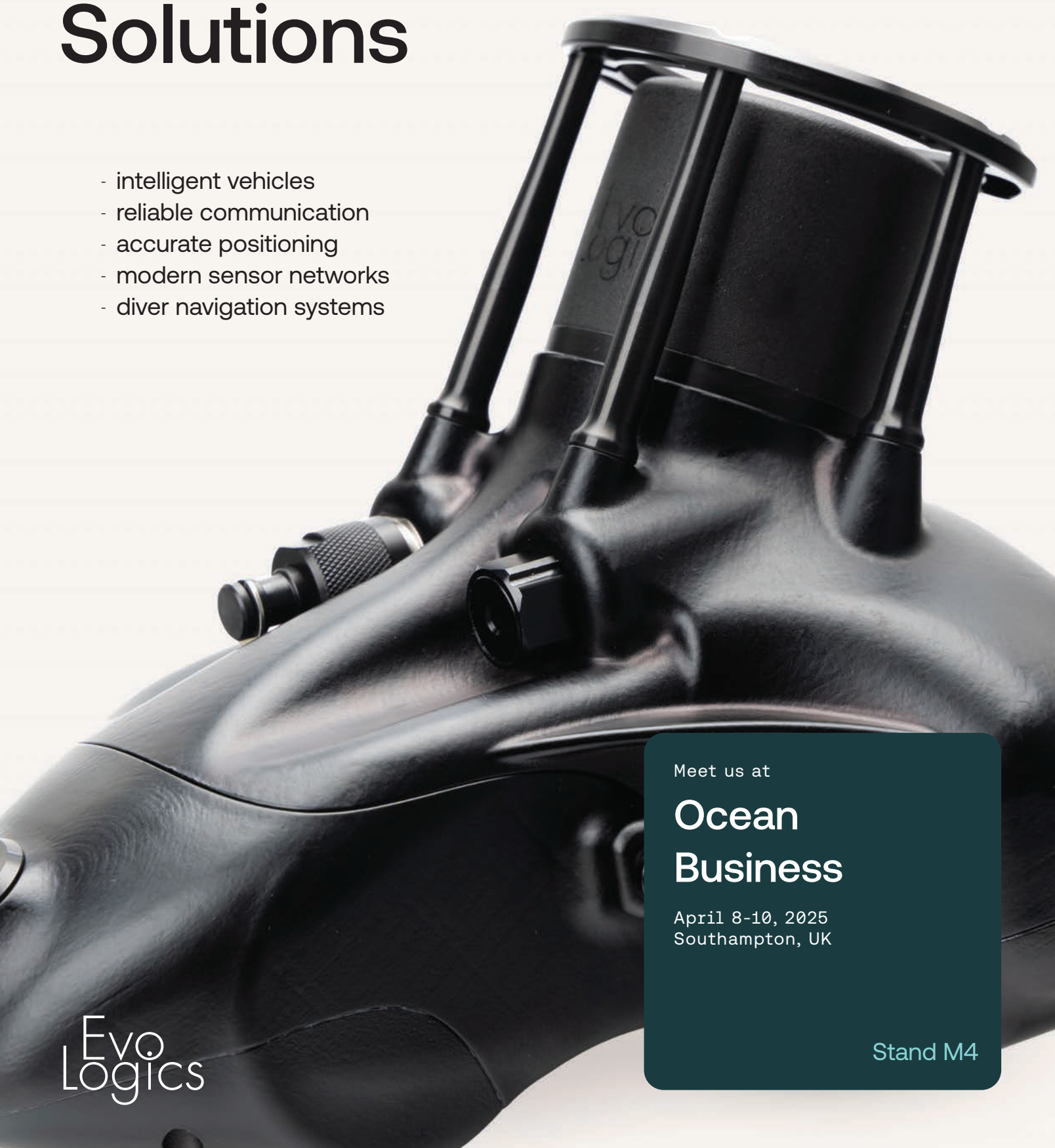

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