MARINE TECHNOLOGY REPORTER

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ARCTIC THREATS
Cybersecurity and the Canadian North

Interview
John Siddorn, CEO, NOC

Inside the Robotics Lab with
Alex Phillips, Head of MARS, NOC

AUVs
Environmental Management on Wind Farms

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Cables & Connectors

Ocean Business 2025
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Volume 68 Number 4


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On the Cover

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Editorial

NOC/Hannah Wyles University of St Andrews

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This edition highlights current global instability with a focus on defense, security and communications—and ***MTR***'s new managing editor (yours truly, but we'll get to that).

It all starts on page 8 with David Strachan's analysis of seabed warfare, followed by Scott Blough's examination of emerging cybersecurity threats in the Arctic. And, as ***MTR***'s bureau chief for Halifax, Nova Scotia, I would be remiss to exclude a focus on the Canadian Arctic, a region facing multilayered and intensifying challenges.

If you missed Ocean Business 2025 in Southampton, England, don't fret. We've got you covered, starting with a roundup of new and emerging technologies to keep an eye on. Greg Trauthwein takes readers behind the scenes at the National Oceanography Centre, interviewing CEO John Siddorn and Alex Phillips, head of Marine Autonomous Robotic Systems (MARS).

Cables and connectors make up a third theme in this edition, in recognition of the growing demand for underwater uses. As renewable energy production ramps up to meet global needs and regulation, subsea cables have an enormous role to fulfill—a challenge explored by Wendy Laursen. Additionally, Kevin Hardy, president of Global Ocean Design uses his recurring column Lander Labs to offer guidance when selecting cables and connectors—a process that demands careful thought and planning.

Later this summer, we'll welcome the MTR 100, now in its 20th year. I urge you to consider applying (see page 40) to share your technology and advancements with our readership.

As for me, I have the privilege of being ***MTR***'s new managing editor beginning with this issue, though I'm no stranger to this magazine. I served as an editorial intern in the summer of 2020 and have been a contributing writer since January 2021. During that time, I graduated from the University of Rochester in 2022 with a Bachelor of Arts in environmental studies, then from Dalhousie University in 2024 with a Master of Environmental Studies (MES). I'm based in Halifax, in the heart of the Maritimes, with the ocean at my doorstep. My passions include theatre, music, dance and nature in all its forms. I'm honored to be here and extend my gratitude to Greg Trauthwein, who not only took a chance on a college student five years ago but has provided immeasurable guidance and support since then.

I hope you enjoy this edition and that it serves as a guide to better understand the world around us.

Celia Konowe
Managing Editor

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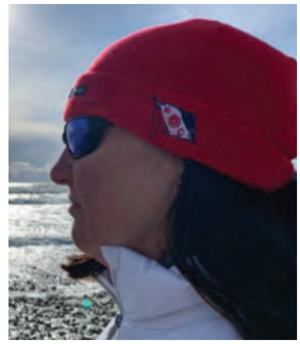
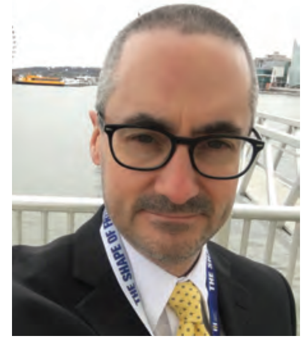


Strachan



Blough

Scott Blough is a strategic partner. He is a respected figure in national and international security circles, actively contributing to initiatives such as NATO's Combined Joint Operations for the Sea Centre of Excellence's Maritime Security Information Sharing Working Group. A renowned speaker and thought leader, Mr. Blough has shared his insights at prestigious venues, including NATO, DHS Centers of Excellence, and the US Coast Guard.

Laursen

Wendy Laursen has 20+ years of experience as a journalist. In that time, she has written news and features for a range of maritime, engineering and science publications. She has completed a Master of Science research degree in marine ecology as well as diplomas in journalism, communication and subediting.

Moniz

Rhonda J. Moniz is host of MTR's DEEP DIVE podcast. She is an underwater forensics expert specializing in diving technologies and subsea systems. She has more than 25 years of experience as a ROV pilot, master dive instructor, scientific diver, and dive safety officer. She is the president of the board of directors for the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS).

Strachan

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

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Gallaudet

The Honorable Tim Gallaudet, PhD, Rear Admiral, U.S. Navy (ret) is the CEO of Ocean STL Consulting and host of *The American Blue Economy Podcast*. He serves on several boards, is a fellow at The Explorer's Club, and is a strategic advisor for a few dozen startups, research institutions, and nonprofits in the ocean, weather, climate, and space sectors. Gallaudet is a former acting Undersecretary and Assistant Secretary of Commerce, acting and Deputy Administrator of the National Oceanic and Atmospheric Administration (NOAA), and Oceanographer of the Navy. He has a bachelor's degree from the U.S. Naval Academy, and master and doctoral degrees from Scripps Institution of Oceanography.

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*.

| DEEP STRIKE |

SEABED WARFARE WILL TARGET MORE THAN CABLES AND PIPELINES

By David Strachan, *Strikepod Systems*

Image above: The RTX Barracuda, a tethered, semi-autonomous mine neutralizing underwater vehicle.

In March 2024, scientists with China's Northwestern Polytechnical University published an article in the peer-reviewed journal Ships and Offshore Structures with the relatively benign title, "Numerical investigation for the blockade capability of the multi-BWBUG cooperative system." In addition to analyzing self-organizing underwater mesh networks of blended wing body underwater gliders (BWBUGs), the article explores the potential for pods of BW-BUGS to fulfill a combat role by striking targets lying on the seabed. The article features an illustration that, at first glance, appears to depict a strike package of stealth bombers flying low over rugged terrain. Except the craft aren't stealth bombers—they're BWBUGs. And the terrain isn't rolling countryside—it's the ocean floor.

Discussions of seabed warfare are usually centered around attacks on critical underwater infrastructure (CUI)—power and telecommunications cables, oil and gas pipelines. But while these nodes in the global information and energy grids are indeed critical, they represent just one target set within a rapidly evolving undersea domain. Seabed warfare will increasingly be defined by the need to contest a dense battlespace teeming with sensor networks, communications nodes, autonomous vehicle hubs, and energy systems, with a range of commercial, scientific, and military assets, potentially finding themselves on a subsea strike target list. A 2023 Hudson Institute report, "Fighting Into the Bastions: Getting Noisier to Sustain the U.S. Advantage," goes so far as to frame the coming battle for undersea supremacy as an analog to World War II and Cold War air operations. "Improved adversary defenses could degrade or defeat US undersea operations, preventing U.S. submarines from conducting critical missions such as sinking a Chinese invasion fleet or tracking Russian ballistic missile submarines (SSBNs)," writes Bryan Clark and Timothy A. Walton, Senior Fellows at the Hudson Institute's Center for Defense Concepts and Technology. "To sustain its offensive undersea advantage, the U.S. Navy will need to take some lessons from air warfare and begin supporting submarines with systems designed to suppress or destroy enemy undersea defenses."

What exactly are some of these assets and defenses?

- **Fixed Sensor Networks:** Designed for surveillance of chokepoints, EEZs, and even open ocean transits, these sensitive arrays provide persistent monitoring of surface and subsurface operations. Severing, spoofing, or jamming them would create blind spots in situational awareness.
- **Energy and Docking Stations:** Enabling long-duration, in-situ deployment of UUVs and other autonomous un-

dersea systems, these might include UUV docking systems, like the U.S. Navy's Forward Deployed Energy and Communications Outpost (FDECO) concept, or resident energy sources, like Teledyne Marine's Subsea Supercharger, as well as tidal, thermal, or cabled recharging stations.

- **Communication Relays:** Subsea acoustic relays, optical links, and data transfer nodes will be critical for enabling distributed underwater operations, and for linking undersea platforms to surface, air, or space-based assets.
- **Position, Navigation, Timing (PNT) Infrastructure:** Recalibration nodes for submerged vehicles operating beyond GPS coverage, as well as LBL beacons for local or regional UUV deployments, will be essential to ongoing underwater operations. Disabling or spoofing them could misdirect assets, increasing risk of mission failure.
- **Modular Launch Systems:** Payload modules containing unmanned vehicles, sensors, or effectors could be prepositioned during peacetime for remote activation in the event of armed conflict. Destroying them preemptively would remove this latent capability before it can be brought to bear.

Subsea strikes will require platforms capable of precision localization, maneuverability, and autonomous delivery of kinetic or non-kinetic effects using pre-programmed or remotely updated targeting. Several such systems are approaching maturity and may be ready for deployment in the near future:

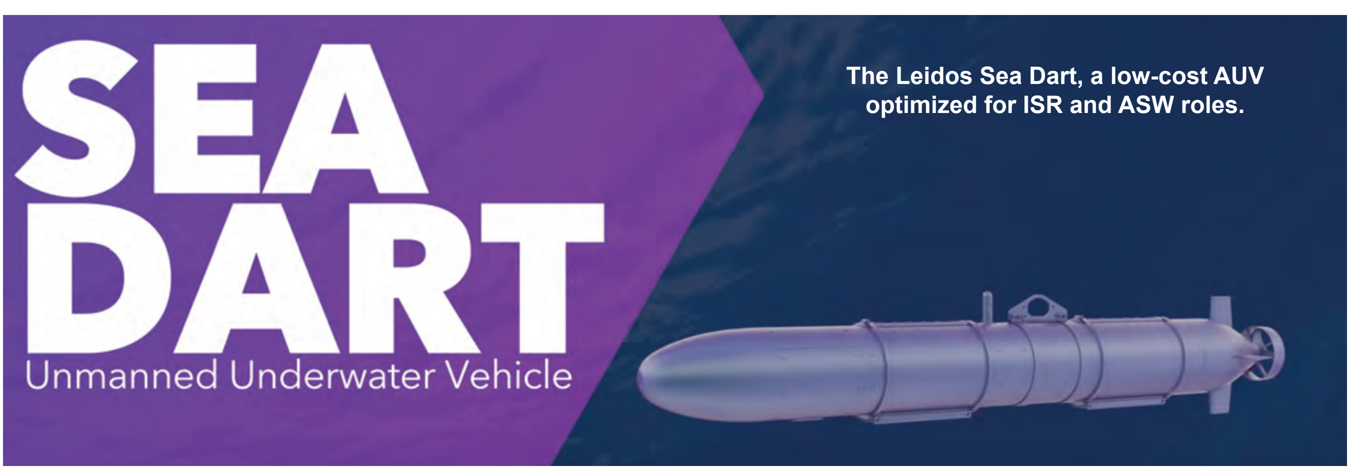
The Anduril Industries Copperhead is a "high speed underwater munition" hybrid UUV/torpedo, available in two variants—a 21-inch diameter vehicle, analogous to the U.S. Navy's Mk-48 heavyweight torpedo, and the Copperhead-M, a 12.75 inch diameter vehicle, analogous to the U.S. Navy's Mk-54 lightweight anti-submarine warfare (ASW) torpedo.

The Leidos Sea Dart, a low-cost AUV optimized for ISR and ASW roles, could be weaponized to attack seabed targets. Its 19-hour endurance and depth rating of 600 meters (1968 feet) would enable standoff deployment against a wide range of undersea infrastructure. The Sea Dart is currently available in 6 and 9 inch (152 and 226 mm) diameters, with a 12.75 inch (323 mm) under consideration.

The RTX Barracuda, a tethered, semi-autonomous mine neutralizing underwater vehicle could be repurposed as an offensive subsea strike weapon. Mine countermeasures (MCM) is essentially a defensive operation for striking seabed kinetic effectors emplaced by adversaries to shape or deny the maritime battlespace. Deployed from a canister launcher aboard

UCT 2's Construction Dive Detachment Charlie (CDDC) is performing subsea cable maintenance at the Pacific Missile Range Facility (PMRF).

Credit: U.S. Navy photo by Builder 2nd Class Joseph Hophan/Released



The Leidos Sea Dart, a low-cost AUV optimized for ISR and ASW roles.

Credit: Leidos

an unmanned surface vehicle (USV), the Barracuda could conceivably be reengineered with increased pressure tolerance and a longer tether, or untethered acoustic communications for autonomous operations, to strike deeper seabed targets.

The Areté REMORA, developed under a Navy SBIR/STTR contract, is a scalable, hydrodynamic payload delivery system that allows expendable payloads to be externally deployed from virtually any UUV. The REMORA module attaches to the vehicle's hull using a high-strength vacuum force, and is self-deployed by the host vehicle using a high-frequency, through-hull acoustic signal. A BWBUG such as Northrop Grumman's Manta Ray could carry multiple REMORAs in order to deploy clusters of kinetic effectors against seabed targets. Subsea strike would not require a target's complete or even near destruction to achieve operational or strategic effects. Minor damage, such as throttled power throughput, a degraded hydrophone array, or a compromised pressure housing could achieve mission kills like localized ISR blackouts, severed C2 comms, drained batteries, or the suppression of a prepositioned effectors. Moreover, repair or replacement of damaged systems would require specialized vessels, ROVs, and trained crews operating in challenging conditions. Adversaries may lack the capacity, or an uncontested environment, to respond, turning a minor subsea strike into a long-term disruption.

Just as air warfare evolved to target logistics hubs, radar arrays, communication nodes, and munitions depots, subsea and seabed warfare (SSW) will see states and nonstate actors target not only CUI, but the full range of systems and infrastructure populating the underwater battlespace. At the operational level of war, subsea strike will be essential for enabling freedom of maneuver for crewed submarines and other high-value undersea platforms. But it will also offer a means to project power and impose costs without crossing the threshold of open conflict, all while avoiding detection or attribution, making it a strategic force multiplier as well.

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.

U.S. Navy photo by Mass Communication Specialist 1st Class Justin Yarborough/Released

THE FROZEN FRONTIER'S HIDDEN THREAT: Cybersecurity in the Arctic's New Era

By Scott Blough

Image above: The Arctic region has become an area of intense geopolitical interest and competition. Field technicians assigned to the Arctic Submarine Laboratory prepare to remove ice from the Los Angeles-class attack submarine USS Hampton (SSN 767) at Ice Camp Whale on the Arctic Ocean, during Operation Ice Camp (ICE CAMP) 2024. ICE CAMP is a three-week operation that allows the Navy to assess its operational readiness in the Arctic, increase experience in the region, advance understanding of the Arctic environment, and continue to develop relationships with other services, allies, and partner organizations.

The Arctic, once a remote and isolated frontier, is rapidly transforming into a hub of activity. Increased shipping, resource exploration, and scientific research are reshaping the region, ushering in a new wave of challenges – particularly in the critical domain of cybersecurity. As a maritime cybersecurity expert, I observe unique threats emerging in this icy environment, where fragile infrastructure, escalating geopolitical tensions, constrained communication bandwidth, and the looming specter of deliberate cable disruption create a perfect storm for cyberattacks.

The Shadow of Deep-Sea Cable Cutters

Beyond traditional cyber intrusions, a significant and tangible threat is now emerging: the reported Chinese patent on a deep-sea cable cutter. While ostensibly designed for maintenance or salvage operations, the existence of such technology raises serious concerns about its potential for malicious use. In the Arctic, where undersea data cables are increasingly vital for communication, scientific data transfer, and even military operations, this technology presents a direct physical threat to critical infrastructure.

Imagine the impact of a deliberate cut to a vital undersea cable in the Arctic. It could cripple communication networks, disrupt navigation systems essential for safe passage in treacherous waters, and severely impede scientific research. The remoteness and harsh conditions of the Arctic would make detection, repair, and attribution incredibly challenging, amplifying the potential for prolonged disruption and strategic advantage for the perpetrator.

Infrastructure Limitations: A Vulnerable Foundation

The Arctic's unforgiving environment and dispersed population present formidable obstacles to building and maintaining robust infrastructure. Limited access to dependable power, internet connectivity, and physical security measures inherently weaken systems against both cyber and physical attacks. This vulnerability is particularly alarming for essential infrastructure such as ports, communication networks, and navigation aids, all crucial for safe and efficient operations in this challenging region.

Consider a remote research outpost relying on a single, vulnerable fiber optic cable for its connection to the outside world. This lifeline becomes a prime target, not only for cyber intrusion but also for physical severance. A successful attack, whether digital or physical, could paralyze operations, lead to environmental damage, economic repercussions, and even endanger lives.

Geopolitical Tensions:
Nation-State Actors in the High North

The Arctic is also an arena of growing geopolitical significance, with numerous nations vying for influence and control. This competition has fueled increased military presence and a heightened risk of cyber espionage, sabotage, and potentially, the strategic disruption of undersea infrastructure. Nation-state actors are increasingly targeting critical infrastructure and sensitive data in the Arctic, seeking strategic advantages or aiming to destabilize operations. The presence of technology capable of severing vital communication links adds a dangerous new dimension to these tensions.

Envision a scenario where a sophisticated cyber-physical attack combines a digital intrusion with the deliberate cutting of a key Arctic undersea cable. This could have profound economic and security ramifications, disrupting global trade, hindering military capabilities, and significantly escalating tensions between nations.

Communication Bandwidth: A Bottleneck for Security and Resilience

Limited communication bandwidth remains a significant impediment in the Arctic. The reliance on satellite communication, with its inherent latency and restricted capacity, complicates the implementation of robust security measures, such as real-time monitoring, intrusion detection, and swift incident response – both for cyber and physical incidents. The vast distances and challenging conditions also make rapid repair of damaged undersea cables a logistical nightmare.

Picture a scientific expedition in the Arctic diligently collecting critical climate data. Constrained bandwidth makes secure and timely transmission of this data back to research centers a challenge, increasing the risk of data interception or manipulation. Furthermore, in the event of a cable cut, the limited alternative communication channels would severely hamper repair efforts and coordination.

Navigating the Heightened Challenges: A Multi-Layered Approach

Addressing these multifaceted cybersecurity challenges, now compounded by the physical threat to undersea cables, demands an even more comprehensive, multi-layered approach:

- **Strengthening Infrastructure and Physical Security:** Investing in resilient infrastructure, including secure communication networks, reliable power sources, robust physical security measures for cable landing stations, and enhanced monitoring capabilities for undersea cables.

- **International Cooperation and Transparency:** Fostering greater international cooperation to share threat intelligence – including information on potentially threatening technologies – develop common security standards for both cyber and physical infrastructure, and coordinate incident response efforts. Increased transparency regarding the deployment and purpose of deep-sea technologies is also crucial.
- **Enhanced Security Measures:** Implementing robust cybersecurity measures, including strong authentication, encryption, intrusion detection systems, regular security assessments, and developing specific protocols to detect and respond to potential physical threats to undersea cables.
- **Cybersecurity and Physical Security Awareness:** Educating personnel operating in the Arctic about both cyber and physical security threats and best practices, emphasizing the vulnerability of undersea infrastructure.
- **Developing Rapid Response Capabilities:** Investing in technologies and logistical capabilities for the rapid detection, assessment, and repair of damage to undersea cables in the Arctic's challenging environment.

The Arctic is a unique and increasingly critical environment, and safeguarding its digital and physical infrastructure must be a paramount priority for all stakeholders operating in the region. By understanding the specific and evolving risks, including the tangible threat posed by technologies like deep-sea cable cutters, and implementing appropriate security measures, we can strive to ensure the safe, sustainable, and secure development of this vital part of our planet.

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About the Author

Scott Blough is a strategic partner. His deep understanding of the intricate security challenges facing today's businesses, coupled with his extensive background in law enforcement, corrections, criminal justice information systems, financial fraud, and digital forensics, positions him as a sought-after advisor.

Credit: Lieutenant (N) Pamela Hogan, Naval Reserve Headquarters Public Affairs

COMING IN FROM THE COLD:
CANADIAN ARCTIC SECURITY TAKES CENTER STAGE

By Celia Konowe

Image above: Sailor First Class Clay Ridd conducts ice dive in Tuktoyaktuk, NWT on Operation NANOOK NANULIVUT.

More than 75% of Canada's world-leading coastline (upwards of 150,000 miles or 240,000 kilometers) is Arctic, along with roughly 40% of the land. Geopolitical instability, mixed with strained relations with the United States, a rapidly warming climate and constant technological advancement have heightened northern security concerns, especially for a nation so intertwined with Arctic ecosystems and communities.

WARM WEATHER, FROSTY RELATIONS

Although challenges to Arctic security are not singular to Canada, they are numerous and complex, requiring multifaceted solutions. "The Arctic has historically been a region of cooperation; [yet] strategic competition, climate change, technological advancements and economic interests are coming together in a way that makes this region more strategically important than ever before," explained Nick Drescher Brown, spokesperson for the Department of National Defense (DND). "Competitors are demonstrating a more assertive posture and employing dual-use tactics, such as seemingly innocuous economic or scientific activities that act as a cover for military intelligence collection and planning."

The Arctic is warming at four times the global average, making a vast and sensitive region even more accessible to other nations with an interest in hitherto inaccessible transportation routes, natural resources, critical minerals and energy sources. By 2050, according to Canada's 2024 defense policy "Our North, Strong and Free," the Arctic Ocean could become the most efficient shipping route between Europe and East Asia. The Northwest Passage has already begun to see more activity and increased accessibility may allow Canada to build more of its own infrastructure, but that leaves the door open to outside interests seeking to capitalize. Changing glaciology also requires new and updated technology that can keep pace with a melting environment.

At the same time, rapid advances elsewhere speed up the impact of competition and global warming. "Artificial intelligence, quantum computing, synthetic biology, data analytics, autonomous systems, robotics and advanced cyber and space technologies are frontier technologies whose military and non-military uses create new vulnerabilities and complicate our national security interests," states the defense policy.

Arctic security threats go beyond Canada, extending to the whole of North America. "In the face of these unprecedented, intersecting challenges in the Arctic, Canada and our allies must prepare to respond in a manner that addresses persistent activity that threatens the rules-based international order and provide increased safety and security, while improving the lives of Indigenous and Northern communities," said Drescher Brown. As a nation that is uniquely Pacific, Atlantic and Arctic, solutions must be sought at home and advocated across borders.

ELBOWS UP

In 2022, Canada announced an investment of $27.7 billion (CAD$38.6 billion) over the next 20 years in the North American Aerospace Defense Command (NORAD). "This upgrades our NORAD capabilities and our ability to respond to any threats posed by the increased accessibility of our shared continent due to climate change, shifting geopolitics and new military technologies used by our adversaries," said Drescher Brown.

The funds will modernize surveillance systems and defensive weapons, including those to counter hypersonic and

Image below: Members of 1 Canadian Ranger Patrol Group and Sergeant Andrew Deutsch of the CH-147F Chinook crew loading a snowmobile to prior to takeoff to the Ski Landing Area (SLA) camp as part of Operation NANOOK-NUNALIVUT in Inuvik NWT.

Credit: Corporal Jacob Hanlon, Canadian Forces Photo cruise missile threats, as well as increase technology-enabled decision making, infrastructure and support capabilities, plus research, development and innovation.

Within Canada, Operation (Op) NANOOK, run by the Canadian Armed Forces (CAF), plays a crucial role in domestic defense and security measures. Op NANOOK is a comprehensive series of activities taking place annually across Yukon, the Northwest Territories and Nunavut, with more than five deployments throughout the year. The latest iteration comprised 450 CAF members alongside about 110 troops from the United States, Belgium, the United Kingdom, Finland, Sweden, Norway and Denmark.

"At its core, Op NANOOK strengthens the CAF's knowledge of this vital region, allows us to work hand-in-hand with our fellow Arctic nations and key allies, and fortifies our close partnerships with federal, territorial and local communities," explained Drescher Brown. "Working in Canada's North also hones our ability to operate in a challenging environment requiring unique skillsets, in-depth local knowledge, and support and equipment designed to operate in extreme weather conditions."

TECH FROM DOWN UNDER

Defense tactics outlined in "Our North, Strong and Free" include a renewed and expanded submarine fleet, specialized maritime sensors, a new satellite ground station in the Arctic, expanded helicopter capabilities, new vehicles adapted to local conditions, establishing northern operational support hubs, new defense infrastructure, and establishing a CAF Cyber Command.

Drescher Brown noted that as part of Canada's NORAD investment, DND is acquiring Jindalee Operational Radar Network technology from BAE Systems Australia that will be critical to establishing the Arctic Over-the-Horizon Radar (A-OTHR) system and strengthening domain awareness in the North.

The $4.31 billion (CAD$6 billion) A-OTHR, announced by

Image below: Canadian Armed Forces members from the Advanced Naval Capabilities Unit deploy the Prosecutor Remote Operated Vehicle (ROV) for a search and retrieval exercise in a dive site located in the Arctic Ocean, off the coast of Tuktoyaktuk as part of Operation NANOOK-NUNALIVUT.

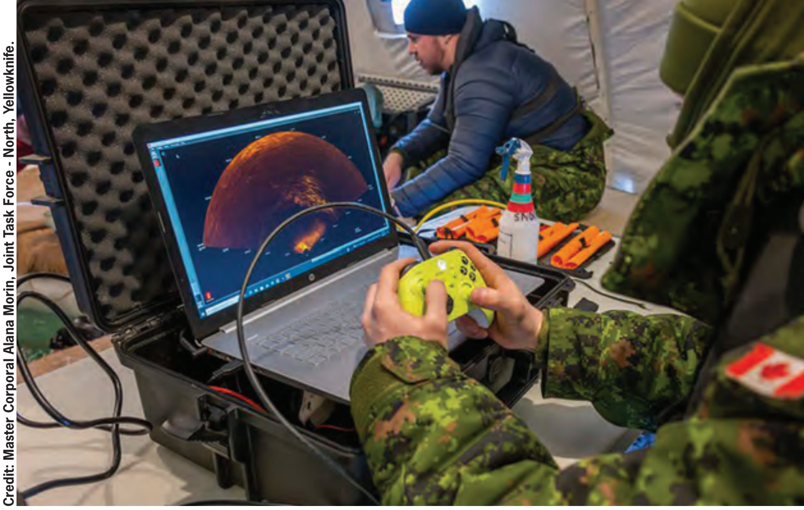
Credit: Master Corporal Alana Morin, Joint Task Force - North, Yellowknife.

Prime Minister Mark Carney in Iqaluit, Nunavut on March 18, will provide advanced early warning and long-range surveillance, enabling faster CAF detection and tracking of a wide range of threats in northern air and maritime approaches, while strengthening NORAD domain awareness. The A-OTHR radar sites will be based in southern Ontario, with up to four areas for the system's transmitters and receivers.

FOR CANADA, FOR NATO

Canadian Arctic security measures, while serving primarily to protect that nation and the United States, are also critical in broader defense of NATO's western and northern flanks against rising adversaries. "Investments in this unique responsibility enable Canada to engage the world from a position of strength and support our allies against potential threats and challenges to our sovereignty," said Drescher Brown.

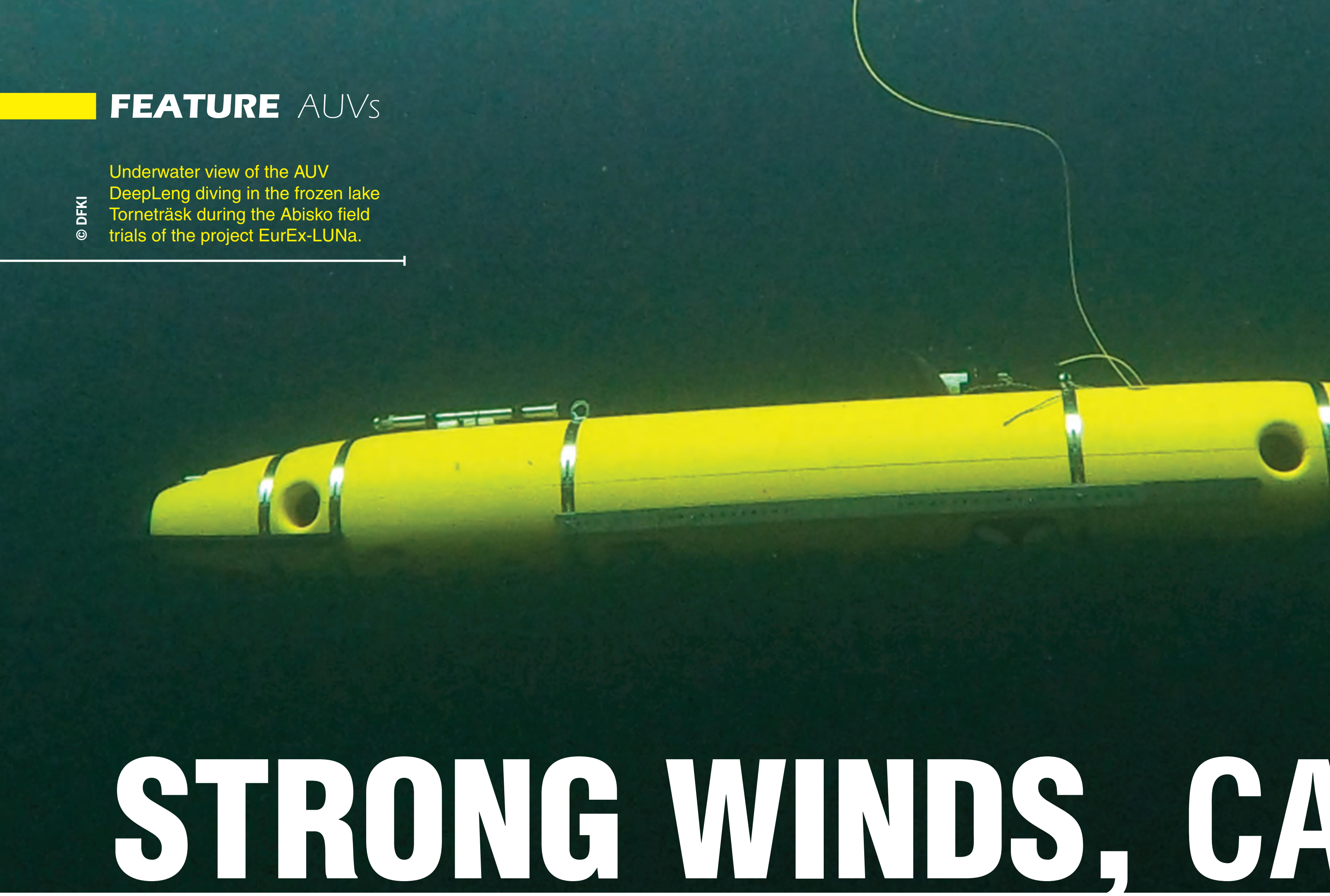
In isolation, a revanchist Russia and emboldened China leveraging everything from subtle grey-zone subterfuge to the latest hypersonic missile technology imperil the long-held assumptions that underpin Canadian Arctic security. Combine them with a warming climate, increased foreign competition and an undermining of the rules-based order and it's clear that Canada must be bold in its northern defense strategy and investments.



Credit: Master Corporal Alana Morin, Joint Task Force - North, Yellowknife.

With the April 28 federal election now behind him, Carney will be expected to deliver not just A-OTHR, but also new submarines, additional heavy icebreakers and an expanded Canadian Coast Guard as part of his party's defense commitment.

"We recognize that we must place particular focus on defending the Arctic and North and its approaches against new and accelerating threats through credible deterrence," said Drescher Brown. "We will secure our Arctic and North by increasing the presence, reach, mobility and responsiveness of the Canadian Armed Forces in the region, and along our coasts and maritime approaches. We will also develop greater striking power to deter adversaries and keep threats farther from our shores."



Underwater view of the AUV DeepLeng diving in the frozen lake Torneträsk during the Abisko field trials of the project EurEx-LUNa.

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STRONG WINDS, CA

AUVs to facilitate wind farm marine ecosystem analysis and protection

By Celia Konowe

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In the race for renewables, scientists and researchers must keep operations as sustainable as the energy itself. Offshore wind is no exception; as the industry sees increasing demand and quick growth, establishing environmentally responsible operations and monitoring early on are key for long-lasting systems that are not destructive to local biodiversity.

The SeaMe project (Sustainable Ecosystem Approach in Monitoring the Marine Environment), set to run from 2024 to 2026 at an RWE AG wind farm in Kaskasi, Germany, is trying to do just that. With innovative technologies like autonomous underwater vehicles (AUVs), researchers can conduct comprehensive ecosystem monitoring that is less costly, invasive and CO2-intensive. Findings will highlight the overlap between offshore wind farms and the local ecosystem by collecting physical and biological data. Parameters like temperature, salinity and oxygen may identify changes in the distribution and abundance of species, stated a press release from RWE. This includes critical contributors like phyto and zooplankton, which play fundamental roles in the food chain but are often overlooked.

The demands of the SeaMe project require multiple partners with varied expertise, each covering a special task within the wind farm's ecosystem, explained Marius Wirtz, Dipl.-Ing. (FH), Engineer at the German Research Center for Artificial Intelligence (DFKI) and project leader of the AUV team. In addition to DFKI, collaborators include the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI), Helmholtz Institute for Functional Marine Biodiversity at the University of Oldenburg (HIFMB), BioConsult SH, the Danish company DHI A/S and the Norwegian company Spoor AS.

ECOSYSTEM EXAMINATION

The AUV team from DFKI will monitor the underwater ecosystem. "The goal is to replace invasive sampling methods such as fishing with trawler nets, reduce CO2 emissions and help to generate a more complete view of the ecosystem. Our underwater robot, DeepLeng, aims to detect fish and sea mammals using computer vision and cutting-edge machine learning technologies." Plus, the vehicle will record oceanographic parameters such as temperature, salinity, chlorophyl-a and turbidity, creating a holistic understanding of the wind park's ecosystem.

The project also offers a deeper look into the applications and needs of offshore wind and the opportunity to gain more experience with robots.

DFKI boasts an impressive selection of robotic systems, but DeepLeng made the cut because of its relatively small size while carrying a big number of sensors and capabilities required for the task, explained Wirtz. Data sampling should also be fully autonomous with DeepLeng, allowing for better collection and pushing boundaries in future deployments. The AUV also already carries multiple onboard cameras for fish detection and a payload bay for additional scientific instruments.

In addition to DeepLeng's current abilities, it will host a newly designed object detection neural network to identify and clarify various species observed by onboard cameras. "The trained model will be deployed on a dedicated computing module for real-time, in-situ predictions, enabling the AUV to detect specific species and respond accordingly," Wirtz noted. "This approach, we believe, will allow the system to capture richer data, improving the quantification of species abundance in the studied habitats."

DeepLeng will be deployed by a crew transfer vehicle (CTV) that enters the wind park daily to transport technicians and equipment to the individual turbines. The AUV will be the only one deployed for data collection at this point.

The coming month will see the team moving out of the lab and into the offshore environment. DeepLeng will be tested in a water tank, followed by trials in a nearby lake, said Wirtz. "Eventually, testing will extend to our marine test field in the North Sea, off the coast of Heligoland, which we operate in collaboration with Fraunhofer IFAM. Starting from October our team will also participate in the offshore field trials in the wind park Kaskasi, 35 km north of Heligoland, Germany." Ideally, depending on weather and seasonality, data will be collected once a month.


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Launching the **AUV DeepLeng** into the frozen lake Torneträsk during the Abisko field trials of the project EurEx-LUNa.

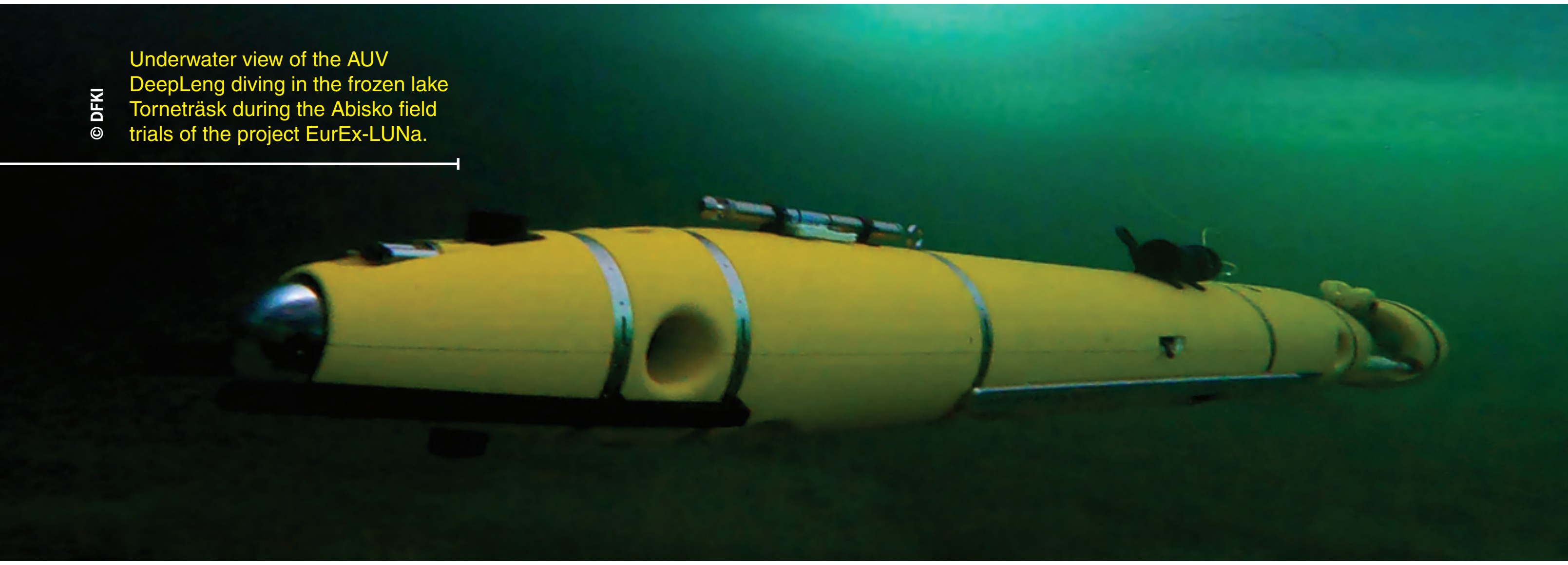
TRAILBLAZING TECH

Underwater vehicles serve a significant role in the future of the maritime industry across multiple uses and for numerous reasons. "There are many applications such as conventional or renewable energy production, general infrastructure inspection and maintenance in harbors or inland waters, food production (fish or algae farms) or surveillance of critical infrastructure," explained Wirtz. The offshore wind industry in particular is rapidly growing, in both coastal areas and deeper waters. There is an increasing number of wind parks and related tasks (including construction, inspection, maintenance and decommissioning), but a lack of specialists. Human safety is also of the utmost importance.

Unmanned vehicles, whether autonomous or teleoperated, can fill these gaps. They are also more efficient in terms of work and emissions and can reduce costs by avoiding the need for bigger vessels, Wirtz said.

SYNERGIZING SUSTAINABILITY

The SeaMe project offers a look into proactive sustainability measures for offshore wind farms, as environmentally responsible energy production must account for local ecosystems. Through unique research collaboration, impacts on marine biodiversity around the wind farm can be monitored, minimized and mitigated. DFKI's DeepLeng AUV plays a key role in data collection and AI-based video monitoring, providing information on species in their habitat without disruption.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Underwater view of the AUV DeepLeng diving in the frozen lake Torneträsk during the Abisko field trials of the project EurEx-LUNa.

Inside the NOC ROBOTICS CENTER

Much innovation in subsea robotics starts in academia, and the National Oceanography Centre in Southampton, UK, is a global leader with a fleet of more than 40 systems and 60 engineers and scientists. **Alex Phillips**, is the Head of Marine Autonomous Robotic Systems (MARS) at NOC, and ***Marine Technology*** recently caught up with him in his workshop to discuss key drivers in the evolution of efficient, effective underwater autonomous systems.

By Greg Trauthwein

Alex, can you give us a brief career background and your role here at NOC?

I'm a naval architect by training. I thought I would go and design yachts for a living;, I got a little distracted, and started sinking things. About 15 years ago, I got involved in a student competition to design and build AUVs. And that was much more interesting than what I was doing for a real job at the time. I got to build these small AUVs, do all the software, do all the hardware, do all the electronics, to break them… they never really worked very well. But in that process, I got a real passion for building this kind of technology. So, I finished my PhD at Southampton, and then came down to the NOC 10 years ago to run projects and build a team to develop new and cool robots. Ten years later, I'm heading up the facility here. So, we've got about 40 marine robots, and we've got about 60 engineers, computer scientists, and researchers. And we're all here to develop, build, operate, [subsea vehicles] and go and make measurements in the ocean for the ocean science community.

Why don't you tell us a little bit about the NOC's autonomous robotics fleet?

We have a fleet of about 40 vehicles, and they vary substantially. So, we buy in a lot of kit, so we buy underwater gliders. We've got a large ROV. We also design, build, and operate the Autosub AUVs. And these are the bit that really excite me because this is all the stuff that we do in-house. We've designed them, we've built them, we've written all the software, we've designed the control systems. We've crashed them, thrashed them, and occasionally lost them. But we really understand every bit of the subs, and that allows us to adapt them for trying to gather different types of ocean science data that people haven't done before.

What are the drivers for these vehicles today?

So, we see a lot at the moment around persistence, being out in the water for longer. So, whether that's deploying gliders from shore and having them operate for weeks or months; putting these long-range vehicles out for weeks and months, that ability to get vehicles out and about without the need for a research ship, that's really quite a big driver for us at the moment. It just allows us to expand on what we can do. We can't do anywhere near everything they do with a ship with one of these, but we can do some of it. And if by doing some of it, we free the ship up to go and do the stuff we can't do, so it's a win-win.

On the science requests side, we always see requests for under ice. A lot of the Autosub program originated with some of the under ice work in the early 2000s. So that's always a driver, and we're just seeing more and more of it, driven by the need to understand melt rate of glaciers, sea ice thinning, all of these really important problems. We are also seeing a lot more requests around the carbon cycle, so understanding how the ocean sequesters CO_2. And, obviously, if you can put sensors onto these vehicles that can measure things like pH, total alkalinity, dissolved inorganic carbon, you can start to help scientists get to grips with what's a really complicated problem.

In the span of your career, what technologies do you count as being the most dramatic in their impact on the efficiency of these operations?

The really boring answer: a lot of it is just about polishing the basics. Actually, having these systems be robust, so you put them in the water and they work. And that takes a long time. Go and ask anyone who develops ocean tech, and it takes a long time to get things really robust in the water. And if we're honest, we've spent a long time doing that with our tech. But, now, we've got a very stable, robust platform. We've got some really interesting opportunities to leverage some of the new technologies that are coming. So, there's some really interesting sensor technology coming through at the moment, which is allowing us to measure new parameters. Some of the lab-on-chip type technologies that are developed here, now, able to put a full chemistry lab onto these vehicles to measure the nutrients and the carbon chemistry in the water column.

New imaging systems that we can put onto these vehicles to

"One of the areas that we're interested in is using some of the machine learning tools is to identify faults onboard the vehicle because, sometimes, it's really hard to disentangle why a vehicle isn't going up or down in the water column. Is the pitch sensor broken? Is it the pressure sensor broken? There are all sorts of different failure modes which can lead you to not be moving up and down in the water column the way that you'd like to."

– Alex Phillips,

Head of Marine Autonomous Robotic Systems (MARS)

either look at the plankton in the water column or count the critters on the seabed. The increase in sensor capability has allowed us to tackle some new problems. But, also, the long-range vehicles we have, because they're a bit bigger, it allows us to stack more sensors on board so you're not just measuring a single parameter now, you've potentially got, as I said, lots of carbonate chemistry, lots of nutrient chemistry, all going on board with turbulence, with CTD. You can build a much more capable platform. And as we're getting more data, then you're starting to really run into things like machine learning and the need for those kind of technologies to deal with the data sets that are coming off the platforms, particularly around the imaging. Hopefully, the days of PhD students having to go through 100,000 Autosub images with the seabed to count the critters are gone, and we can start to use some smarter tools for that.

Can you talk wholistically about AI, machine learning, and how that is materially impacting the work that you do?

We use it in a number of areas. We've been doing some work with Oxford Robotics Institute, running gliders up in the North Sea, where they've designed some clever algorithms to pilot gliders, and reduce the human overload with constantly running vehicles. We use AI, as I talked about, for data interpretation. That sits over more with the science community, and they use it extensively to try and deal with the data sets that we're generating.

One of the areas that we're interested in is using some of the machine learning tools is to identify faults onboard the vehicle because, sometimes, it's really hard to disentangle why a vehicle isn't going up or down in the water column. Is the pitch sensor broken? Is it the pressure sensor broken? There are all sorts of different failure modes which can lead you to not be moving up and down in the water column the way that you'd like to. So, can you use some of the machine learning tools to do anomaly detection in the first instance? If something's wrong, can we do something about it? Or can you more accurately identify and pin down faults to particular systems so that you can react in an advisable way, given the information you've got?

When you look back, was there one mission, one particular use of your vehicles, that you were like, "Wow," that really stands out?

I think with the Autosub long-range vehicles, the activity we did last year as part of the NERC funded BIO-Carbon Program. We launched two ALRs from Iceland with biogeochemical sensor fits, and the ambition was to get them all the way back to Scotland. We didn't quite manage that with both vehicles, one did have to be recovered early. But the other vehicle made it all the way from Iceland to Scotland, which was quite a long way for an AUV.

What was really interesting was the kind of science that we were doing, the sensors that were on board. It was packed full of these lab-on-chip chemical sensors, and we spent a huge amount of time working with the science users just to figure out what they were trying to measure, and how we had to get the vehicle to operate. With a normal AUV, you imagine them flying at a constant depth, or a constant altitude, above the bottom. With a glider, you manage them yo-yoing through the water. With these vehicles, we were doing a hybrid. We were stepping through different layers in the water to make chemical measurements in different water masses. We were doing the profiling up and down to get the vertical gradients. We were chasing floats. We were meeting up with ships. We were out in the water for six weeks, and it was a really exciting activity for us because it really started to show what you can do with this kind of tech.

Persistence is important, and there's a lot of work going into keeping the vessels at sea longer, include 'electrification' of the seabed. Where are we today in terms of keeping these AUVs powered, out and persistent?

It's a really interesting question. There are two approaches out there for this persistent AUV operation. You've got more hover-style vehicles that are docking onto the seabed and recharging to keep their energy supplies up. We've taken a much simpler approach: where we just pack the things full of primary batteries to get that long endurance. With that, we go for low-power sensors; we go through the water slowly. By managing that energy budget, you can potentially eke out one of these vehicles to six months operation. But then you're into a whole load of new pain, with biofouling, corrosion, and other issues that you don't worry about for a two-week deployment.

*The preceding was edited for content and clarity. Watch the full interview with **Alex Phillips** on **Marine Technology TV**:*

MARINE TECHNOLOGY TV

JOHN SIDDORN

CEO, NATIONAL OCEANOGRAPHY CENTER (NOC)

In a world increasingly shaped by climate uncertainty and geopolitical volatility, understanding the ocean — Earth's largest and least explored environment — is no longer a scientific luxury; it's a global imperative. At the helm of one of the world's premier marine research institutions is **John Siddorn, Chief Executive, National Oceanography Centre (NOC)**, who discussed with ***Marine Technology Reporter*** from his office overlooking the Port of Southampton, the people, the priorities and the assets of NOC to effectively, efficiently and safely explore the world's oceans.

By Greg Trauthwein

Appointed CEO in 2023, John Siddorn brings more than three decades of expertise in ocean physics and climate modeling to the role. His leadership marks a strategic shift for NOC as it expands its role beyond academic research to become a pivotal partner for government, industry and society in the blue economy.

NOC: A Leader in Ocean Study

NOC as we know it today dates back to precursor institutions, each with long histories. As a national institution, it was formed in 1949 as the National Institute of Oceanography (NIO). NIO grew from the work of scientists working at Antarctic whaling stations and the complimentary voyages including Captain Scott's Discovery expedition and a small group of young scientists brought together during WWII, to study how the movements of the waves affected amphibious landings.

NOC's operations based in Liverpool stem from the Liverpool Observatory founded in 1843 (to measure the longitude of Liverpool and to measure tides). After a short period based in Liverpool it moved to Bidston and in 1919 became the Liverpool Tidal Institute. It led development of the methods of tidal prediction used world-wide today. It broadened its research over the years into prediction of storm surges and then

John Siddorn, right, with MTR's Greg Trauthwein on the balcony outside his office overlooking the Port of Southampton.

sea level science more generally, as well as coastal and continental shelf sea oceanography and marine data management.

In 1965 both the NIO and the Liverpool Tidal Institute became part of the then newly-formed Natural Environment Research Council (NERC), with the Tidal Institute becoming the Proudman Oceanographic Laboratory and NIO become the Institute of Oceanographic Sciences (IOS) in the 1970s. Both fwere then brought back together in 2010 as part of NERC's National Oceanography Centre (NOC).

Today, NOC is based in Southampton and Liverpool and has quickly become one of the most advanced centers for integrated oceanographic research and engineering worldwide. With a staff of more than 600 and assets ranging from deep-sea research vessels to fleets of autonomous underwater and surface vehicles, NOC serves as the UK's principal marine science body.

For Siddorn, who began his career as a physical oceanographer in the 1990s and spent significant time at the UK Met Office developing coupled ocean-atmosphere models, the role at NOC is the culmination of a lifetime dedicated to understanding Earth systems.

"This is the best job in the world," Siddorn says. "What attracted me most is NOC's ability to unite cutting-edge engineering, advanced science, and real-world societal impact under one roof."

"NOC is unusual in the sense that it does such a wide range of things in terms of the science it does, but it also does a really wide range of the engineering and the development of the underpinning capabilities that support that science. So, everything exists in this building in the sense that we have the ships to collect the observations. We also have cutting-edge novel technologies around the autonomy and those ships and autonomy coming together with the fixed-point moorings give us a very big part of the picture of what the ocean's doing."

That convergence of capability is what gives NOC its edge. From seabed sensors to satellite-linked gliders, from autonomous platforms to full-scale research ships, NOC delivers the data and insights that shape ocean policy, climate adaptation, and sustainable marine development.

The Backbone of Ocean Intelligence

NOC operates two major research vessels, the RRS Discovery and RRS James Cook, both central to the UK's national marine science infrastructure. These vessels are not just floating laboratories — they are foundational tools for understanding everything from volcanic seabed activity to carbon cycling in the open ocean.

"Our ships are capital-intensive, but they remain irreplaceable," Siddorn said. "Autonomous platforms are advancing fast, but ships still provide the necessary human and technical capacity for complex, remote missions."

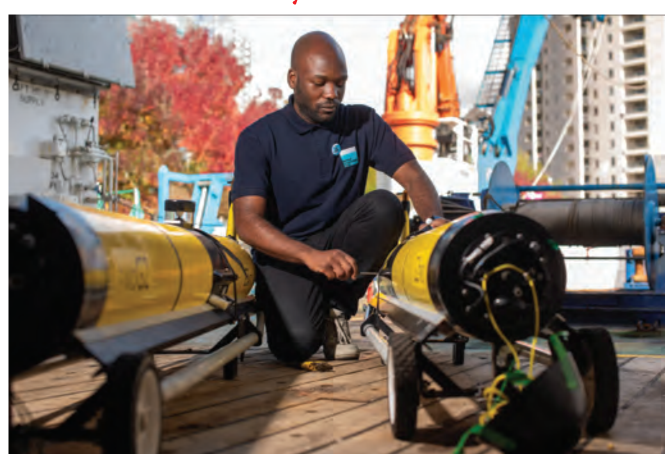
One recent voyage in the Mediterranean, for example, focused on seismic activity and gravity waves within an underwater volcanic caldera. Such missions are crucial for monitoring geohazards that threaten subsea infrastructure, including the world's expanding network of critical data cables. Another expedition in the mid-Atlantic examined the mechanisms by which carbon is sequestered into the deep ocean—a key process in understanding and mitigating global climate change.

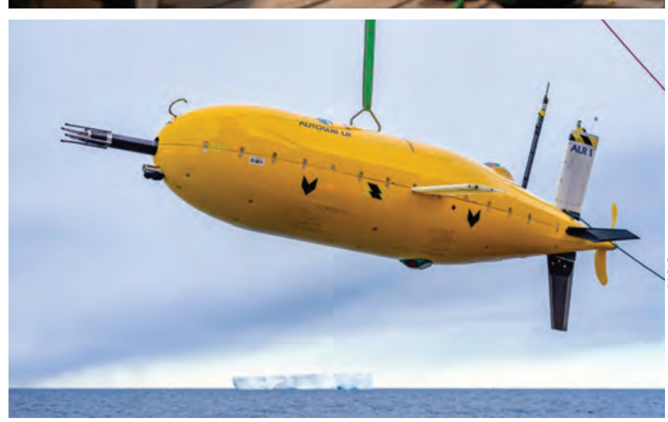
"These are not academic exercises," Siddorn notes. "They underpin our understanding of global systems that affect fisheries, weather patterns, climate policy and international security."

While air, ocean surface and subsurface autonomous vehicles tend to grab the headlines, Siddorn is resolute in his belief that ships have, and will continue to have for many years, a central role in studying the oceans.

"Ships are presently the only way we can get out into the deep ocean in a consistent way, carrying large payloads. There are some elements of autonomy now that are moving in that direction, but largely, they work in synergy rather than separately. You can use your ships to transport autonomy. And the way I see it in the future being the growth of this activity is that you'll have ships and autonomy scaling up where perhaps ships aren't necessary to do all of the heavy lifting in terms of gathering the data, but they are doing a lot of heavy lifting in terms of getting kit into the right place," said Siddorn. "You can't do novel engineering at 4,000 meters on a submersible. You can do it 10,000 miles away from a coastline on a ship with people on board testing things, checking to ensure things are working. So, you need the ships to progress science even where autonomy is a partner in that."

The Rise of Autonomy





Images courtesy NOC

> **This is the best job in the world.** ***What attracted me most is NOC's ability to unite cutting-edge engineering, advanced science, and real-world societal impact under one roof."***
> **– John Siddorn,** Chief Executive, NOC

While ships remain vital, NOC is leading the transition toward more scalable, cost-effective, and carbon-efficient methods of ocean observation. Its fleet of autonomous platforms — subsea gliders, autonomous underwater vehicles (AUVs) and unmanned surface vessels — represents one of the most diverse in the world.

Siddorn sees autonomy not as a replacement for traditional research infrastructure, but as a powerful force multiplier.

"Autonomy is at an inflection point. Five years ago, we couldn't dream of doing eDNA sampling or real-time chemistry from these platforms. Now we can," he says. "This technology is absolutely key to monitoring at scale."

With autonomy comes the challenge of scale. Siddorn envisions a future where NOC's ships act as motherships for fleets of autonomous vehicles, deploying and retrieving them for operations that stretch over thousands of miles and months at sea, as well as being able to deploy robotics from shore.

"There's a shift from bespoke, manual deployments to persistent, scalable monitoring systems," he says. "To meet the growing demands of the blue economy and climate observation, we must move toward more intelligent, distributed observation networks."

The manual nature of how we've done things in the past is just not going to solve the problems in the future. So, autonomy is very much the solution of the coming decades.

Alongside autonomy, Siddorn notes another transformative force: digitalization. From artificial intelligence to digital twins of ocean basins, advanced computing is allowing scientists to not only visualize the ocean in real time but also predict future changes with unprecedented accuracy.

Since joining NOC in 2020 as Associate Director of Digital Ocean, Siddorn has championed the embedding of digital approaches to furthering science, including through the use of digital twins and has been key to thought leadership in his field and in shaping the current landscape of digital twin innovation.

By integrating data from satellites, ships, sensors and simulations, NOC is building a global-scale, near-real-time digital replica of the ocean — one that can be used to track carbon, forecast extreme weather, or assess offshore infrastructure risk. "This is where the future of oceanography lies," Siddorn said. "You can't manage what you can't measure, and digital systems allow us to measure, model and manage marine environments more effectively."

Science for Society & Industry

Historically, NOC has been focused on serving public research and government needs. But Siddorn is keenly aware of the growing role industry must play in achieving sustainable ocean stewardship. Whether it's offshore wind, deep-sea mining, aquaculture, or subsea telecoms, private-sector actors are increasingly shaping the marine environment. "NOC has a duty to engage more deeply with industry," Siddorn says. "The blue economy is growing fast, and companies need access to the best science and tools to operate responsibly."

That's why NOC is ramping up its partnerships in commercial sectors, offering data services, autonomous platforms, and scientific expertise to help industries reduce their environmental impact and improve resilience.

"We can help maritime operators understand their carbon footprint, plan cable routes more safely, or monitor biodiversity at their offshore installations," Siddorn notes. "There's tremendous value in bringing our science to industry."

Challenges Ahead for All

While the people, facilities and maritime assets under Siddorn's command are diverse and impressive, he acknowledges the challenges ahead. Decarbonizing NOC's own fleet, funding high-cost infrastructure and aligning long-term scientific goals with immediate operational pressures are just some of the complexities he faces as CEO.

But what is his biggest priority? Ensuring NOC remains forward-looking. "Our mission is to ask and answer the questions that matter most—questions about climate, hazards, food security, and biodiversity," he says. "That means investing not just in today's tools, but in tomorrow's solutions."

Siddorn's leadership is already having an impact. He's working to ensure NOC's next generation of scientists and engineers reflect a diversity of backgrounds and perspectives. He's investing in simulator-based training and AI-enhanced analytics. And he's helping NOC play a central role in global efforts like the UN Decade of Ocean Science for Sustainable Development.

"We have to look ahead 10, 20, 30 years," he said. "Our job is to ensure the ocean is understood well enough today so that it can be protected, used wisely, and sustained tomorrow, so our children and grandchildren don't end up with a world that's worse than the one we are in."

Image courtesy Hannah Wyles University of St Andrews

Autosub Long Range (ALR) better known as **'Boaty McBoatface'** being lowered into water.

NOC @ Sea: Assets & Capabilities

Research Vessels

NOC operates the UK's two state-of-the-art deep-sea research vessels as part of the National Marine Facilities (NMF) division. Both ships are operated and maintained by NOC on behalf of the UK scientific community.

- **RRS James Cook**

Commissioned: 2007
Length: 90m
Endurance: 50 days at sea
Capabilities: Deep-ocean science, ROV/AUV deployment, sediment coring, seismology, sub-seabed imaging
Berths: 32 science + 22 crew
Dynamic positioning: DP2 certified

- **RRS Discovery**

Commissioned: 2013
Length: 99.7m
Endurance: 50 days at sea
Capabilities: Multidisciplinary research (physical, biological, and chemical oceanography), glider and AUV deployment, high-resolution seabed mapping
Berths: 28 science + 28 crew
Dynamic positioning: DP2 certified

Autonomous & Robotic Systems

NOC operates one of Europe's most advanced fleets of autonomous marine systems, supporting both deep ocean research and scalable data collection for commercial and governmental missions.

- **Uncrewed Surface Vessels (USVs)**

Used for remote ocean observations, communications relay, and environmental monitoring
Platforms include the C-Enduro and AutoNaut systems

- **Autonomous Underwater Vehicles (AUVs)**

Seven AUVs including the Autosub Long Range (aka "Boaty McBoatface")
Mission endurance: Up to 3 months
Depth rating: Up to 6,000m
Sensor payloads: ADCPs, CTDs, eDNA samplers, biogeochemical analyzers

- **Gliders**

Long-endurance, buoyancy-driven platforms
Continuous water column profiling for physical, chemical, and biological parameters
Often deployed in swarms for ocean-scale monitoring

- **Fixed & Mobile Moorings**

Extensive network for long-term observations in the North Atlantic, Arctic, and global oceans
Includes sediment traps, carbon flux buoys, and ocean-bottom pressure sensors

UPSCALING P

CABLE AND CONNECTOR MANUFACTURERS ARE RUSHING TO MEET THE GROWING DEMAND FOR SUBSEA CABLES AND CONNECTORS AS RENEWABLES UPSCALE, BUT WHETHER IT'S RENEWABLES OR OIL AND GAS, THERE'S ALSO GROWING DEMAND FOR HIGH-TECH SUBSEA COMMUNICATIONS.

By Wendy Laursen

Nexans supplied the high-voltage direct current (HVDC) cable for TennetT's DolWin6 project.

Image courtesy TenneT

The export cables that bring offshore wind power to shore are already so massive that one meter of cable can weigh 300kg. Nexans had previously upscaled its production facilities to cater for increasing demand; now it is upscaling its HVDC cables, typically 400kV, to 525kV. The company will be supplying at least 10 of these cable systems to European grid operator TenneT for multiple 2GW projects.

The cables will be heavier, and they have the potential to get hotter, necessitating deeper burial in the seabed. The potential risks can be a determining factor in the design of the cable. If a live cable were to be damaged, says **Pascal Radue, EVP for Power Transmission at Nexans**, the power released would be like that of bringing a French high-speed train travelling at 350 kilometers an hour to a standstill in 50 meters.

Therefore, part of the calculation that goes into determining the cost of offshore wind power is what insulation technology is suitable and what scope there is for standardizing cable layout across the geographic range of the project. Most of these cables are tailor made for an application, says Radue, so there's not a lot of repeatability.

Tidal energy systems face similar challenges to offshore wind, with the harsh constant motion of tidal areas a key challenge. SMI recently took part in the upscaling of a tidal system in Japan led by system integrator Proteus Marine Renewables. Here the durability, longevity and reliability of the cabling system was critical to success.

Glen Richardson, Engineering Director at SMI, says water resistance is also a top priority. Polyethylene-based polymer cables have demonstrated exceptional subsea performance, maintaining durability for over 25 years with minimal degradation. "SMI's traditional design philosophy prioritizes using thermoplastic over-molding to seal cable terminations to connectors, especially with polyethylene-based polymer cable sheaths," says Richardson.

However, due to budget limitations and the need to perform terminations locally in Japan, SMI's linear seal technology was chosen. The linear seal provides a durable and consistent seal between the polyethylene cable sheath and the connector. "It applies a measured level of compression akin to traditional O-seal technology, ensuring the seal remains intact during operation and exposure to the challenging turbine environment," says Richardson.

Jonathan Hardisty, Head of Product Development for Subsea Products, Siemens Energy, sees upscaling in the subsea connector business as the need for higher power transmission grows. "We are developing a 66kV subsea wet-mate connector system, aiming to be the first in the market with this rating, surpassing our current highest-rated 45kV system." The product is set for release later this year and targets subsea electrification and floating offshore wind energy markets. Feasibility studies have been conducted for wet-mate connectors rated at 150kV for subsea electrification projects and future floating

"Polyethylene-based polymer cables have demonstrated exceptional subsea performance, maintaining durability for over 25 years with minimal degradation."
– Glen Richardson,
Engineering Director, SMI


Image courtesy SMI


Teledyne Impulse-PDM's latest developments in optical expanded beam technology are designed to withstand the most extreme marine environments.
Image courtesy Teledyne


Optical fibers are often used in systems that require greater bandwidth over longer distances, with a smaller footprint—smaller hull penetrations— for applications such as offshore oil and gas, towed arrays, side scan sonar systems, and oceanographic instrumentation.
Image courtesy Birns

wind applications to address the requirements of longer step-outs, deeper water and higher volumes of subsea consumers. New subsea LV control connectors and HV connectors for production and processing are also under development.

Demand for greater subsea connectivity is pushing the cable and connector market forward. Hardisty says big data is being utilized subsea to improve well efficiency and economic performance. This trend requires ethernet and fiber optic products. "Recently, we completed a project that involved installing a fiber optic subsea network to facilitate communication between onshore locations and multiple offshore oil and gas production units."

There is also a transition towards all-electric trees. Siemens Energy has introduced a high-performance fiber optic wet-mate connector for subsea networks, supporting oil and gas and future offshore wind applications.

Additionally, efforts are being made to digitalize connectivity products. Siemens Energy is collaborating with UK universities to develop first-generation digital connectivity products as it explores ways of introducing health monitoring into its products to boost asset management capabilities. This could allow a customer to get data feedback from sensors in a connector system that tells if it is working well or has performance issues such as running too hot or being subject to adverse shock.

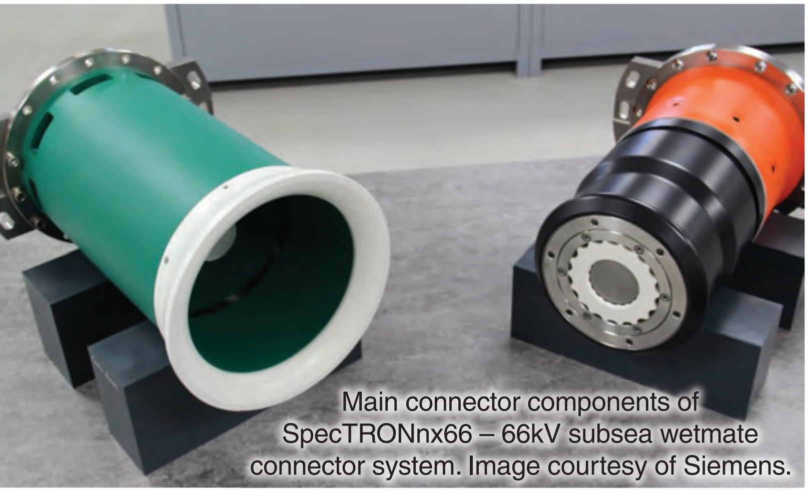
Teledyne Impulse-PDM specializes in high-performance subsea fiber optic connectors and interconnect systems, and Andy Cackett, Teledyne Impulse-PDM European Business Development Manager, says he is seeing growing demand for solutions that can perform reliably in less-than-ideal installation conditions. Expanded beam optical connectors are an ideal solution for fiber optic cables, he says, because they use lenses to transmit light between fibers without requiring direct physical contact.

The company's latest developments in optical expanded beam technology are designed to withstand the most extreme marine environments, offering enhanced resilience to dust and misalignment during installation. "The ability to clean the optics in the field without specialized equipment makes it an ideal choice for demanding offshore applications," he says. "Additionally, it can be integrated with electrical contacts, providing a versatile solution for complex subsea systems."

BIRNS has opened a new extreme depth hydrostatic pressure testing facility that allows 48 hour+ continuous precision testing of fiber optic connectors and cable assemblies at 6km in a controlled 2°C (±1°C) environment. The company's products for these conditions include the Millennium™ underwater dry-mate subsea interconnect series that features fast data speeds and extreme cold and depth pressure resistance. Optical fibers are often used in systems that require greater bandwidth over longer distances, with a smaller footprint, smaller hull penetrations, for applications such as offshore oil and gas, towed arrays, side scan sonar systems and oceanographic instrumentation.

Frontiers in hazardous conditions are continuing to drive the cable industry forward. Space Norway, for example, has announced **SubCom** as the contractor for a new high-speed connection from the Norwegian mainland to Jan Mayen and Svalbard. The 2,350km subsea fiber optic Arctic Way Cable System will be located entirely within the Arctic Circle.

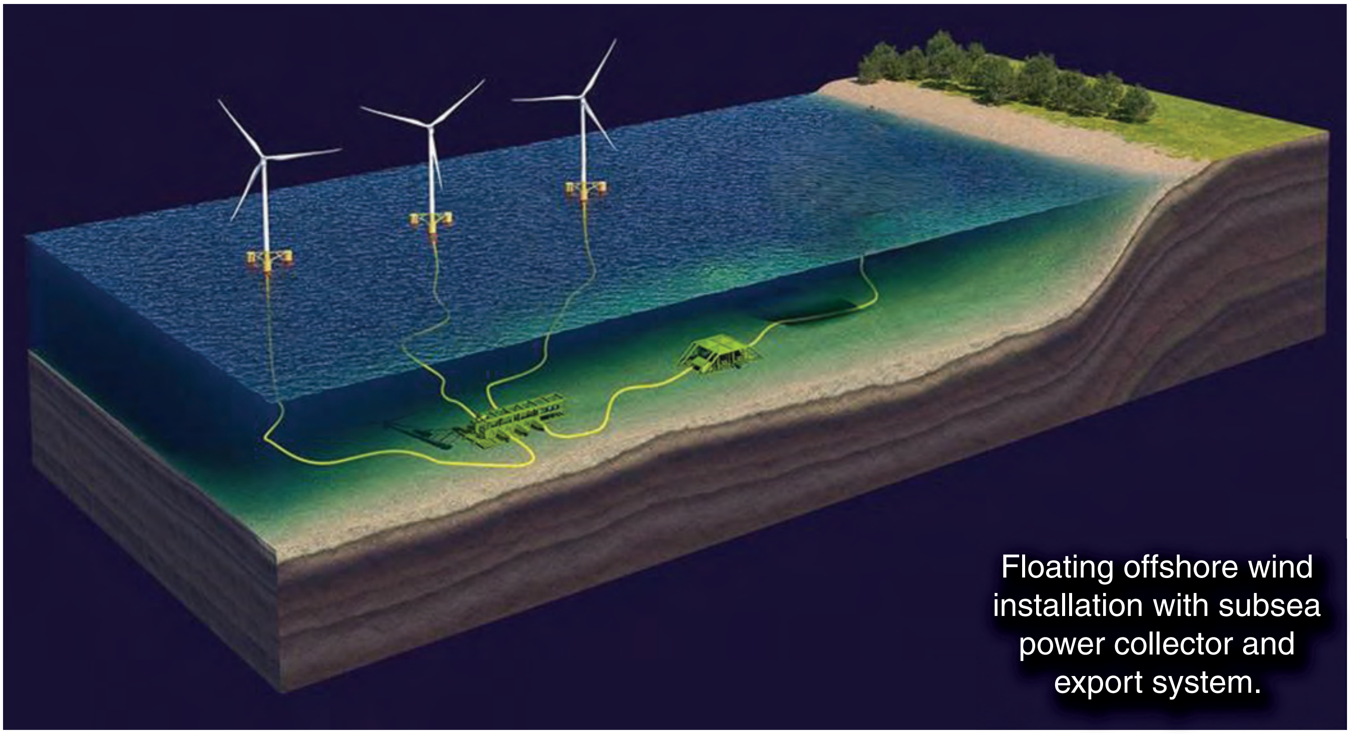
And in February, Meta announced its most ambitious subsea cable endeavor yet: Project Waterworth. The project will reach five major continents and span over 50,000km (longer than the Earth's circumference), making it the world's longest 24 fiber pair cable project. Meta is also maximizing the cable laid in deep water—at depths up to 7,000 meters—and using enhanced burial techniques in high-risk fault areas, such as shallow waters near the coast, to avoid damage.



Main connector components of SpecTRONnx66 – 66kV subsea wetmate connector system. Image courtesy of Siemens.

“We are developing a 66kV subsea wet-mate connector system, aiming to be the first in the market with this rating.”

– Jonathan Hardisty, Head of Product Development for Subsea Products, Siemens Energy



Floating offshore wind installation with subsea power collector and export system.

Images this page courtesy Siemens

SELECTION CRITERIA FOR UNDERWATER CABLE AND CONNECTORS

By Kevin Hardy, MTR Columnist, President, Global Ocean Design

Figure 1 (above)

Underwater bulkhead connectors and mating in-line connectors come in a myriad of shapes, sizes and pin patterns from several companies. The system designer is faced with a daunting challenge to select the one best suited to their application.

Underwater connectors and mating cables provide system flexibility, ease of service, and other advantages to undersea system designers and field engineers.

They also bring their own suite of added complications and problems.

There is a lot to consider. System designers need to be conscious of the connector they select. A criteria-of-selection provides a programmatic approach to narrowing down and choosing the right underwater connector. Sales reps can provide guidance, but it is ultimately the responsibility of the engineers to write the specifications.

I've always held that connectors are a mechanical problem first. If the seals don't work, then what's inside doesn't matter anymore. Not that it wasn't important to begin with. I also pressure test connectors to be sure there is no production flaw with any critical step. Best time to learn of a problem is onshore, weeks before deployment. Yes, it's extra work. Your team is counting on you. Play like a champion.

What's your application? Determining the need.

Underwater Connector Selection Criteria

1. Will the connector transfer power or signal?
2. What is the expected operating service depth and design safety factor?
3. What is the expected deployment duration or system service life?
4. What are the expected environmental conditions (cold, anaerobic, saline, etc.)?
5. Must the connector mate to an existing system?
6. Must the bulkhead connector retrofit to an existing hull penetration? Is a thread extender required for thick hulls? Are locking sleeves or retaining straps an option?
7. What is the available mounting space? Does it allow room for torque wrench installation?
8. Would a low-profile right-angle connector be appropriate? Can the contact orientation be rotated to an optimum position?
9. Must the connector have seal or contact redundancy?
10. What are the cost and delivery constraints?
11. Must the connector be underwater mateable? With power on?
12. Is the connector field serviceable? What level of technician skill is necessary?
13. Avoid dissimilar materials between the bulkhead connector and the housing that will lead to galvanic corrosion or cathodic delamination.
14. Are there any Mil Spec Requirements to be met?
15. Are there any other special requirements to be met (i.e., fiber optic, neutrally buoyant, Fluid filled/ pressure balanced)?
16. What is the cable type to be wired and bonded to the connectors (i.e., twisted single pair, parallel bundle, coaxial, electromechanical)? What is the jacket material, construction, and fillers? Is it suitable for overmolding?
17. Is the instrument package designed to be handled in the field without danger to the connectors? To use handles, tagline rings, and cleats to prevent accidental damage to the connector? Is the connector protected from side impact? Can the cable be strain relieved?

Designers should consider the use of connectors of different pin counts or use of sockets rather than pins to differentiate connectors meant for different tasks. It ensures you're plugging the right cable into the right port. The cost to order isn't bad, but stocking spares is more of a challenge.

I pay attention to the manufacturer's **engagement sequence** that makes certain the pins and sockets are aligned before plugging together, such as key/keyway or an alignment pin. Many rubber molded connectors use an asymmetric pin/socket pattern to confirm proper alignment.

- **Interchangeability:** Rubber molded connectors provide greater tolerance of mated parts, and even some room for center-to-center pin differences, giving the best chance for mixed manufacturers' parts working together. Pin lengths and diameters may vary, though. Hard shell connectors are not as forgiving. As a rule, stick with the same manufacturer for mating connectors. No manufacturer can reasonably guarantee another manufacturer's tooling and production quality—nor should they be expected to. If a mated pair doesn't work, it'll be the engineers who have to figure it out.

- **Selecting a manufacturer:** Ask if they sell in small volumes. Do they have a stocking distributor? What sort of inventory do they normally carry? Who else uses them? The industry has come a long way in the past 40 years, and many of the basic problems, such as o-ring seal design to Parker Spec, have been resolved.

Use of this checklist during the early design phase of a new underwater system will assist the designer or program manager avoid predictable problems with these fundamental underwater system components. Work with your intended supplier; they want you to be successful, too.

Follow-on: This story is about selecting the best connector for your application. There are many details following that: installation, greasing lightly, "burping" rubber molded connectors, cable splices, cable bend radii, cable strain reliefs, and other important matters. Ask lots of questions of others in the field, look at what choices other people have made, and start to build your own preferences based on experience. It's an exciting and evolving industry, filled with good people.

Figure 2

A 20-inch Vitrovex hollow borosilicate glass sphere is fitted with feedthroughs, making it a self-buoyant instrument housing.

Underwater Connector Companies to Consider

- **AK Industries** https://ak-ind.com/
- **Amphenol Deeptronica** (drymate, MCBH) https://amphenolltw.com/product-info/DeepTronica/. Made in China for Amphenol.
- **Birns** https://birns.com/
- **Blue Link** https://blue-linked.com/underwater-connectors
- **Blue Robotics** https://bluerobotics.com/product-category/cables-connectors/
- **Burton Subsea Connector** (Eaton) (Google "Burton Subsea")
- **Dragonfish** https://dragonfishmfg.com/
- **Electro Oceanics (EO)** (Eaton/Cooper Interconnect) (Google Electro Oceanics Cooper)
- **Hydro Group Systems** https://www.hydrogroupsystems.com/
- **Marsh Marine** The original. The name is still around.
- **Souriau-Sunbank (Eaton)** https://usa.souriau.com/en-en/products/connectors/underwater-connectors
- **TE/SEACON** (Google "TE SEACON")
- **Teledyne Impulse** https://www.teledynemarine.com/brands/impulse
- **WeTechnologies** https://wetechnologies.com/

Acknowledgements

I learned a lot from Ray Hayworth, General Dynamics Electric Boat Division, who shared his experience broadly, spoke at MTS cable and connector conferences, and published design guidelines for use at Electric Boat. R. Frank Busby's Manned Submersibles text is still a classic and available as a free download (https://archive.org/details/mannedsubmersibl00busb). Bob Wernli and Bob Christ's "The ROV Manual: Second Edition," has a lengthy chapter on cables and connectors. Thanks to Andy Gardener, Teledyne Impulse, who suggested revisiting this topic.

"Lander Lab" is a hands-on column of Ocean Lander technologies, an often-overlooked class of unmanned undersea vehicles. It is meant to serve the ocean lander community in the manner of Make Magazine and other DIY communities.

Comments on this article, or suggestions for stories of interest to other Landereans are welcome. MTR invites you write to Kevin Hardy <**khardy@marinelink.com**>.

MARINE TECHNOLOGY REPORTER

2025 Editorial Calendar

01 | Jan/Feb 2025
Ad close Dec. 31, 2024

Underwater Vehicle Annual

- Subsea Defense
- Manipulator Arms & Tools
- Autonomous Navigation
- Battery Technology

Events
UDT, Oslo, Norway

DEEP DIVE
PODCAST: Underwater Vehicle Tech

02 | February 2025
Ad close Feb 4.

Oceanographic

E-Magazine Edition

Tech Focus: Sonar, Telemetry & Data Processing Software

DEEP DIVE
PODCAST: Digitalization

03 | Mar/Apr 2025
Ad close Mar. 21

Oceanographic Instrumentation & Sensors

- Offshore Energy
- Seismic & Geotechnical Surveys
- Inspection, Repair & Maintenance
- Workclass ROVs

Events
Ocean Business 2025, Southampton, UK
OTC, Houston, TX
IPF Wind Conference, New Orleans, LA
AUVSI Xponential, Houston, TX

DEEP DIVE
PODCAST: Subsea Survey Technology

05 | May/Jun 2025
Ad close May 21

Dredging Technology

- Subsea Defense
- Hydrographic Survey
- Scientific Deck Machinery
- Cables & Connectors

Events
Underwater Technology Conference, Norway
WEDA Dredging Summit & Expo, San Diego

DEEP DIVE
PODCAST: Dredging Technology

07 | Jul/Aug 2025
Ad close Jul. 21

Autonomous Vehicle Operations

- Underwater Tools & Manipulators
- GPS, Gyro Compasses & MEMS Motion Tracking
- Deck Machinery & Cranes
- Battery Technology

Events
Offshore Europe, Aberdeen, Scotland
Oceans 2025, Great Lakes

DEEP DIVE
PODCAST: Subsea Defense

08 | August 2025
Ad close Aug. 1

Hydrographic

E-Magazine Edition

Tech Focus: Underwater Communications

DEEP DIVE
PODCAST: Research Vessels

09 | Sep/Oct 2025
Ad close Sep. 21

MTR 100

Focus on 100 Leading Companies, People and Innovations in the Subsea Space

DEEP DIVE
PODCAST: Inside NOAA

11 | Nov/Dec 2025
Ad close Nov. 21

Ocean Observation: Gliders, Buoys, & Sub-Surface Networks

- Instrumentation: Profilers, Samplers & Sediment Corer
- Subsea Defense: The U.S. Navy
- Subsea: Electrification
- Cameras & Multibeam Sonar

Events
Underwater Intervention, New Orleans, LA

DEEP DIVE
PODCAST: Ocean Observation

12 | December 2025
Ad close Dec. 4

Subsea Vehicles

E-Magazine Edition

Tech Focus: Underwater Imaging: Lights,

DEEP DIVE
PODCAST: Subsea Vehicle Technology

OCEAN BUSINESS 2025:
REVIEW OF NEW TECHNOLOGIES INTRODUCED

***Ocean Business (OB) 2025**, which was held in early April 2025 in Southampton, UK, hosted over 300 maritime science and technology companies and professionals, creating a space for innovation, collaboration and advancement of subsea technologies. Before, during and after the event, companies from around the world shared insights on new and emerging technologies, all designed to make working around and under the world's waterways more efficient, safe and effective. Here's a recap of what you may have missed:*

By Celia Konowe

■ **Cathx Ocean**

■ **RBR Ltd.**

■ **Tritonia**

Cathx Oceans' INKA Iris camera seeks to solve the challenge of data bottlenecks, where vast amounts of raw subsea data require time-consuming post-mission processing, leading to delays and increased operational costs. INKA is Cathx Ocean's onboard hardware processing platform, designed to bring real-time AI-driven decision-making to subsea vehicles. Iris is the first camera built on the INKA platform, delivering imaging and onboard data processing in a compact, power-efficient package. Unlike traditional systems that require extensive post-processing, INKA Iris processes data in real time, directly on the device. This capability reduces manual processing steps after acquisition, enhances survey efficiency, and accelerates decision-making—particularly for mid-sized autonomous underwater vehicles (AUVs) and compact remotely operated vehicles (ROVs) operating in shallow water. By running automated workflows on the vehicle, including AI models, INKA Iris enables valuable use cases such as image enhancement, instant event detection, and automated classification.

RBR Ltd., a provider of oceanographic instrumentation, announced the integration of Hydromea's LUMA FLEX optical modem into its range of standard loggers. This partnership enables the wireless transmission of oceanographic data from subsea environments. The integration of LUMA FLEX technology into RBR's instruments empowers users

■ Teledyne Marine

■ Teledyne Marine

■ Kongsberg Discovery

to collect large volumes of data wirelessly using AUVs and ROVs, supporting the rapidly expanding ocean economy. A dock demo hosted by Hydromea at OB offered attendees a firsthand look at the capabilities of the LUMA™ FLEX-enabled RBRconcerto3 CTD, wirelessly transmitting conductivity, temperature and depth data.

Tritonia unveiled Hydrophis, its marine data platform, at OB. Designed for marine surveyors, offshore operators, and regulatory bodies, Hydrophis changes how organizations host, visualize, and analyze underwater survey data by integrating advanced georeferenced 3D photogrammetry, AI-driven analysis, and multiple data types (such as side-scan sonar, orthomosaics and multibeam sonar data) into one platform.

Teledyne Marine launched several new industry solutions and technologies in Southampton this year:

• **Compact Navigator –** the world's smallest and highest performing, fully integrated autonomous navigation solution is revealed at Ocean Business

• **SeaBat T51-S –** the enhanced SeaBat T51 now reaches 6000m depth while ensuring reliable, hands-free operation

• **Workhorse Proteus –** an evolution of the original Workhorse ADCP combines ultimate flexibility and unparalleled data

• **BlueStreamX2 –** the latest upgrade doubles Benthos Acoustic Modems' (WideBand C) data rate to 4800bits per second and enhances UTS topside systems

• **Valeport pH –** an innovative self-calibrating, highly accurate, and robust pH sensor from Teledyne Valeport

• **Intrepid System –** a GNSS/Inertial Navigation System for unmanned surface vehicles, seamlessly integrates with the SeaBat T20-ASV processor for precise positioning

Teledyne Marine also announced the purchase and delivery of a Gavia Autonomous Underwater Vehicle (AUV) to one of the subsidiaries of the Sea Vorian group, SEA360, located in Caudan, France. The newly acquired AUV is equipped with technologies like the EdgeTech 2205 sonar, with bathymetric and gap-filling module, EXail PHINS C3 Inertial Navigation System (INS), and USBL modules. These technologies will enable Sea360 to perform geophysical survey missions, underwater inspections, and environmental monitoring at depths of up to 1,000 meters.

Kongsberg Discovery hosted product demonstrations for the EM2042 Multibeam Echosounder and Seapath 385 GNSS aided inertial navigation system onboard the Fugro FTV Xplorer vessel, in addition to dockside demos with the Flexview multibeam sonar deployed on a ROV for underwater infrastructure inspection and gas seep detection. Kongsberg Discovery also teamed up with Saildrone to give delegates an insight into remote deep-water multibeam survey operations, with a real-time demonstration of a Saildrone Surveyor USV fitted with EM304 MKII sensors and software.

Kongsberg Discovery also unveiled Geomatics, a new digital product designed to transform how ocean data is captured, managed and accessed. The solution enables both traditional and uncrewed vessel operators to streamline data operations, unlock operational insights and improve global collaboration between vessels and shore-based teams.

The benefits include centralized data collection and logging from all onboard and remote sensors, automatic cataloguing and indexing to prepare data for exploration and analysis, and seamless data distribution to mirrored cloud environments or other data management systems. Visualization of data is possible with both real-time and historical data georeferenced in dashboards, maps, and time series viewers and a high degree of customization available (allowing users to filter and tailor displays according to specific needs).

The Geomatics architecture is AI and machine learning ready, building a foundation for the integration of digital twin technology and further enhancing processing capabilities. A new Analytics product is also under development, allowing for automated processing and in-depth data analysis.

GeoAcoustics Ltd debuted a new Side Scan Sonar range, adding to its hydroacoustic technology portfolio. The previous GeoScan range featured two models, both offering simultaneous broadband dual frequency operation and advanced sonar processing features. The GeoScan 2361 operates at 300 kHz and 600 kHz to maximize range performance, while the GeoScan 2491 runs at 400 kHz and 900 kHz to

■ GeoAcoustics Ltd

■ Norwegian Subsea

■ Sonardyne

■ GeoAcoustics Ltd

deliver even higher image resolution. Both include a fast 60 kHz update rate, CW and Chirp pulse options, no near-field blurring, and a maximum operating depth of 300 metres.

GeoScan features high-definition capabilities that combine ultra-short pulses and pulse compression to enhance image resolution and range definition. A dynamic variable aperture focusing system enables higher resolution at shorter ranges and improved image quality at longer ranges, while an automated image equalization function ensures high contrast across different seafloor types. Both models include integrated pitch, roll, heading and pressure sensors for precise navigation and depth measurement, helping users to collect accurate, high-resolution data in the most demanding underwater environments.

GeoAcoustics Ltd also announced an expansion of its custom cable molding and assembly services for subsea equipment manufacturers, marine systems integrators, and offshore contractors. The expansion follows GeoAcoustics' acquisition of a specialist cable molding company located near its Great Yarmouth headquarters. This move unlocks increased capacity and specialist expertise, enabling the delivery of complex, high-reliability cable moldings and terminations for a wide range of marine and subsea applications.

Norwegian Subsea introduced an updated MRU lineup featuring full aiding capabilities. Based on the same MRU platform, this newly packaged solution delivers precise roll, pitch, and heave data in addition to independent heading and velocity. It removes dependency on RTK or GNSS signals, eliminating common vulnerabilities that challenge efficiency and quality in bathymetric surveying. Built for plug-and-play compatibility with sonar systems including multibeam echo sounders, interferometric sonars, side-scan sonars, sub-bottom profilers, and forward-looking sonars, Norwegian Subsea MRUs enable consistent, high-quality heave data in real time. The MRU 9000 series is aimed at marine surveyors seeking the highest quality multibeam motion correction data but at approximately 50% of the list price of the most advanced competing systems. With 0.01° accuracy in roll and pitch, and high-precision surge and sway measurements, it is ideal for the most demanding sonar motion compensation applications. The broader MRU range also includes 3000 and 6000 series units, offering scalable performance depending on the use case, from general monitoring to active heave compensation and winch control.

Sonardyne International Ltd has integrated a CONTROS HydroC dissolved CO_2 sensor from -4H-JENA engineering into its Origin 600 ADCP (Acoustic Doppler Current Profiler), unlocking new capabilities for marine research into ocean acidification. The combined solution enables precise, real-time monitoring of dissolved carbon dioxide levels alongside detailed current profiling, providing insights into the impacts of rising CO_2 concentrations on marine ecosystems and biodiversity. The HydroC sensor integrates with Sonardyne's Origin 600 through either direct connection to the ADCP's external sensor port or via the versatile Origin E-Mux multiplexer, which supports up to four external sensors simultaneously and extends power supply capability for longer deployments.

Kraken Robotics launched a synthetic aperture sonar (SAS) service for the global offshore energy market, with dedicated KATFISH towed SAS systems available for rental starting July 2025. The system offers real-time 3 x 3 cm resolution with a range of up to 200 meters per side, providing some of the industry's highest area coverage rates available. The high resolution of Kraken SAS helps to derisk projects, with the ability to differentiate between man-made and natural contacts and identify small contacts that may be on or near infrastructure. Kraken's SAS service was recently selected by Offshore Renewable Energy (ORE) Catapult, the UK's leading technology innovation and research center for offshore renewable energy, to be part of its Launch Academy.

■ Kraken

Through Launch Academy, Kraken will be given access to world-class testing and research programs as well as the opportunity to work with industry, academia, and government to position SAS survey services for the offshore wind industry.

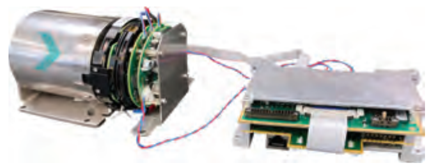
Forum Energy Technologies, Inc. announced it has upgraded its video recording solutions, optimizing the survey and inspection of subsea assets. This latest advancement will deliver superior video quality and a versatile array of signal inputs.

FET's VisualSoft Suite 11.1 introduces features that integrate with the company's newest digital video recording hardware, VisualDVR. This multi-channel, rack-mountable system is engineered for deployment on remote operating vehicle (ROV) spreads across the energy, defense, research, ocean science and other blue economy sectors. The highlight of this technological leap is the support for IP Cameras, enabling users to connect up to four IP sources or a combination of IP and SDI sources, with resolutions reaching as much as 1080p at 60fps. Also included in the V11.1 is the new Switchable Source Mode, which allows the operator to have multiple cameras connected to the DVR and to record any one of them, switching between them quickly and easily while still recording.

■ Forum Energy Technologies

■ Klein Marine Systems

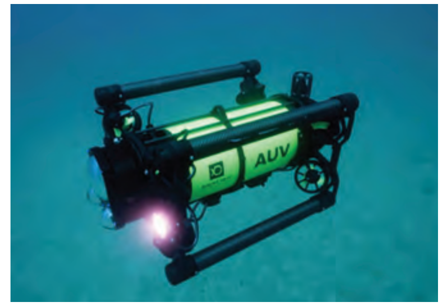
■ Exail



Klein Marine Systems has selected the Exail Octans Nano OEM Attitude and Heading Reference System (AHRS) as the standard navigation solution for their 5900 Side Scan Sonar (SSS). The Klein 5900 SSS is known for its high-resolution seabed mapping capabilities, supporting critical tasks such as geophysical surveys, wreck detection, and the identification of unexploded ordnance (UXO).

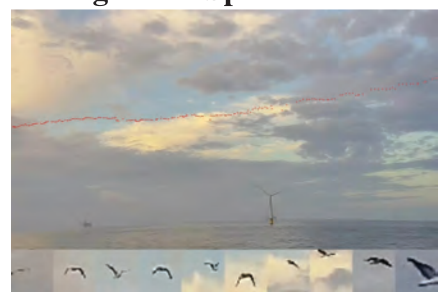
The **Exail** Octans Nano OEM AHRS offers a heading accuracy of 0.5° secant latitude, and pitch and roll accuracy of 0.1°, ensuring stable and precise attitude and heading data. The system's compact design and low power consumption allow for seamless integration into subsea platforms, making it ideal for extended underwater missions where precise attitude data is critical.

■ Boxfish Robotics



Boxfish Robotics announced the launch of its first generation of fully autonomous tetherless hovering Boxfish AUV (Hovering Autonomous Underwater Vehicle). The Boxfish AUV is equipped with Boxfish's latest proprietary autonomy software. The AUV supports benthic photogrammetry work, seabed mapping, coral reef and artificial coral reef monitoring, coral bleaching studies, fish studies, and invasive species studies. The Boxfish AUV operates without a tether at depths of up to 600 meters, with future enhancements planned to reach 1000 meters. The Boxfish AUV can carry a number of sensors to measure water quality and take high-quality video complemented by stereo cameras for fish census surveys.

■ Fugro and Spoor



Fugro and Spoor signed a memorandum of understanding (MOU) to develop a new bird-monitoring solution for offshore renewable energy projects. The solution uses video cameras installed on Fugro's SEAWATCH® Wind Lidar and other metocean buoys to record bird activity at wind farm locations. Spoor's computer vision and AI software then analyses these recordings to quickly and accurately identify bird species. The launch of this new bird-monitoring solution was successfully tested at Hywind Tampen offshore wind farm in the Norwegian North Sea.

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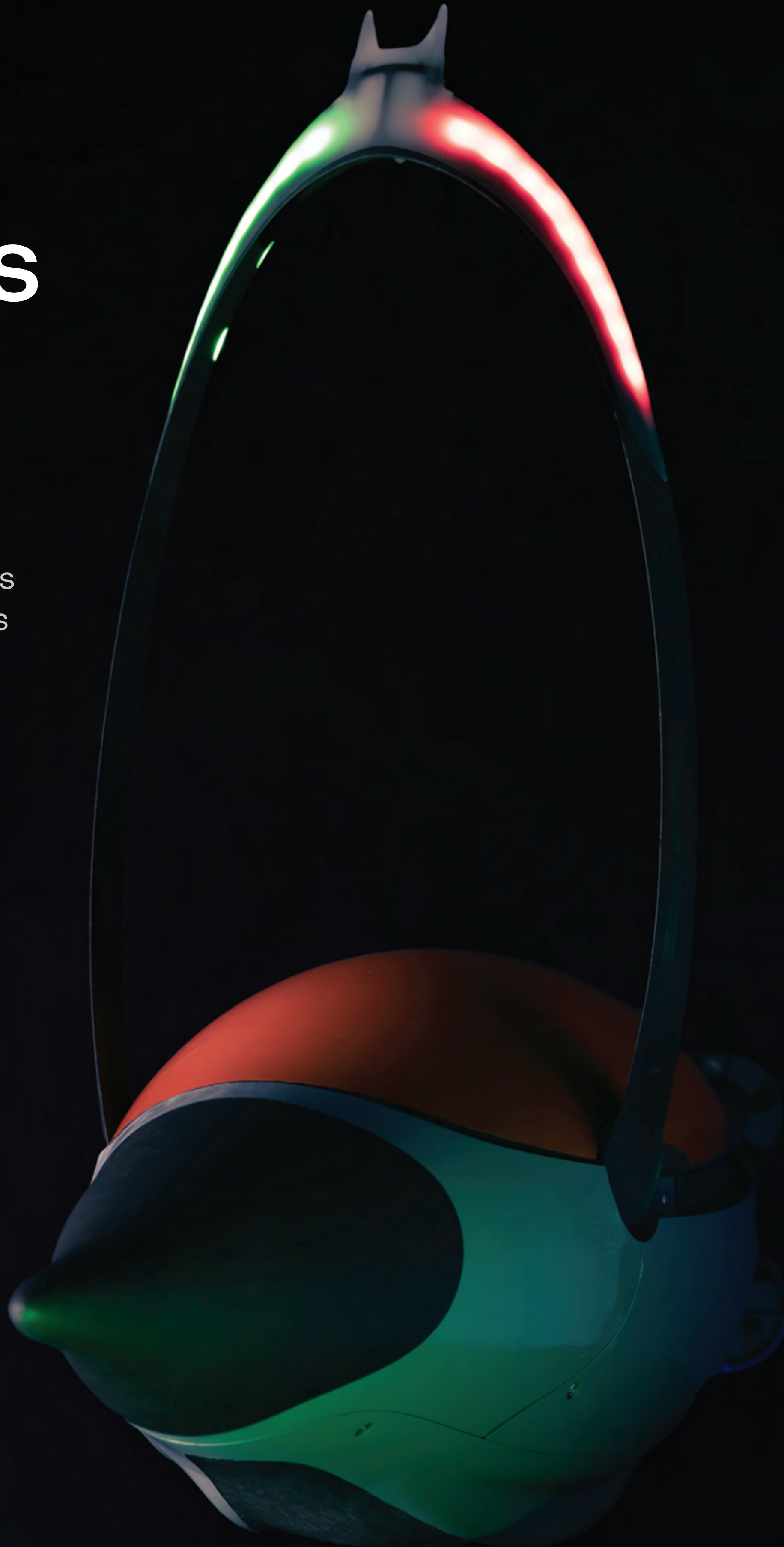

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