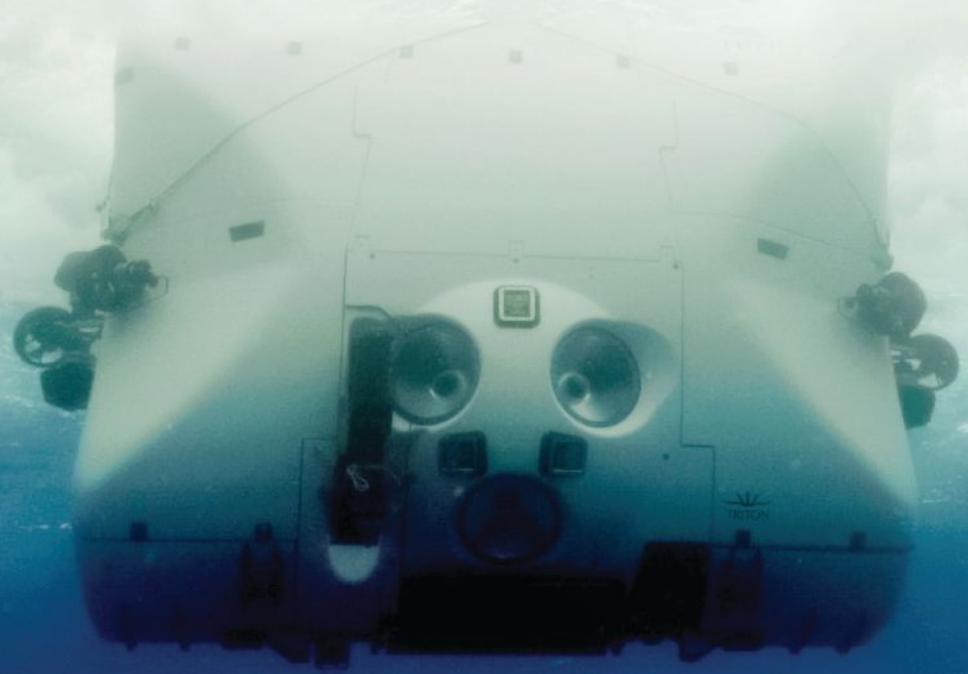


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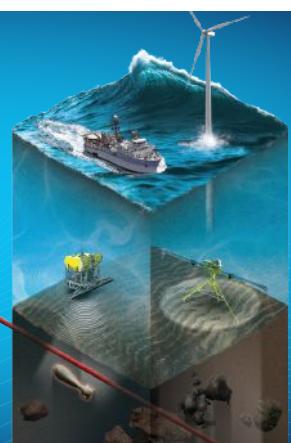
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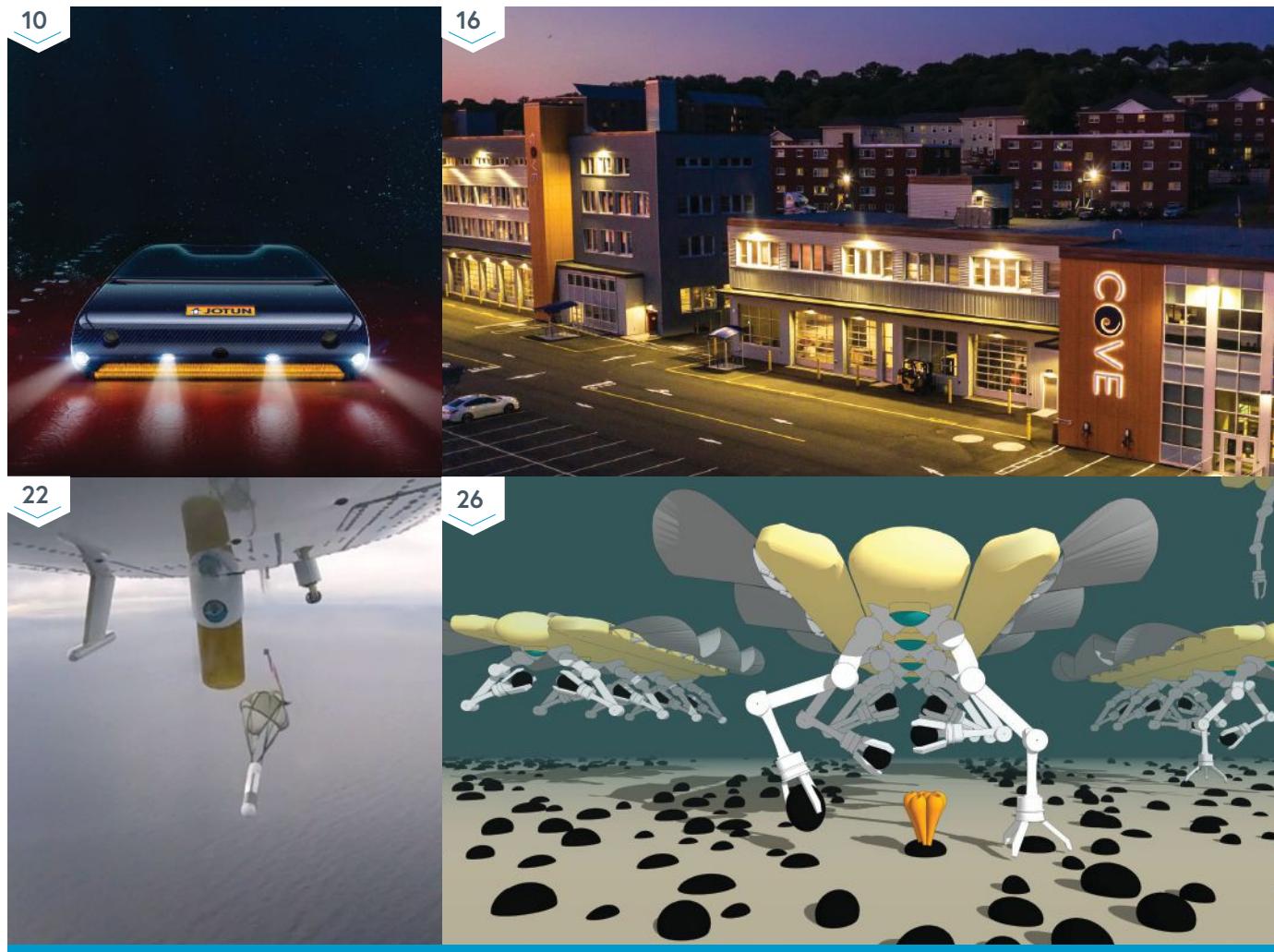
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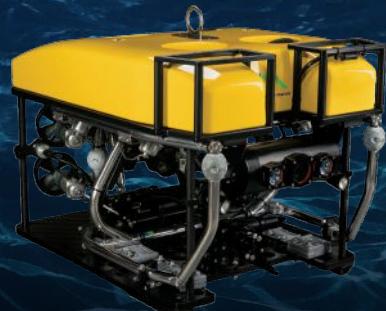
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## A MANNED SUBMERSIBLE WORLD

**WILL KOHNEN,**

*Chair Manned Underwater Vehicles Committee  
Marine Technology Society*

Since 1960, the global manned submersible industry has provided safe, technologically advanced, and secure Manned Underwater Vehicles (MUVs) for military, research, commercial, and tourism markets. Many of the specific innovations developed in our sector, especially in the areas of engineering design, material science fabrication, and technology have had a positive impact across the marine (autonomous, ROV) and aerospace sectors. These contributions, along with the outstanding safety record of MUVs, are testament to a committed group of manufacturers and operators focused on operational excellence and professionalism, all fueled by a spirit of innovation, exploration, and discovery.

Historically, there have been a total of 365 MUV submersibles built around the world. Since 1995, the industry has seen a dramatic period of growth and innovation. Much of this growth can be directly linked to advances in materials technology, especially acrylic, which can now be used to manufacture transparent hulls up to 12 inches thick. Today there are 165 active vehicles, half of them rated to 500 m or deeper. Twelve are rated to depths greater than 2000 m, of which seven were built in the last 20 years alone. Significantly, 62 of the active subs (over half) were built in the past 10 years. Notably, 33 of these newer submersibles are centered on an all-acrylic hull, with 23 of them rated to 1000 m.

Along with material innovations, our MUV industry is responsible for developing 11,000 m rated Lithium-Ion battery technology, which is now a standard for all un-

derwater vehicles—AUVs, ROVs, etc. In addition, the industry has seen a proliferation of subsea expeditions for science, research, and discovery over the last 18 months. Manufacturers, including Triton, Seamagine, and U-Boat Works, among others, have been involved with significant missions around the world. The *Five Deep Expedition* is the first manned descent to the bottom of each of the planet's five oceans. This fully classed two-person submersible traveled 47,000 miles and completed 39 dives.

Advances in materials, batteries, navigation and controls are all trends over the past few years that influenced the growth and innovation currently being observed in our industry. In the past, MUV industry hubs have been centered in North America, Europe, and Japan. Recently, we have seen expansion worldwide, particularly in the Indo-Pacific region. Future technological advancements will incorporate increasingly advanced systems; artificial intelligence; advanced energy storage; supercapacitors; advanced DC motors; enhancements in navigation systems; and underwater sensors. Ultimately these technologies will cross platforms, from manned to unmanned.

This year, the United Nations declared the start of the Decade of Ocean Science with plans for the SEABED 2030 endeavor to map the ocean floor, and all industries are challenged to contribute. With only 15 percent of the seafloor mapped so far, great expanses remain, a task most suited to unmanned vehicles. However, mapping seabed ecosystems themselves will require further examination, and the

ability of MUVs to provide in-situ, intelligent assessments will no doubt play an important role in transporting the scientific community to an ever-greater depth of understanding.

The MUV COMMITTEE, a global organization of operators, manufacturers, and support services, meets yearly at the Annual MTS MUV Symposium. Next year, the conference will be held at Woods Hole Oceanographic Institution, in late Spring, and we look forward to discussing the next chapter in the story of MUVs.

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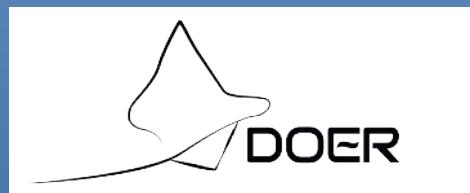
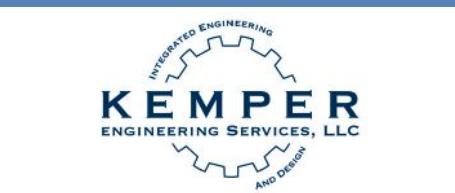
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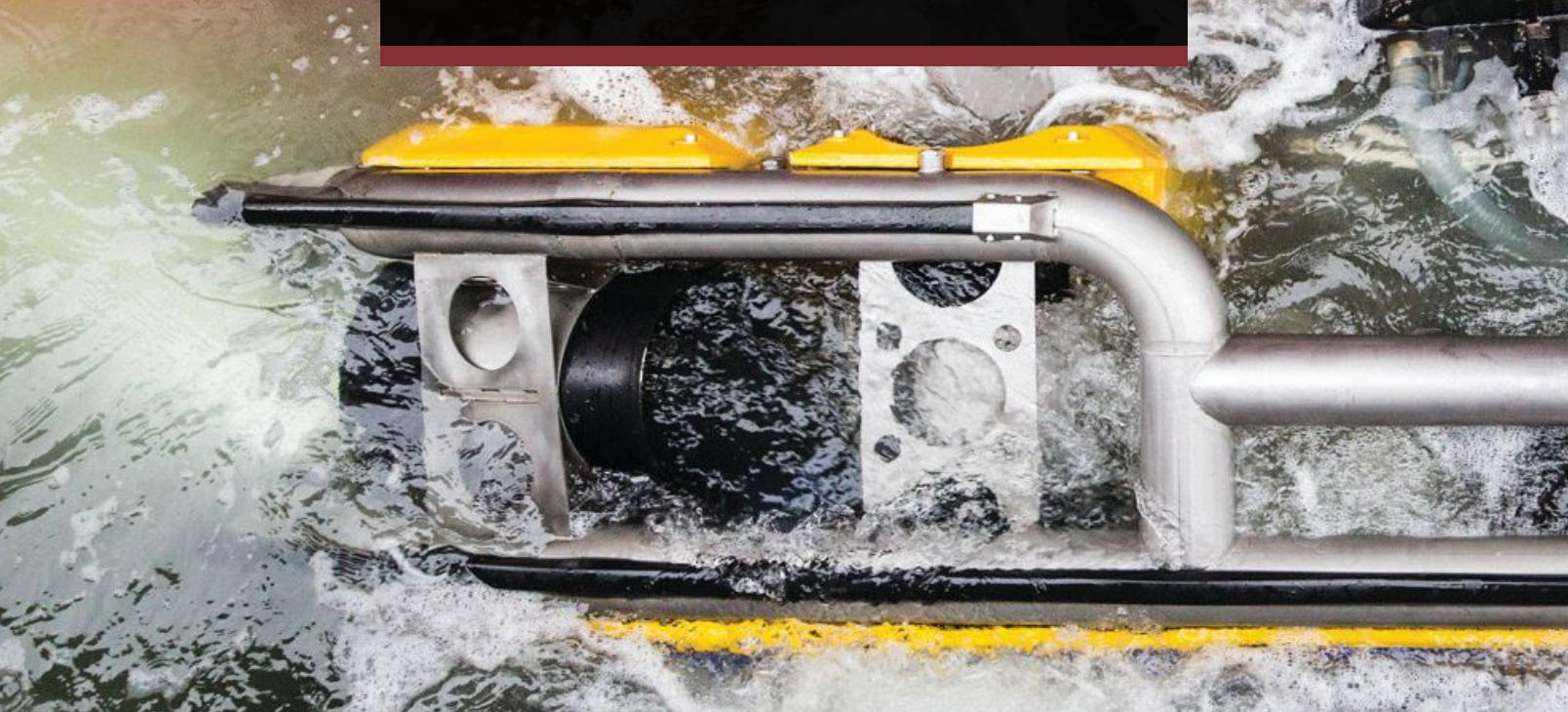
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# NO MORE FOUL PLAY:

## *Time to Tackle Biofouling*



As regulatory pressures associated with hull biofouling mount, could recent advances in marine robotics pose the solution?

Some problems are too big for one industry alone to solve. They require sector collaboration and the cross pollination of fresh ideas. Vessel biofouling—the undesirable accumulation of plants, algae and microorganisms on a ship's hull—is one such dilemma and an issue that, owing to the planned tightening of maritime regulations, demands immediate action.

### UNDERSTANDING THE ENEMY

Biofouling benefits no one, other than invasive aquatic species, perhaps. When vessels travel in and out of international waters, from one port to another, they provide perfect passage for these nomad biofoulers, and inadvertently spread intrusive foreign species to other parts of the world. Besides this mounting biothreat to our planet's marine ecosystems, there are the escalating costs of at-sea inefficiencies

to contemplate: Colonized hulls cause exponential friction which, according to the Office of Naval Research, can cause up to 60 percent more hydrodynamic drag; the more drag, the higher the fuel consumption and, of course, the corresponding CO<sub>2</sub> emissions.

The numbers are staggering: The International Maritime Organization (IMO) suggests that clean, smooth hulls and propellers can equate to fuel savings of as much as 10 percent, a figure supported by U.S. Navy studies that cite biofouling as a "chronic and costly problem," while the Clean Shipping Coalition estimates that biofouling on hulls cost the shipping industry as much as \$30 billion per year.

### SETTING STANDARDS FOR MITIGATION

Biofouling rates are influenced by a number

of factors—from naval architecture to coating systems to waters navigated—so accumulation patterns vary. This makes monitoring this out-of-sight enemy tricky, but imperative. The first stage, exacerbated by warmer port waters, is the attachment of biofilm, a process that begins within hours of hull submersion. This initial layer can be removed without excessive force but as it accumulates it becomes increasingly difficult to detach without causing damage to expensive—and often toxic—hull coatings. In other words, the timing of biofouling inspection and subsequent intervention is critical to both hull performance and integrity.

There are decreed international standards, certainly; ISO 19030-1:2016 outlines general principles for the measurement of changes in hull and propeller performance and defines a

» HullWiper, one of a growing number of specialized ROVs designed to provide proactive "hull grooming" services. (Photo credit: HullWiper)



set of KPIs to help vessel operators determine an appropriate schedule for hull husbandry. But this essentially involves correlating elementary navigational variables between two set time periods, as opposed to anything remotely resembling dynamic data analytics.

However, GreenSteam, a software company backed by BP/Castrol, advocates a smarter approach to condition-based monitoring, powered by machine learning. GreenSteam has developed a number of platforms to empower ship operators to better manage their carbon footprint, including the Fouling Analyzer, which, in addition to historical data, leverages machine learning software and real-time data to provide accurate insights and actionable advice regarding cleaning schedules, as well as the performance of active hull coatings.

Similarly, Propulsion Dynamics, out of Denmark, use theoretical and empirical algorithms to analyze the influence of

hull and propeller biofouling through their CASPER—Computerized Analysis of Ship Performance—platform. By using a Digital Twin hydrodynamic model, the company's naval architects analyze vessel data and generate a daily report that provides precise calculations of speed, fuel consumption and resistance and, most importantly, accurate estimations on the fuel penalty caused by hull and propeller fouling.

#### ROBOTICS AS AN INTERVENING MEASURE

Clearly, a clean smooth hull is a win-win situation for industry and environment and, irrespective of other antifouling measures, at some point cleaning is inevitable. For years, commercial divers have played an indispensable role in this process, from in-port assessment to hacking away at stubborn barnacles. Diligent divers can be a cost-effective way of recalibrating a hull's hydrodynamics, but forceful cleaning can result in significant coating damage, the

release of toxic bottom paint, inevitably leading to a period of costly drydocking. While vessel operators cannot avoid drydocking forever, however, the interval between drydocks can be extended and the scope of restorative work will often depend on how assiduously the hull has been monitored and maintained.



» Jotun's HullSkater system is designed and optimized for proactive cleaning using non-abrasive brushes to remove fouling without damaging the anti-fouling coating. (Photo credit: Jotun)

In recent decades, advances in mechanical engineering have ushered in a more tech-assisted approach to hull cleaning. Not so much man versus machine, but rather a case of using breakthrough technologies to enhance a service. Subsea Global Solutions, a long-established provider of underwater repair and maintenance services, promotes a diver-operated approach to incorporating subsea technology, and has developed a number of ride-on cleaning systems—including the Whale Shark—to help vessel owners "manage their coating." Similarly, Piccard Divers has also developed their own equipment, which includes the BRUSH-KART, which allows divers to clean up to 3,600 m<sup>2</sup> per hour, depending on the degree of fouling.

Of late, however, there has been growing interest in developing marine robotics—unmanned systems—to provide proactive "hull grooming" services, specifically designed to remove fouling at the biofilm level. In time, these systems may help reduce the volume of commercial divers needed in port waters—a notoriously dangerous occupation—and instead give rise to a new breed of ROV operators and expert hull inspectors.

So far in 2020, we have seen a number of high-profile contract announcements and product launches in this space. Greensea, for example, has begun marketing a man-portable robotic Crawler that is controlled via a proprietary hull-relative navigation system and is paired with a VideoRay MSS Defender ROV, allowing it to fly between areas of interest, reattach in seconds, and efficiently perform inspection and intervention tasks with a degree of precision not possible with a smaller free-flying ROV.

"Providing a stable base platform for a camera, laser imaging scanner, or manipulator

will greatly enhance accuracy, and ultimately safety, by enabling small robotic systems to perform work previously requiring a diver," according to Karl Lander, Greensea Program Manager.

Jotun also made a splash earlier this year with the launch of the company's Hull Skating Solutions, with the HullSkater ROV as lead protagonist. The Norwegian manufacturer of protective marine coatings has partnered with Kongsberg to champion a "revhullution," a service that offers "high performance antifouling, proactive condition monitoring, and inspection and proactive cleaning." The HullSkater attaches to a hull with its magnetic wheels, each equipped with electric motors for propulsion and steering, and uses its cameras and sensors to help navigate and document the fouling, before removing it with its motorized brush. An umbilical connects the ROV to the control center and 4G coverage enables remote operations from anywhere in the world. The HullSkater is the culmination of years of testing at selected ports around the world.

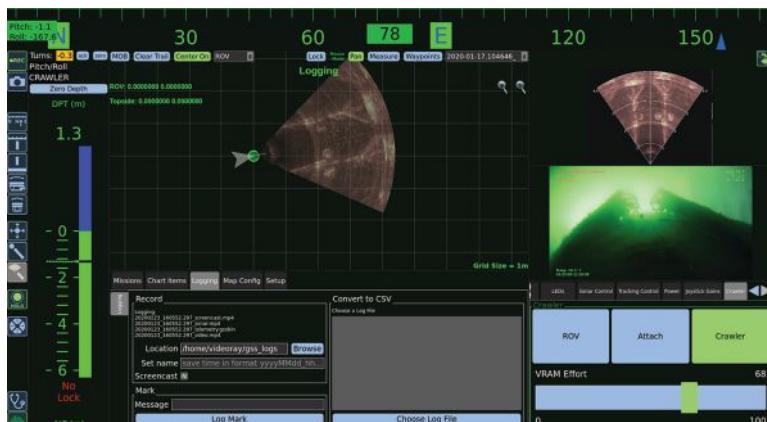
SeaRobotics is another organization that has been busy in the field, testing their SR-HullBUG system, which, like the HullSkater, favors brushes—nine in total—for its grooming tool. But the real gamechanger, according to company president Don Darling, is the system's unique capture and filtration system which "reduces fouling to the micron level and allows us to remove particulate and heavy metals from the water." This distinction is particularly pertinent amid the surging environmental pressures—cleaner hulls impede cleaner seas if the offending effluents are simply pumped back into the water. The SR-HullBUG has already proven effective in the cruise line industry, but clearly there are broader applications for a sophisticated filter

system among the ocean industries.

As opposed to brushes, HullWiper uses adjustable high-pressure seawater jets to avoid, the company maintains, the use of abrasive scrubbing or harsh chemicals. Whether waterjets are more effective than brushes at removing microorganisms remains unclear—and certainly warrants further *in-situ* research—but, in general, they require greater power sources. The captured residues are then pumped through a filter unit and into dedicated drums onshore. The Hullwiper service has proven popular and the company has established operational bases in Panama, Australia, Spain, Mauritius, as well as various ports serving the Middle East. With plans to expand operations to the Asian Subcontinent and the Far East, the appetite for ROV-deployed solutions is undeniable.

## NAVIGATING THE REGULATORY REALITIES

In 2018, the IMO's Marine Environmental Protection Committee (MEPC) laid out some ambitious—but motivating—goals to reduce global CO<sub>2</sub> emissions, headlined by the target of reducing GHG contributions "by at least 50% by 2050 compared to 2008, while, at the same time, pursuing efforts towards phasing them out entirely." This was followed, in June 2020, with the launch of the Global Industry Alliance (GIA) for Marine Biodiversity, an initiative managed by GloFouling Partnerships, a five-year (2019-2023) global IMO project on biofouling mitigation. The GIA intends to work with private companies from a range of industries beyond shipping—including aquaculture, offshore oil & gas, offshore renewable energy—and provide a forum for collaborative steps to tackle two key environmental issues: protecting marine biodiversity and reducing greenhouse gas emissions.



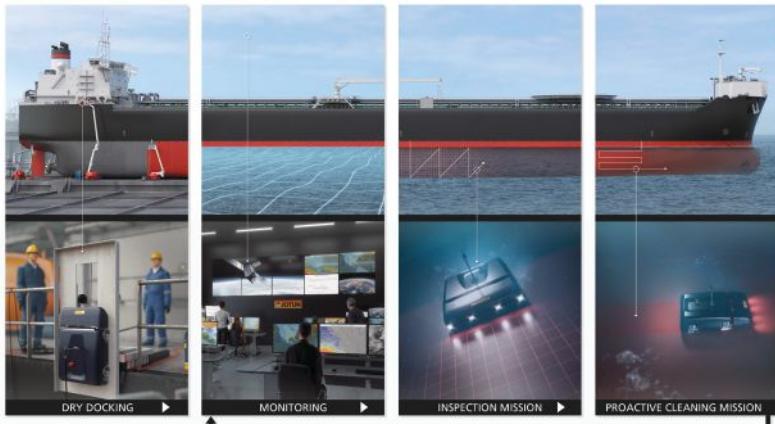
» The Greensea Crawler can be upgraded to incorporate a FOG-based inertial navigation system (INS) and advanced control software to provide enhanced precision positioning and control for automated deployment. (Photo credit: Greensea)



» Greensea's navigation system pairs with a VideoRay MSS Defender ROV to offer the stability required to perform inspection and intervention tasks with a degree of precision not possible with a small free-flying ROV. (Photo credit: Greensea)

## JOTUN HULL SKATING SOLUTIONS

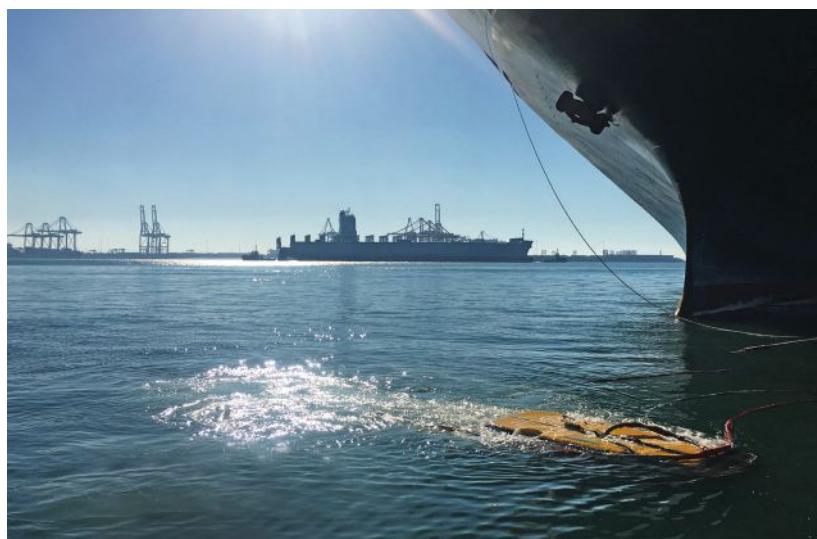
HOW IT WORKS



» The HullSkater can be remotely operated from shore via 24/7 operating hubs that allow for high definition inspection through multiple camera feeds and is supported by cloud-based data storage. (Photo credit: Jotun)



» SeaRobotics' SR-HullBUG uses nine rotating brushes to gently remove biofilm before passing effluents through a sophisticated filtration system, which, in turn, reduces fouling to the micron level. (Photo credit: SeaRobotics)



» Since its launch in late 2013, HullWiper has expanded operations from its first base in Dubai to include key locations across the Middle East, as well as ports in Sweden, Norway, Qatar, Denmark, Singapore, Spain, Egypt, Australia, Panama and Mauritius. HullWiper is also available for lease where the company does not have its own base. (Photo credit: HullWiper)

The GIA will leverage the influence of key partners such as the World Ocean Council (WOC), the project's lead for engaging the ocean business community, to foster and facilitate investment in time-critical solutions to biofouling. IMO Secretary-General Kitack Lim said, "Under this new initiative, these industry champions, from different sectors, are coming together to address common challenges and move towards a more sustainable use of ocean resources."

Concerted efforts of this magnitude require more than just governance; they require cooperation, collaboration, and, indeed, compliance. Success, out on the high seas, will be contingent on shipowners documenting their hull management measures, while ports will demand increasing transparency on hull conditions and, as has been the case in New Zealand, be ever more likely to expel vessels failing to act accordingly.

### RAISING STANDARDS FOR THE FUTURE

The challenge, then, will be to establish a specific set of hull-cleaning standards by which any of the 80,000 globe-circulating merchant ships, and any other vessel for that matter, can self-police any "foul" play. BIMCO, the world's largest shipping association, is the driving force behind efforts to define such gold standard criteria, which they aim to have sanctioned by the IMO. This similarly requires multi-tiered stakeholder management, but first and foremost the alliance of vessel owners, paint manufacturers and the hull cleaning supply chain. As drafts are refined, the next step will be to apply practical tests to establish an approval standard that outlines the minimum requirements for in-water cleaners based on thorough water testing verified by accredited laboratories. How long this process will take is unclear, perhaps 2 – 3 years, but evidently this is a critical moment for the marine technologies looking to be part of the solution.

However, even as attitudes shift towards proactive hull grooming, questions remain. The enormity of the problem can be daunting, the scale of which overshadows any one industry. Advances in coatings could prove pivotal, especially if we see a movement for more non-biocidal formulas; or perhaps materials will be defined by the technologies developed to clean them; Jotun's Hull Skater Solutions would certainly hint to a trend for synergistic R&D.

Busier shipping lanes only intensify the current biofouling predicament but in 2020, paradoxically, amid the COVID-19 pandemic, slumps in international trade have resulted in widespread cargo ship redundancy; oil tankers have become floating reserves; and the cruise industry has proverbially run aground. This period of relative inactivity may have helped momentarily offset CO<sub>2</sub> emissions but, somewhat mercilessly, vessels lying at anchor—especially in port—are prone to accelerated rates of biofouling. In short, our loss of productivity is inversely proportional to the gains of our adversary. The time to act is now.

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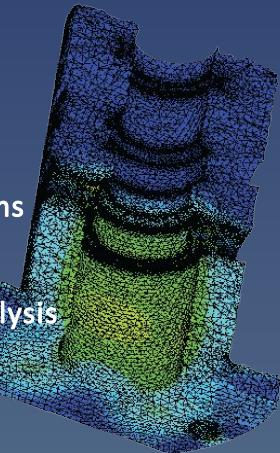
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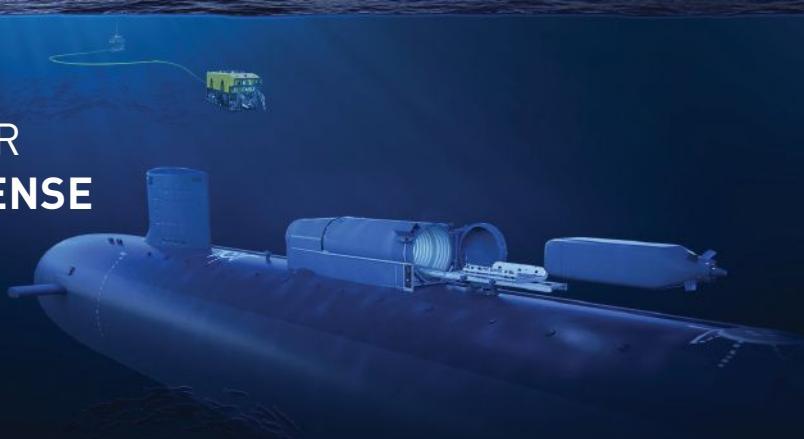
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| FEATURE |

# COVE: A HAVEN FOR OCEANTECH INNOVATION

By Justin Manley, Just Innovation Inc.

The Centre for Ocean Ventures & Entrepreneurship (COVE) is a collaborative facility for applied innovation in the ocean sector. Its mission is to propel the ocean economy by providing high quality marine infrastructure and a collaborative space in which a community of ocean enterprises can start, grow, and prosper. The primary goal is to support ocean technology commercialization.

Located in what was once the Canadian Coast Guard facility on Halifax Harbour, this hub is home to local and global ocean technology businesses, post-secondary institutions, researchers, and marine-based and service businesses that support the ocean sector. The COVE site features extensive marine facilities with two large, deep-water piers, office space, an incubator and space for shops and labs.

COVE is a community that brings together the best and the brightest to push ocean tech advances to market. It's a space that fosters innovation and cross-pollinates expertise, ideas, and resources

among members, COVE is where business growth, opportunity, and technical advances happen.

Tenants have access to shared equipment and infrastructure, and the resources of the management team to nurture partnerships in forming technology leadership projects. As well, with initiatives and a site designed to encourage formal and informal networking, COVE tenants connect with the people, companies, and opportunities essential to grow their business.

The facility includes a mix of short and long-term workspace to support on-site employees and those visiting from other locations. There is also a full mix of programming that can be accessed on site and on a virtual basis. The amenities available to tenants of COVE include electronics fabrication and testing facilities, mechanical fabrication space, office space, storage spaces, waterside marine services, and shared services such as reception and a large multipurpose room for training and events.

While the facility and staff are key assets at COVE the tenants are the core of the organization. These are typically small to medium enterprises (SMEs) with a specialization in some facet of ocean technology. A few core categories include instrumentation, field operations and services, and the emerging field of data as a service.

Ocean instrumentation is an especially strong sector in Nova Scotia. Some SMEs in this domain make sensor products, others the platforms that carry such sensors and some provide core sub-components necessary to these advanced technologies. COVE is home to participants at all these levels of the supply chain: Turbulent Research develops products including broadband recorders, processors, real time digital hydrophones and noise mitigation products; Dartmouth Ocean Technologies Inc. is focused on delivering ocean sensor platforms including a family of towed stable depressors called the "V-Wings" that are available in a variety of sizes and can be outfitted

with sensors for a diverse range of applications; Xeos Technologies Inc. provides reliable & innovative ways to track, monitor and control moorings, buoys and autonomous vehicles in harsh environments; and Sensor Technology Ltd. is a leading designer and manufacturer of piezoelectric ceramic solutions, custom acoustic transducers and custom hydrophones.

To support work in the demanding ocean environment, COVE welcomes many tenants providing field and engineering services. While these companies clearly add value to their fellow COVE tenants, they also provide services to the extended ecosystem in Atlantic Canada and visiting participants and customers as well. At COVE, tenants support operations at sea and in the laboratory or workshop. LeeWay Marine is a leading Atlantic Canadian marine service company providing fully crewed offshore ships and inshore vessels with the region's most experienced technical team. They specialize in supporting a broad range of activities from hydrographic and geophysical surveys to rapid environmental response. Precise Design Engineering Solutions offers customers one stop design and manufacturing solutions. Addressing projects from the conceptual design stage through to volume production and assembly, and every part in between. J-Squared Technologies is a solutions provider delivering rugged computer systems and embedded solutions to address unique operational requirements in the ocean tech and defense sectors. Through ESL Technology, J-Squared provides a full range of environmental testing services enabling companies to meet stringent product qualification and certification requirements.

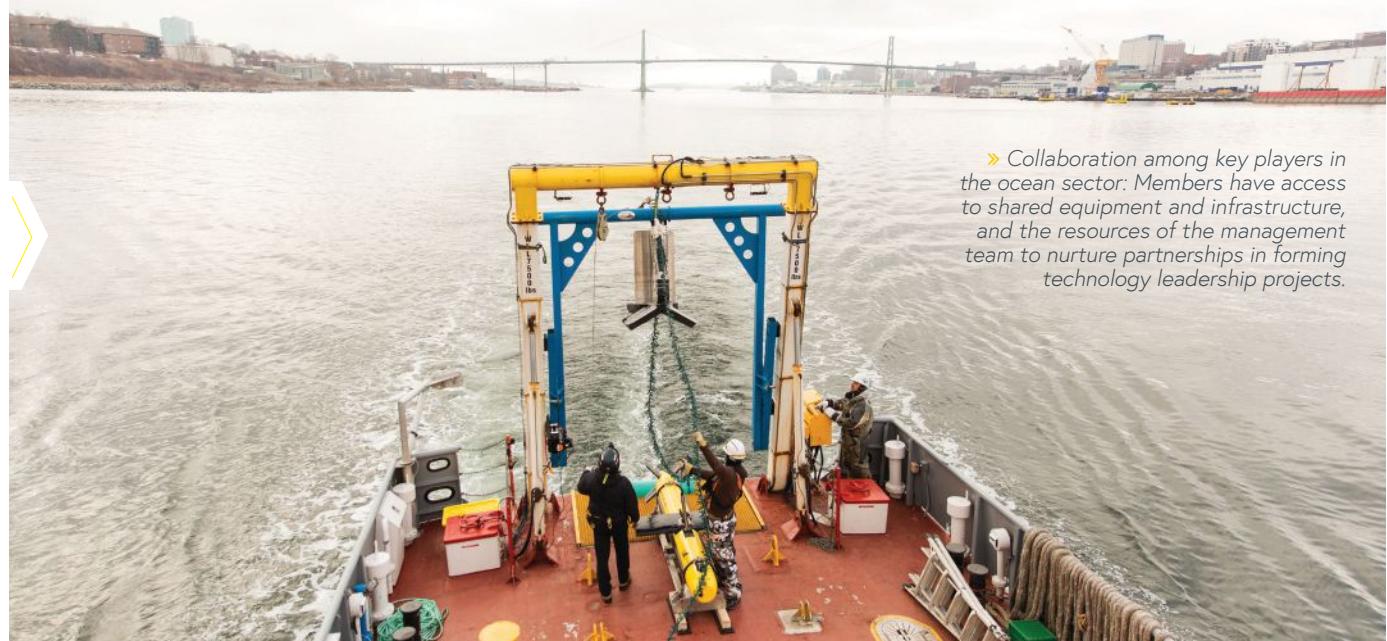
The emerging fields of data analytics and data as a service are growing in importance in the ocean sector. Again, COVE shows the breadth and strength of their tenants with several emerging global leaders and new innovators. PanGeo Subsea is a marine geophysical-geotechnical service delivery company specializing in high resolution 3D acoustic imaging solutions to mitigate risk in offshore installations by imaging and identifying geohazards in the seabed and providing detailed soil stratigraphy. Kraken Robotics Inc. is a marine technology company engaged in the design, development and marketing of advanced sensors used in military and commercial



» Dartmouth Ocean Technologies' (DOT) V-Wing towed underwater compressor, just one example of the caliber of ocean innovation at COVE.

applications. Kraken is recognized as world leading innovator of Synthetic Aperture Sonar (SAS), an emerging underwater imaging technology that improves seabed surveys by providing ultra-high-resolution imagery at superior coverage rates. They employ this capability through a "robotics as a service" model. Rimot was born out of decades of experience in the communications industry focused on customers who need a high-value yet affordable remote monitoring solution for critical infrastructure in the field. While Rimot had been focusing these skills on maritime users they demonstrated typical COVE tenant creativity and have pivoted to provide a contactless screening station and online portal for COVID-19 in employment settings, which will include maritime environments.

The breadth of expertise found at COVE is truly impressive. The tenants there are engaging many of the most compelling applications and markets in the ocean. Today, while the global community faces the immediate concerns of a pandemic, there are many long-term challenges to our ocean planet. Maritime safety and security in an opening arctic, expanded aquaculture for a protein hungry planet, and increasing development of renewable offshore energy are some core concerns for the entire ocean community as the 2020s open. Harnessing innovation to safely operate in the global ocean and deliver on the potential for new commercial growth is the future for COVE and its tenants. True to its Coast Guard roots, COVE is a haven for ocean tech innovation in a complex and dynamic world.



» Collaboration among key players in the ocean sector: Members have access to shared equipment and infrastructure, and the resources of the management team to nurture partnerships in forming technology leadership projects.

# A DEPTH OF EXPERTISE

*Having generated more than \$90-million in positive mainstream media coverage in the last two years, Triton Submarines is arguably the highest profile company operating in the subsea sector today. How does this boutique engineering firm continue to achieve the extraordinary?*

By Craig Barnett



» Triton Submarines - Headquarter facility in Sebastian, Florida.

In delivering practical and reliable results for discerning private clients, marine research institutes, documentary production companies, and commercial submersible operations, Triton Submarines has demonstrated an unerringly ability to engineer varied solutions that achieve a wide spectrum of unique challenges posed to them.

Headquartered in Sebastian, Florida and with a second R&D, production and service facility in Barcelona, Spain, the company's record in just the last year suggests a peerless depth of experience and expertise in the field of manned exploration of the ocean.



» DSV Limiting Factor - Atlantic Productions.

Having received the only 'Unlimited Depth' certification issued by DNV-GL, the Triton 36000/2 submersible and three accompanying Landers set numerous records during the successful Five Deeps Expedition and eight manned missions to Full Ocean Depth in Challenger Deep. As such, it is the first vehicle in the history of mankind to provide unrestricted access to the entirety of the world's oceans.

The extremities of depth are not the only envelope Triton is pushing, however. Earlier this year the firm delivered the first significant commercial tourism submersible in the last two decades, aboard the 24-passenger DeepView 24 model. The handover of the ninth 1,000 m capable Triton 3300/3 model places it as the most successful series-built submersible in history, while also currently in production are the deepest diving acrylic pressure hulled submersible (Triton 7500/3), a 1,000 m rated 6-person model (Triton 3300/6), a large capacity 7-person unit with 500 m depth capacity (Triton 1650/7 Configurable), along with a host of other units from the model range.

Alongside providing submersible platforms for manned exploration of the depths,

Triton turns its hand and resources to aiding others in their specific goals. The company's hyperbaric test chamber—the largest in Europe—has been instrumental in the testing of vital components to full Ocean Depth, including a line of modular batteries certified to FOD that Triton will soon bring to market. They have also assisted Omega in their production of pressure tolerant watches and undertaken numerous other projects on behalf of a diverse range of clients.

So how does this boutique 40-strong subsea engineering company consistently achieve the extraordinary? "Triton's success is unquestionably down to curating a team of the most experienced submersible designers, engineers and operators on the planet," according to company president Patrick Lahey. "We recently conducted an internal survey and discovered amongst the 450+ years of in-house subsea experience, our personnel have worked on over 100 different submersibles."

Lahey continues: "I'd say the team is an asset of a value that money can't buy, but this resource is available to assist any company or individual in the accomplishment of their ocean-related goals. We've yet to be posed a challenge we couldn't overcome."



## TRITON: ACHIEVEMENT AT DEPTH

### OPERATIONAL HIGHLIGHTS:

- Conducted ten 11km descents to Challenger Deep
- Discovered new species of Snailfish & stalked Ascidean
- Dived to Titanic for first time in 14 years + 4K filming
- Studied life in the deepest part of all five oceans
- Produced the first live underwater news broadcast
- World's deepest Octopus captured on camera

### ENGINEERING DEVELOPMENTS:

- World's only submersible rated to "Unlimited Depth"
- Full Ocean Depth, solid-state, modular batteries announced
- All-acrylic tourist submersible delivered - DeepView 24
- World's only acrylic pressure hull rated to 2,200m
- World's largest acrylic pressure hull ever tested



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# REAL-TIME ACCESS TO ANTARCTIC TIDE DATA

One of the most important challenges, when designing monitoring facilities in remote locations, is resilience. Remote tide gauge systems operate in extremely harsh environments and require robust communications systems that almost never fail and are capable of storing large amounts of data locally as an extra protection for data. Scientists from the National Oceanography Centre (NOC) are therefore upgrading the South Atlantic Tide Gauge Network (SATGN) to include the latest low power dataloggers with built-in satellite telemetry capability – the SatLink 3 from OTT Hydromet.

The SATGN is maintained and operated by the National Oceanography Centre, which is the UK centre of excellence for sea level monitoring, coastal flood forecasting and the analysis of sea levels. It is the focus for marine water level research in the UK and for the provision of advice for policy makers, planners and coastal engineers.

The SATGN measures sea levels in some of the most remote places on Earth. Monitoring sites include Antarctic locations such as Rothera and Vernadsky; located around 1,400 km below the southern tip of Argentina. Prior to the installation of this network there was a lack of information on sea level variations in the Southern Atlantic and a bias in tide gauge records towards the more densely populated Northern hemisphere. Over the last 30 years data from the SATGN have improved estimates of global sea level change, such as those reported by the Intergovernmental Panel on Climate Change.

The NOC at Liverpool operates and maintains the SATGN providing near real-time sea level data for operational purposes and scientific research. This has helped to provide a long-term sea level record that is used by UK scientists and the wider scientific community to monitor the Antarctic Circumpolar Current (ACC) variability. The data is also being used to help in the 'ground truthing' of satellite altimetry as well



» Sutron SatLink3 Satellite Transmitter Logger

as the evaluation of climate variability on various timescales including longer term changes. In addition, the data is being used by local communities to provide essential information for both government and port authorities.

## Monitoring/telemetry system upgrade

In recent years, the SATGN has undergone a refurbishment program to reduce running costs and to safeguard local populations and infrastructure by providing tsunami monitoring capability and improving resilience. These new gauges couple Global Navigation Satellite System (GNSS) land level monitoring technology with tsunami capable radar and pressure sensors, transmitting data in near real-time by satellite-based communications systems to operational monitoring centres.

As part of this NOC ongoing program, the tide gauges' main datalogger and transmitter have been upgraded to incorporate OTT's new Sutron SatLink3. The first site to receive this upgrade was the Vernadsky station located in Antarctica, which is now operated by Ukrainian scientists and is soon to be followed by the tide gauge at King Edward Point, on the South Georgia islands.

A further advantage of the upgrade is the SatLink3's ability to communicate via Wi-Fi with wireless devices, including smart phones, tablets and computers. This means that local staff can connect wirelessly to the logger from a few meters away, which is a major advantage during inclement weather conditions.

## Sensors

The SatLink3 datalogger is capable of accepting readings from a wide variety of sensors, with 2 independent SDI-12 channels, 5 analogue channels, one 4-20 mA channel and 2 digital inputs. The Vernadsky station includes a barometric pressure sensor, a radar level sensor installed over a heated/insulated stilling well (keeps the inner core free of ice) and two OTT PLS pressure level sensors which provide accurate measurements of water depth.

The network is using the Geostationary Operational Environmental Satellite (GOES) to transmit data. GOES is operated by the United States' National Oceanic and Atmospheric Administration (NOAA)'s National Environmental Satellite, Data, and Information Service. One minute averaged data is transmitted every 15 minutes. The data is then made freely available on the IOC Sea Level Station Monitoring Facility website, [www.ioc-sealevelmonitoring.org/list.php](http://www.ioc-sealevelmonitoring.org/list.php).

Satellite telemetry is becoming increasingly popular in many other parts of the world. "Some government and non-commercial organisations are able to utilize a variety of satellites free of charge," explains OTT's Nigel Grimsley. "However, the cost of transmitting data via satellite has reduced considerably recently, and now rivals the cost of cellular communications."



## MARISCOPE MEERESTECHNIK: INNOVATIVE ROVS FOR UNDERWATER CLEANING AND MONITORING



» The Commander MK III Off-Shore is a multitask platform designed, developed and customized to carry out special tasks in offshore environments and features six vectorized thrusters that deliver speeds of up to 5 knots and maximum maneuverability

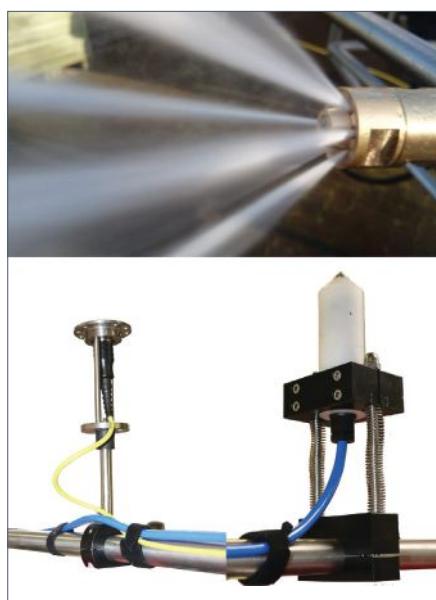
Mariscope Meerestechnik has been developing and manufacturing high quality underwater technology since the early 1990s and specializes in designing and integrating customized responses to client specific needs. The company offers fit-for-purpose solutions to extraordinary problems, at affordable prices.

One of Mariscope's most recent ROVs, the Commander MK III Off-Shore, was initially designed for the cleaning and inspection of offshore oil structures, but was later adapted for use in other industries, such as aquaculture. Tasks are carried out by CP & UTM probes mounted to the front of the ROV and a cavitation cleaning unit on the back side.

Development of this model started in 2010, when interest in this kind of solution was relatively low. It represents an evolution of the Commander MK III (a comprehensive multi-task platform that was already available in the field) and maintains the 6 vectorized thrusters that deliver speeds of up to 5 knots and maximum maneuverability.

The cleaning system installed in the back of the ROV works using cavitation. The system is notably lighter than those that feature high pressure water jets, so guarantees optimized operational efficiency. Also, the

re-fouling process on cleaned surfaces is drastically delayed (by up to three times as long) because the cavitation process destroys the cells of fouling organisms. For this particular ROV, a new multi nozzle head (MNH) that uses rotary brushes was introduced to deliver even greater efficiency gains.



» The modular design of the Commander MK III Off-Shore allows for full payload customization

The measuring CP & UTM probes, attached to the front of the Commander MK III, facilitate the measurement of subsea cathodic protection during the cleaning process with the use of surface control and recording systems.

Another innovative feature of this ROV is how the cleaning and measuring systems are mounted on external tilting frames controlled from surface, which allow for 360-degree deployment.

This ROV is completely symmetrical and uses the same Full HD cameras and LED lights for all sides, which are mounted on internal tilting units to allow for precision control—in high definition—of the cleaning and measuring tasks.

These product features have culminated in an efficient, easy to use, and high-quality platform capable of working 24/7 to minimize both cleaning times and risks to divers.

As with all Mariscope ROVs, this exclusive model comes with a lifetime warranty, a unique benefit of all Mariscope products.

For more information, visit  
[WWW.MARISCOPE.DE](http://WWW.MARISCOPE.DE)

# ADDRESSING SENSING CAPABILITY GAPS USING ECONOMICAL PROFILING TECHNOLOGY

By Michael Rufo, director of Boston Engineering's Advanced Systems Group, and David Shane, project manager and business development lead at Boston Engineering's Advanced Systems Group



*Figure 1 - NOAA Testing MASED in Alaska.*

The ability to collect oceanic data quickly, accurately, and economically has a significant impact on the success of commercial, military, and maritime research operations. Requirements and applications for oceanic sensing vary significantly based on the type of information targeted in specific weather patterns, climate regions, and oceanic zones. Boston Engineering's new sensing technology platform is addressing a breadth of maritime data collection needs by reducing barriers created by high costs and harsh environments.

## MARITIME SENSING TECHNOLOGY SNAPSHOT

Buoys, unmanned vehicles (UxVs), and sondes each have their advantages, but high costs and data collection limitations can make it prohibitive to deploy these technologies. As an example, the average price tag of a tethered weather buoy can reach \$375,000. UxV costs can also be high for some applications, and require capture for reuse. Lower-cost sonde instrument probes such as Expendable Bathymeterographs (XBT) have a limited field of exploration because data transmission requires cable or wire connectivity.

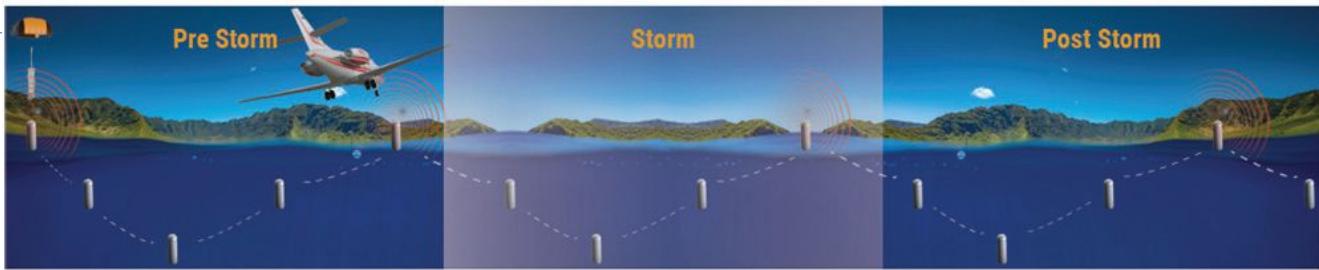
To reduce the cost per data-point collection in mission-critical maritime environments, Boston Engineering is developing a maritime

sensor family of platforms to support a range of applications across multiple industries. The platform's "plug-and-play" capabilities enable the rapid integration and use of a myriad of commercial sensors. Boston Engineering's platforms are capable of being widely distributed at reduced cost.

## MASED Overview

The following MASED overview highlights how Boston Engineering is applying its maritime sensor platform to address specific needs. MASED—a Multipurpose Above/Below Surface Expendable Dropsonde—is the first product to collect ocean data during developing hurricanes via multiple submerge-and-surface cycles. The data collected by MASED will allow researchers to better understand, analyze, and forecast hurricanes. Additionally, it will contribute to significant financial and economic benefits for affected hurricane regions.

Cost was a significant consideration in developing this expendable (if desired) product. At costs per profile in the range of hundreds of dollars, MASED will complete a user-specified number of profiles (a minimum of five) over two days. Developed through a National



MASED Transmits Multiple Sensor Readings via Satellite, Enables Mission Configuration by Duration, Profile Frequency, and Depth.

Oceanographic and Atmospheric Administration (NOAA) SBIR grant, Boston Engineering is providing NOAA's Aircraft Operations Center with prototypes for field testing.

### Illustrating Expendable Maritime Sensor Capabilities via MASED

MASED includes the following technologies and capabilities that are also used throughout the company's maritime sensing product line:

- Variable Buoyancy System (VBS):** Achieves multiple submerged water column profiles through its Variable Buoyancy System (VBS). The ability to change buoyancy allows MASED to make multiple controlled descents to a preprogrammed depth then ascend to the surface to transmit the collected data.
- Modular Software and Operating System:** Provides control via microcontroller of IMU, GPS, SATCOM, datalogger, CTD, and other sensors. Enables users to communicate, upgrade, modify, and test systems with ease.
- Sensor Nose (with CTD sensing):** Measures water temperature, conductivity, and pressure through the water column profiles and while at the surface. The modular design enables multiple types of sensors to be deployed.
- Electronics and Communications Modules (Satellite Communication with GPS):** Missions can be preprogrammed but a sample is that the device collects baseline data on day one, profiles again (multiple times) while the storm passes over, then transmits the data via Iridium to the Iridium satellite constellation, which can then be accessed quickly from anywhere in the world.
- Ruggedized Design:** Operates in harsh conditions. MASED is deployed from standard AVAPs launch tubes from aircraft flying up to 45,000 feet. The parachute system automatically detaches when in the water.

Boston Engineering is utilizing MASED's core technologies to address needs for the Naval Air Systems Command (NAVAIR), Naval Sea Systems Command (NAVSEA), and the Office of Naval Research (ONR). Figure 1 shows the Boston Engineering product family, into which MASED's core technologies were incorporated.

### BUILDING A MARITIME SENSOR PRODUCT LINE

The modularity and adaptability of MASED provides a significant advantage to address multiple applications and markets. Boston Engineering can deliver reliable, low-cost products by utilizing the latest technologies, and by applying our expertise in modularizing designs through design for manufacturing and optimization (DFx) best practices (see Table 1).

### Additional Maritime Sensor Products

In addition to MASED, Boston Engineering is developing the following capabilities:

**Proteus** is a persistent ocean profiling system that gathers high-density measurements through hundreds of profiles over the course

of many months to provide the Navy with accurate year-round ocean environment data at a lower cost than today's methods. Proteus provides highly reliable oceanographic data with sensors including GPS, water temperature, water salinity, pressure (for depth calculation), turbidity, and background noise. Proteus is being developed under a NAVAIR Phase II SBIR.

**MEDUSAE** is an autonomous, jellyfish-inspired vehicle capable of conducting autonomous station-keeping in dynamic environments to act as an oceanographic sensor node for 2-12 months. MEDUSAE utilizes its own energy harvesting sub-system to continuously provide highly reliable oceanographic data using a variety of sensors. MEDUSAE is being developed under an ONR Phase II STTR.

**SVP Sonde** is a low-cost MASED variant that provides sound velocity profiles (SVP) and conductivity readings in support of U.S. Navy Littoral Combat Ship (LCS) operations. SVP-Sonde is being developed under a NAVSEA Phase II SBIR.

Sensing Product	Application	Deployment Options	Duration
MASED	Enhance hurricane forecasting	Targeted, aerially deployed	Days (varies based mission configuration)
SVP Sonde	Collect readings for U.S. Navy mine countermeasures (MCM)	Targeted, UxV or vessel deployed	Days (varies based mission configuration)
Proteus	Persistent ocean profiling system with sensors for anti-submarine warfare (ASW)	Deployed in advance, aerially deployed	Months
MEDUSAE	A jellyfish-inspired vehicle that acts as a sensor node with autonomous station-keeping	Deployed in advance, various deployment methods	Months

Table 1: Boston Engineering's Expendable Maritime Sensor Product Family (Note: product scale is not exact)

### DELIVERING LOW-COST SENSING FOR MARITIME APPLICATIONS

Boston Engineering is developing and delivering reliable, low-cost maritime sensing products for multiple maritime applications. The company is building on its experience integrating and optimizing industry-leading sensing technologies to operate in harsh or congested environments. Its maritime technologies include the BIOSwimmer UUV, GhostSwimmer AUV, robotic systems, and other capabilities for mission-critical environments.

# TDI-BROOKS COMPLETES GEOTECHNICAL CORING PROGRAM FOR NOAA OER EXPEDITION

TDI-Brooks was contracted by Coastal Environments Inc. and Gray & Pipe, Inc. who received funding from NOAA's Office of Ocean Exploration and Research for this expedition. TDI-Brooks performed geotechnical piston coring at Sabine Pass 6 and High Island Blocks 117, 118, 130, 160, 177, 178 and A7. These efforts are part of the expedition *Paleolandscapes and the ca. 8,000 BP Shoreline of the Gulf of Mexico Outer Continental Shelf 2020*, designed to gather more information about the environment in which early Gulf Coast inhabitants would have lived.

The original geophysical data collected in early 1980s were printed on thermal paper, before digital data were available, and had become unusable. Coring locations were selected based on 2019 data, as well as by attempting to relocate some of the original cores.

## Paleolandscapes of the Gulf of Mexico Mission Overview

"In 2019, the project team spent two weeks offshore in the Gulf of Mexico collecting data to help answer questions about areas of the continental shelf that were once exposed as dry land.

Throughout time, global sea level has risen and fallen, alternately covering and exposing the land. Today, the Gulf of Mexico is largely known for its shrimping, fishing, and extensive offshore oil and gas development, but evidence of the earliest Gulf coast inhabitants could be preserved, buried under sediment and sea. But on a continental shelf where approximately 40 million acres could have been dry land in the last 12,000 years, where do you start looking?"

The NOAA Office of Ocean Exploration and Research (OER) supports research expeditions to explore previously unvisited areas of the ocean. OER provides partnership coordination, funding, staff, tools, and expertise needed to develop mission plans that deliver rigorous, systematic observations and documentation of biological, chemical, physical, geological, and archaeological aspects of the ocean.

The TDI-Brooks 3-inch-diameter piston coring (PC) system consists of various hardware assemblies designed to be safely and robustly



» With the sun rising over the horizon, the coring rig sits ready for deployment. Image courtesy of A. Herrera-Schneider.



» Figure 2: Piston core deployment

fastened together into a working core rig and deployed to the seabed for extracting a piston core.

TDI-Brooks' piston core deployed from the stern of the vessel, aimed over the target, and allowed to free fall into the sediment (Figure 2). The main winch, main-line coring rope, and the PC coring A-Frame are used for deploying and retrieving the 3-in. piston core rig on TDI-Brooks vessels. In addition to the deployed hardware, several assemblies are mounted to the vessel working deck to manage the deployment and retrieval of the coring rig.

A piston corer uses a free fall of the coring rig to achieve the desired initial force on impact, and a sliding piston inside the core barrel to reduce inside wall friction with the sediment and to assist in the rapid evacuation of displaced water from the top of the corer.

Once the sample is collected, the entire rig is pulled to the surface and placed back into its cradle, which is then recovered on deck. The cutter head and core catcher are removed from the barrel and the liner removed for inventorying and sectioning. We rinse and bag anything from the core catcher and drill bit, but our only other opportunity to see what we might have comes when we section the 6-meter (20-foot) long core barrel into smaller sections for transportation and storage (Figures 3 and 4).

## Lab Testing of Cores

A digital photograph is taken and a visual description of each section is recorded. Lab testing as outlined in the Field Sediment Testing Protocol is performed and the top of the core section is capped. Top and bottom caps are securely taped to the liner. The core sections are stored and secured in a vertical position with the deeper portion of the section on the bottom. The core sections are stored in a manner to minimize individual movement with vessel heave, pitch, and roll. After completion of the coring activities, the core sections are delivered to TDI-Brooks' onshore geotechnical testing laboratory in a timely, uninterrupted manner.



» Figure 3



» Figure 4



» The Cinema Class ROV, Pixel, on the wreck of the Northerner in Lake Michigan, near Port Washington, WI. Photo credit: Evan Kovacs.



## DEVELOPING NEW WAYS TO VISUALIZE THE AQUATIC WORLD

Within just a decade, Marine Imaging Technologies has established a reputation as a pioneer of underwater imagery

Founded in 2010 by Emmy nominated underwater cinematographer Evan Kovacs, Marine Imaging's goal has always been to create innovative camera systems to meet new challenges. With a project history that includes multiple Titanic expeditions and the Apollo 11 engine search and recovery, Evan's first-hand experience with the demands of subsea imaging led to the creation of the handpicked team of seasoned engineers and cinematographers who are Marine Imaging Technologies.

### The Cinema Class ROV » *Pixel*

"Creating an ROV to serve the camera" was the concept behind *Pixel*, the first Cinema class ROV. Breaking from tradition, *Pixel's* multi-camera system was the start of the design process, with the ROV's build evolving to fit the needs of the camera. The goal was to create a cinematic camera platform with imaging capabilities to rival those of land-based systems. *Pixel* is capable of capturing images in incredible detail, thanks to the deployment of Sony's latest UMC low light camera, Nikon's Z7 mirrorless camera, and 50,000 lumens of lighting.

### The Penetration ROV » *The 11th Hour*

*The 11th Hour* was born from the need to explore revered sites with respect and caution. Built in partnership with the National Park Service for entering the USS Arizona Memorial, *11th Hour* carries her tether with her, deploying it as she glides through the deep, pressing further into the unknown and revealing—in UHD—what lies in dangerous environments where the human risk outweighs the reward.

### VIRTUAL REALITY » HYDRUS

Underwater 8k virtual reality was merely a concept, until the creation of *Hydrus*. Eight of Sony's UMC ultra low light cameras on a radial tray with an additional two on the vertical axis has created a new

standard of underwater virtual reality. With a 60% image overlap, *Hydrus* is primed to deliver the next generation of immersive underwater experiences.

### 3D Modeling & Photogrammetry » *Sea Array*

Underwater archeology measured by the hectare. Working with the NPS Submerged Resources Center, *Sea Array* is a UPV propelled photogrammetry system capable of capturing over 10,000 high resolution data points per hour. Her triad of 45mp still cameras offer micro resolution on macro targets. When processed into a model, the *Sea Array* data has a modeling accuracy of millimeters per meter.

Marine Imaging Technologies is a dynamic company with the proven experience of building innovative systems to meet new expectations.



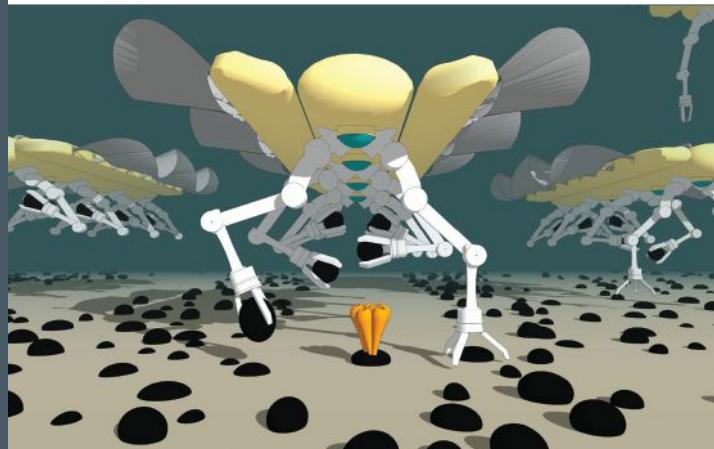
» *The 11th Hour*, the world's first self-spooling submersible ROV, explores the USS Arizona Memorial. Photo credit: National Parks Service photo by Brett Seymour, Submerged Resources Center.

For more information, visit

[WWW.MARINEIMAGINGTECH.COM](http://WWW.MARINEIMAGINGTECH.COM)

# CHECK THE TECH

## OCEAN MINING: TIME TO SWARM THE DEEP?



» Conceptual rendering of a C-Ray swarm collecting nodules.

Present-day ocean mining technologies center around the deployment of seabed crawlers engineered to harvest polymetallic nodules found at depths of over 4,000 m in the Clarion Clipperton Zone (CCZ). While most of the tried-and-tested hardware is borrowed straight out of the offshore oil and gas toolkit, there are escalating concerns that these seafloor extraction methods will trigger irreparable damage to deep-sea biodiversity.

There are some, however, that suggest a more sustainable approach to marine mining is possible. Enter NACROM, or the North American Consortium of Responsible Ocean Mining, a group being formed to leverage recent advances in subsea robotics—driven by AI and autonomous systems—to both mitigate against potential environmental impacts of nodule collection and also drive unmatched efficiencies in terms of yield.

### Swarm Technology

NACROM's lead protagonist is Brooklyn-based Pliant Energy Systems (PES). PES is busy developing C-Ray, an AUV platform that uses undulating drives instead of propellers, making it uniquely suited to nodule collection

on account of its unrivaled efficiency and maneuverability. Unlike a remotely operated crawler—which follows a "mow the lawn" pattern on the seabed—PES envisions a swarm of autonomous C-Ray AUVs that are able to discern which nodules should be removed and which should remain untouched (if they harbor life forms, for example). Individual nodules are then plucked with minimal disturbance thanks to the C-Ray's gently undulating propulsion system.

"The evolution of undersea hardware componentry combined with rapid advances in AI is starting to prove its effectiveness for survey and inspection," suggests Pietro Filardo, Founder and CEO of Pliant Energy Systems. "The environmental and technical challenges of nodule mining present marine roboticists with an opportunity to lead a paradigm shift towards the use of multiple semi-autonomous agents to execute large-scale operations."

### Eliminating Operational Risks

Operating at the depths found in the CCZ comes with inherent risks. When a modular system fails, it results in a complete shutdown of operations and a period of

costly inactivity. In short, putting all your nodules into one proverbial basket—or riser pipe—may not be the most prudent plan. Alternatively, by programming robots to place select nodules into a series of collector cages—raised to the surface with lift bags once full—operators are no longer reliant on conventional offshore assets, such as riser pipes and drill ships. Further, if a problem does occur with one or even several robots at once, they can be retrieved while the swarm continues mining, uninterrupted.

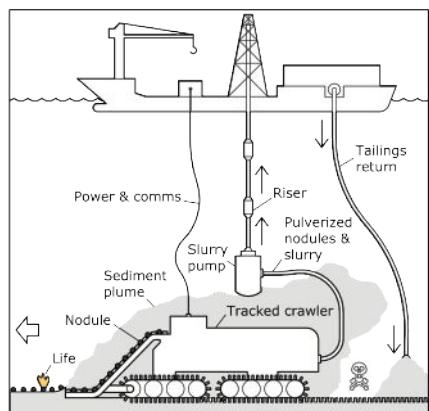
### Guaranteeing Long-term Returns

The long-term challenge with ocean mining, notwithstanding the environmental debate, has always been one of economic viability. That is, how to scale operations to produce a cost-effective yield. But PES argues that C-Ray's battery/thrust capacity could allow operators to gather more nodules, in less time, and with less energy consumption when compared to current proposals. So, this begs the question: How large a swarm is sufficient? How many robots would you need, say, to collect 3,000 tons of nodules a day?

Approximately, 235, according to Mr. Filardo. His estimate is based on BGR's study of the Germany-backed claim area in the CCZ—where over 95% of the seabed presents an average nodule density of 14.7 kg/m<sup>2</sup>—and assumes that only 20% of the nodules are harvested (3 kg/m<sup>2</sup>). If each C-Ray is capable of covering 3m<sup>2</sup>/min (incorporating charge time), around-the-clock operation at 9 kg/min would result in a haul of 12.9 tons/day per robot.

"With a cost of \$100k per unit, CAPEX on robots would be \$23.5M for a 3,000 tons/day operation. If the robots are able to collect 18 kg/min, the cost falls to around \$12M."

Find out more: [NACROM.org](http://NACROM.org)



» Figure 1: NACROM argues that conventional ocean mining proposals (left) are reliant on 20th century technologies and proposes a "blue swarm" approach that is both environmentally benign and increasingly cost effective.

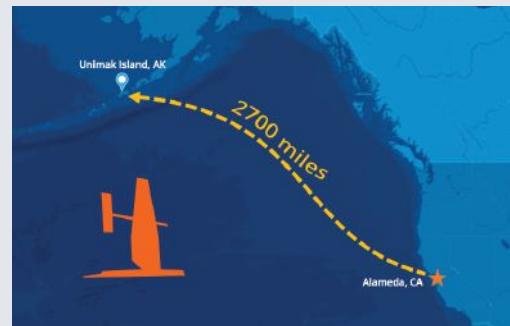
# SAILDRONES ENTER BERING SEA TO START UNCONVENTIONAL FISHERIES SURVEY

Scientists implement a contingency plan to collect valuable abundance data to support sustainable management of the largest commercial fishery in the United States.

Three Saildrones left Alameda, California in May and have arrived at Unimak Pass in Alaska's remote Aleutian Islands. The ocean drones have sailed nearly 2,700 miles at a walking pace, about 2.5 miles per hour (2 knots), which is just about the distance from Seattle to Miami. Once they navigate through the pass, the drones will enter the Bering Sea. This is where they will conduct a two-month-long acoustic survey of walleye pollock.

Several key standard manned-vessel surveys were cancelled this year due to the COVID-19 pandemic. The data the drones collect will help to fill in the gap for fisheries stock assessment scientists who monitor the changes in pollock populations to advise fisheries management. The sonar measurements made by the ocean drones will provide valuable insights on pollock abundance and distribution in 2020.

NOAA Fisheries plan to share more information over the coming months.



» Saildrone transit through Unimak Pass.  
Image: NOAA Fisheries.



» Ugamak Island from  
Saildrone 1049. Photo  
courtesy Saildrone.

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## AUTONAUT USV MAPS NORTH SEA SOUNDSCAPE DURING LOCKDOWN

AutoNaut has played a vital role in enabling The Flanders Marine Institute (VLIZ) to seize upon the quiet of lockdown to map the underwater soundscape of the Belgian section of the North Sea.

Using its near silent AutoNaut USV research vessel, *Adhemar*, VLIZ has been able to record current noise levels, which will be compared with the marine soundscape once normal sea traffic and marine activities recommence. This will help to determine the impact of manmade noise on natural sea life and the marine environment, building a picture of the marine soundscape in conditions that may never again be possible.

Following a 15% fall in shipping intensity in the North Sea since the start of the pandemic, VLIZ put its AutoNaut USV robot *Adhemar* into action to carry out measurements of the underwater noise in the turbid and shallow coastal waters of Ostend-Bredene.

Using Seiche's MicroPAM monitoring and mitigation system, developed specifically for autonomous surface vehicles (USVs), underwater sound was captured using two hydrophones trailed on



» AutoNaut USV research vessel *Adhemar*.

an 8 meter in-water cable with depth sensor. The onboard Seiche electronics module acquired and recorded all data.

Undertaken with the support of the agency for Maritime and Coastal Services (MDK) and FPS Mobility and Transport, the project took advantage of the unique current circumstances that allow a record of reduced human activities to be compared with a more normalized soundscape in post COVID-19 conditions.

Under normal circumstances, human interventions such as noise emanating from shipping, pile driving, and other activities can affect the soundscape of the coastal waters and North Sea, impacting on marine animals. Masking natural ambient noise, this extra underwater sound can disturb sea animal behavior or even result in hearing damage. This is because sound is carried more than four times further in water than in the air, which is precisely why many marine animals use sound to communicate, determine their position and search for prey.

Supported by AutoNaut's wave foil propulsion technology, which produces virtually no underwater noise, VLIZ utilized its USV *Adhemar* as a non-invasive, flexible method of capturing sound data, deploying Seiche Passive Acoustic Monitoring (PAM) technology to build a sound-map of the waters for future comparison.

VLIZ will analyze the sound recordings to identify underwater sounds originating from marine animals and the environment, including sounds from fish, invertebrates and other species that are typically masked by anthropogenic activities. This will allow VLIZ to investigate whether a different underwater soundscape can be observed as a result of reduced shipping traffic.

The results from the study, which are currently being processed, will be announced later this year in the autumn, followed by a further program of additional measurements—part of the LifeWatch observation program—which are planned for the future.

For more information, visit  
[WWW.AUTONAUTUSV.COM](http://WWW.AUTONAUTUSV.COM)

## OCEANOLOGY INTERNATIONAL 2020 SET TO TAKE PLACE DECEMBER 1-3, 2020

The UK Government have announced that from October 1st, 2020 B2B exhibitions will once again be held in England.

Oceanology International (Oi) 2020 is set to take place at ExCel London from 1-3 December 2020, which will make it one of the first major industry events to occur since the start of the COVID-19

pandemic led countries around the world into lockdown. Oi 2020 will benefit visitors from around the world with an unmissable and diverse range of ocean technology and innovation, on-water demonstrations and technical conference content, ideal to help re-establish ocean businesses in the context of the 'new normal'.

To assist exhibitors and visitors in understanding and preparing for exhibitions under the new framework, Reed Exhibitions have developed a 'new normal' guide, which is available on the event website.

For more information, visit  
[www.oceanologyinternational.com](http://www.oceanologyinternational.com)

# SBG SYSTEMS RENEWS ITS POPULAR LINE OF MINIATURE INERTIAL SENSORS



SBG Systems announces the third generation of its popular line of miniature inertial sensors called the Ellipse Series. This renewed product line benefits from a 64bit architecture allowing high precision signal processing. All the INS/GNSS now embed a dual-frequency, quad constellations GNSS receiver for centimetric position and higher orientation accuracy.

SBG Systems is the only manufacturer of miniature to high accuracy inertial navigation systems mastering the Inertial Measurement Unit design, calibration, and filtering. All improvements made in the high-end lines could naturally benefit to the Ellipse miniature line.

## High-end Inertial Navigation Technology in the Smallest Form Factor

The Ellipse Series is composed of four models: The Ellipse-A is a motion sensor, the Ellipse-E provides navigation with an external GNSS receiver, the Ellipse-N is a single antenna RTK GNSS/INS, and the Ellipse-D is a dual-antenna RTK GNSS/INS. With its new 64-bit architecture, the Ellipse Series 3rd generation enables the use of high precision algorithms and technology used in high-end inertial systems such as rejection filters, FIR filtering, etc. All Ellipse miniature INS are now RTK-enabled without extra cost and output raw data for post-processing. All these features are made possible in small and robust aluminum enclosure box version, but also in the 17-gram OEM version providing unmatched performance/size ratio.

## Ellipse-D, the Smallest Dual-frequency, Dual-antenna RTK GNSS/INS

Whether you choose the box or the OEM version, get the best performance/price/size ratio with the new Ellipse-D. With its dual frequency RTK GNSS receiver, the Ellipse-D

provides a centimetric position. Dual frequency provides a more robust heading and position computation than single frequency receivers and allows for unmatched performance in attitude ( $0.05^\circ$ ) and in heading ( $0.2^\circ$ ). With its dual-antenna capability, Ellipse-D provides precise heading in seconds, in all dynamic conditions, even in challenging GNSS conditions. It is also immune to magnetic disturbances. Ellipse-D is quad-constellation is capable of using simultaneously satellites from GPS, GLONASS, BEIDOU, and GALILEO for more signal availability in challenging navigation conditions.

## The Most Reliable Line of Miniature Inertial Sensors with 2-Year Warranty

Robustness and reliability have always been at the core of the Ellipse Series. Designed with high quality industrial-grade components, Ellipse inertial sensors are highly tested and calibrated in dynamic and temperature for a consistent and repeatable behavior in all

conditions. Highly reliable, the Ellipse Series is the only miniature inertial sensors coming with a two-year warranty.

## The Smallest Heave Sensor on the Market

All Ellipse marine versions output a 5cm heave, that adjusts automatically to the wave period. Fusion with DVL could be an additional performance enhancement for real-time navigation. This sensor could be easily integrated into marine projects thanks to compatibility with numerous industry software (TSS1, PASHR, INDYN protocols). Ellipse is the smallest heave sensor at this level of performance, and the OEM version allows tightest integrations.

For more information, visit  
[WWW.SBG-SYSTEMS.COM](http://WWW.SBG-SYSTEMS.COM)



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# NEW AUTONOMOUS GUARD VESSEL CONCEPT DESIGN TO REVOLUTIONIZE OFFSHORE WIND

A new Autonomous Guard Vessel concept, created by a consortium of maritime companies looking to support the offshore industry by harnessing technology available today, is set to revolutionize the offshore wind industry.

The novel design is smaller and lighter than most current guard vessels used to protect offshore operations and boasts sustainable solutions as well as exploiting the benefits of autonomous shipping. In addition, the Autonomous Guard Vessel (AGV) is set to drive efficiency thanks to the significant reduction in overheads associated with a crewless operation.

This clean and lean concept to replace conventional guard vessels came to life in a project group facilitated by LISA,



a community for maritime professionals. The project group resulted in a consortium, which includes C-Job Naval Architects, SeaZip Offshore Service, Sea Machines and recently joined by MARIN and eL-Tec elektrotechniek BV. Their combined industry knowledge created this viable, innovative, and sustainable alternative which benefits both wind asset owners and guard vessel operators.

The Autonomous Guard Vessel is specifically designed for surveillance of offshore structures throughout their life cycle, ranging from wind farms to substation platforms and cable routes. With any area that needs to be secured, the AGV can continuously monitor nearby marine traffic visually as well as via radar and AIS data. With any vessel that approaches the area, measures will be taken to secure the area in order to avoid collisions and damage to the offshore infrastructure. An intruding vessel can be communicated with and will receive information on how to safely navigate the area as well as being physically escorted away from the site by the Autonomous Guard Vessel. Additionally, the encounter will be recorded to provide video footage in case of any violation or accident.

Pelle de Jong, Founding Partner LISA, explains "Guard vessels perform an essential job, however, it is not the most exciting one for crew. Combined with the fact that conventional guard vessels are mostly outdated and thus aren't necessarily the most comfortable let alone sustainable, it can be difficult to find well-trained crew willing to do the job."

"The group set out to improve upon the overall process of securing an offshore area while incorporating sustainable solutions and reducing overall cost. By utilizing the knowledge we have as a group as well as the technology already available, we succeeded in creating a design which does this and more."

Thanks to incorporating state-of-the-art technology, the Autonomous Guard Vessel does not require crew onboard the vessel. Therefore, accommodations can be eliminated in the design, meaning the ship will be considerably smaller than

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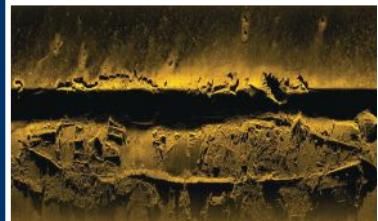
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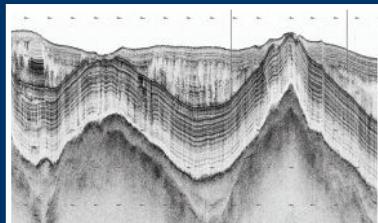
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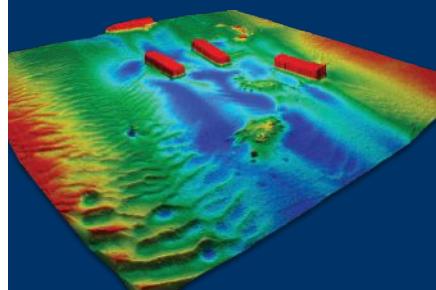
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existing guard vessels. The smaller size creates a number of opportunities, such as using batteries thanks to reduced propulsion requirements. Additionally, the reduced power and lack of onboard crew leads to lower operational costs.

Sustainability is key to ensure both the viability and durability of the design. Rolph Hijdra, Autonomous Research Lead at C-Job Naval Architects, says "We are pleased we were able to develop a battery-powered design, ensuring the Autonomous Guard Vessel is free of harmful emissions. Additionally, the ship has solar panels across the top which allows for the continuation of navigation and communications in case the batteries run out of power."

"Contrary to current guard vessels, the AGV will continue to be operational even with rough sea conditions and have minimal underwater noise owing to the smaller size, reduced propulsion requirements and absence of a diesel engine."

The Autonomous Guard Vessel will recharge its batteries via a charging station. The charging station can be moored independently or connected to existing equipment onsite. Depending on the situation, charging could either be via a cable connection to the on-site equipment such as an offshore transformer platform or locally generated using renewable fuels.

The consortium envisions an offshore site will need a number of Autonomous Guard Vessels, which can take turns in monitoring the area and recharging. Harm Mulder, Operations Manager at SeaZip Offshore Service, says "The Autonomous Guard Vessels will be constantly patrolling the area and take turns recharging. One fully charged AGV will remain on stand-by supporting operations if a situation arises. For example, when an intrusion is detected – one of the AGVs will monitor, warn, and escort the intruding ship to safety, while the others continue normal operations. Alternatively, it could take over from a monitoring vessel in case the battery runs out of power."

While the consortium continues to work on the Autonomous Guard Vessel design, they have considered human intervention for the unmanned vessel. Conventional guard vessels patrolling offshore structures, from installation through to decommissioning, have few incidents that require intervention from those onboard the vessel. For those exceptional circumstances the Autonomous Guard Vessel, if human intervention would be required, will be connected to a Command Center which could control the AGV remotely to ensure correct action is taken. In addition, all data collected by the AGV will be sent to the Command Center. This can be a standalone on a mother ship or a shore-based station.

Frank Relou, Business Development Manager at Sea Machines, says "Smart vessel technology will have the most significant initial impact on small workboats, such as this guard vessel. The development of autonomous technology for vessel operations are occurring on an international level but namely in niche segments, such as the guard vessel and other examples, currently operating in (with supervised autonomy), marine survey, fire, patrol, aquaculture and offshore wind operations."

For more information on the Autonomous Guard Vessel, please contact one of the consortium partners; C-Job Naval Architects, LISA, SeaZip Offshore Service, Sea Machines, MARIN, and eL-Tec elektrotechnologie BV.

info@edgetech.com  
USA 1.508.291.0057

# TRACKING TOMORROW'S CATEGORY 5: MARINE RENEWABLE ENERGY TURNS THE TIDE



» MRE can power everything from coastal cities to the AUVs that predict catastrophic storms. Image credit: Pexels

The ocean holds immense promise and peril. This renewable, plentiful source of energy could do everything from helping satisfy our country's growing energy demands to powering the devices that track the dangerous storms that threaten coastal communities.

Marine renewable energy (MRE) experts at the National Renewable Energy Laboratory (NREL) and the Pacific Northwest National Laboratory (PNNL), in collaboration with the U.S. Department of Energy's (DOE's) Water Power Technologies Office (WPTO), are seeking new ideas for capturing and employing the vast power contained within our oceans and rivers.

As part of this effort, WPTO and the Integrated Ocean Observing System (IOOS®) program at the National Oceanographic and Atmospheric Administration (NOAA) launched the Ocean Observing Prize. The prize inspires innovators to imagine tomorrow's tech to revolutionize data collection to better understand, map, and monitor the ocean, as well as track dangerous storms like hurricanes.

Should they accept the challenge, competitors will be tasked with integrating marine energy systems with ocean observation platforms, such as autonomous underwater vehicles (AUVs), to enable

longer deployments at sea for better data capture.

## Riders on the Storm

This fall will mark the launch of the second stage of the prize: the DEVELOP Competition.

Competitors will integrate wave energy with AUVs, allowing their batteries to be recharged while the vehicle is on mission—specifically for the purpose of hurricane monitoring in the Atlantic Ocean.

Why the focus on hurricane monitoring?

While scientists and researchers have

become fairly adept at modeling and forecasting storm tracks, forecasting storm intensity remains a challenge. And the stakes could not be higher; for example, the difference between a Category 2 and a Category 3 hurricane can be significant, and inaccuracies in forecasting could have dire consequences for coastal communities in its path.

Predicting storm intensity is challenging, largely due to a dearth of data, which can be addressed by collecting in-situ data before, during, and after a hurricane develops and strengthens at sea. Amassing this type of data, however, requires an ocean observing platform that can be deployed at sea for long periods of time to wait for approaching storms.

While some systems do have the ability to stay out at sea for an extended duration, they are often restricted to surface operations or limited in speed, maneuverability, or in the number of data collecting instruments that they can host. A self-charging AUV could address those

limitations—which is where the Ocean Observing Prize comes into play.

#### **Spurring Observation Innovation**

In the DEVELOP Competition, participants will construct functioning prototypes of their AUV designs to be tested in both a controlled environment and, subsequently, real-world conditions in the ocean.

Submissions will be scored on a handful of critical functional AUV requirements such as data collection, recharging, and maneuvering.

The prize aims to ensure that these inspired ideas make it to the marketplace, too.

Participants will be encouraged to consider the business aspects of commercializing their systems and will be provided with support for both their system designs and business models.

The competition is not expecting submissions of commercially ready systems that are prepared for long-term

ocean deployment, but rather is seeking prototypes that can demonstrate the basic functionality of the final system. The idea being that the competitors can build off their prototypes, refining their designs to produce a commercially ready product following the close of the competition.

By dreaming up the deep-sea data collecting devices of tomorrow, the competitors can help improve our understanding of what lies beneath the waves, along with the severe storm prediction necessary to protect our coastal communities.



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# ON A MISSION WITH OKEANUS SCIENCE & TECHNOLOGY

The design and manufacture of rugged and reliable systems for offshore exploration is built upon three pillars: engineering, technology, and science. This is certainly the view held by the team at Okeanus, a based provider of essential marine equipment and instrumentation, and a belief central to the company's product development cycle, according to COO Don Brockett,

"Whether we are custom fitting a heavy pull multipurpose winch or developing a prototype sample collector for deep-sea research, we have the marine engineering experience and the technological know-how to deliver failproof, mission-critical assets."

The breadth and caliber of Okeanus' products and services belie the team's relatively lean structure but serves as clear testament to the firm's highly targeted growth strategy since 2013, which included the acquisitions of Sound Ocean Systems, Inc. (SOSI, incorporated in 1978) in 2016 and DT Marine (incorporated in 1999) in 2017. Today, seven years on, Okeanus is an established market leader for field-proven deck equipment (an expanding portfolio of winches, A-frames, LARS, HPUs, and sheaves), marine research technologies (including GPS products, pressure rated subsea housings, and towfish), and essential instrumentation for hydrographic, offshore geotechnical, and environmental surveys.



» A skid mounted active heave compensation umbilical winch and LARS for an NiGK Seafloor Drill, used for sampling cobalt crust deposits in Japan.

## Customization Comes as Standard

The company's client roster is equally diverse; from DoD contractors and end users to research institutions and commercial operators, from one continent to the next, Okeanus boasts a reputed track record for outfitting vessels and crews with turnkey solutions, on time and on budget. Customization—the ability to partner with customers to develop fit-for-purpose products—has been fundamental to developing long-standing relationships with both the public and private sectors.

"Having worked on so many different offshore projects, from shallow to deep, we understand that there's no one-size-fits-all approach to equipping clients for the rigors of at-sea operations. Custom engineering is a critical part of what we do and ensures that we learn and grow with our customers. We see innovation is a two-way street and understand that our clients demand a dynamic response to product development, with expediency of deployment as a high priority."

## New Frontiers Call for Flexible Solutions

This ability to identify and adapt to shifting market demands has led the team to further expand on existing capabilities at Okeanus' three strategic locations (Houston TX, Redmond WA, and Houma LA) to better serve

the requirements of several key emerging markets, including the US offshore wind sector in the northeast and deep-sea mining operations in the Pacific Ocean.

In these rapidly changing times, flexibility and rapid mobilization are prime considerations and, therefore, Okeanus has further invested in developing its extensive rental portfolio. With a focus on winches, portable A-frames and LARS, game-changing ASV technology and sensor suites, and environmental sampling equipment, the company is able to provide customers with a growing menu of turnkey solutions.

"This is an exciting new chapter in the Okeanus story," Brockett continues. "We have the equipment, manpower and subject matter expertise to service our core Scientific, DoD, Oil & Gas, and international markets, while also developing groundbreaking systems for these new and prospering industries in the offshore renewable energy sector."

For more information, visit  
[WWW.OKEANUS.COM](http://WWW.OKEANUS.COM)



# ENI AND PARTNERS MAKE NEW GAS DISCOVERY OFFSHORE EGYPT



Eni (as the Operator of the Block), BP and Total (as Contractor members) have successfully drilled the first exploration well in the North El Hammad license, in the conventional Egyptian waters of the Nile Delta, on the prospect called Bashrush.

The new discovery is located in 22 meters of water depth, 11 km from the coast and 12 km North-West from the Nooros field and about 1 km west of the Baltim South West field, both already in production. The well discovered a single 152 meters thick gas column within the Messinian age sandstones of the Abu Madi formation with excellent petrophysical properties. The well will be tested for production.

The discovery of Bashrush demonstrates the significant gas and condensate potential of the Messinian formations in this sector of the Egyptian Offshore shallow waters. The discovery of Bashrush further extends to the west the gas potential of the Abu Madi formation reservoirs discovered and produced from the so-called "Great Nooros Area".

Eni, together with its partners BP and Total, in coordination with the Egyptian Petroleum Sector, will begin screening the development options of this new discovery, with the aim of "fast tracking" production through synergies with the area's existing infrastructures.

In parallel with the development activities associated with this new discovery, Eni will continue to explore the "Great Nooros Area" with the drilling, this year, of another exploration well called Nidoco NW-1 DIR, located in the Abu Madi West concession.

In the North El Hammad concession, which is in participation with the Egyptian Natural Gas Holding Company (EGAS), Eni through its affiliate IEOC holds 37.5% interest, the role of Operator, BP holds the 37.5%, and Total holds the 25% of the Contractor interest.

Eni has been present in Egypt since 1954, where it operates through IEOC Production. The 2020 equity production of IEOC is in the range of 280,000 boepd.

## OEE2020 – POWERED BY THE OCEAN

The energy transition towards a carbon-neutral future is more important now than ever. The coronavirus pandemic has only magnified the impacts of the climate crisis, and underlines the importance of investing in robust, shock-resistant industries.

The world is ready for new and sustainable sectors to drive industrial activity and create jobs. Ocean energy technologies are ready to take on the challenge in this economic reality: Indigenous, infinite and decentralized, ocean energy offers real economic and environmental benefits.

Check out this wave energy focused session at [www.oceanenergy-europe.eu/annual-event/oee2020](http://www.oceanenergy-europe.eu/annual-event/oee2020)

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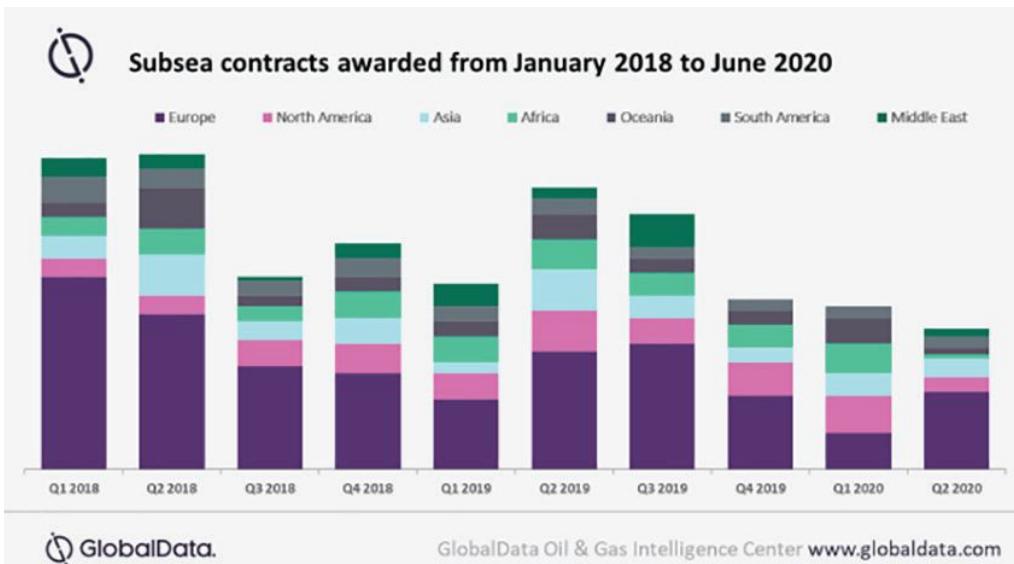


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# SUBSEA PRODUCTION SYSTEMS EXPAND BOUNDARIES OF DEEPWATER HYDROCARBON E&P



Subsea technology has drastically improved in the last two decades in terms of functionality and reliability, with notable strides made in areas such as subsea processing, subsea storage, subsea-to-shore and power distribution. This has enabled upstream companies to expand the scale of their deepwater projects, says GlobalData, a leading data and analytics company.



» A TechnipFMC Remotely Operated Vehicle (ROV) is deployed to provide subsea services. (Photo credit: TechnipFMC)

GlobalData's latest thematic report, *Subsea Technologies for Oil and Gas Offshore Exploration and Production (E&P)*, notes that advancements in subsea technology are paving the way for a more complete subsea system, controlled from onshore, providing cost and safety benefits. A notable example of this is Equinor's Snøhvit Gas Project in the Barents Sea, which has a subsea production system that transports feed gas to an onshore liquefied natural gas (LNG) liquefaction terminal at Hammerfest, Norway. Presently, most of the subsea systems depend upon a topside platform for production capabilities, power source and control hub.

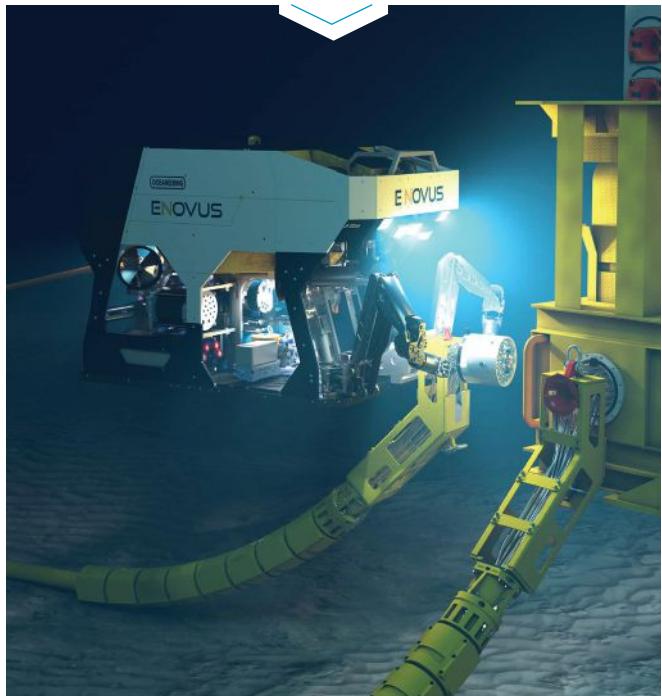
Ravindra Puranik, Oil and Gas Analyst at GlobalData, comments: "Over 400 offshore oil and gas fields are presently under development in different parts of the world. Although, over 60% of these fields are based in shallow waters, those located in deeper sections are attracting higher investments from oil and gas companies. In 2019, capital spend on deepwater and ultra-deepwater projects collectively accounted for approximately 55% of the total offshore spend. By 2024, the deeper sections would garner nearly two-thirds of the offshore spend."

"The high investment in deepwater developments is largely attributed to the project complexities involved in bringing these fields online. Subsea production systems play a critical role in such projects from a technical and economic perspective. These systems facilitate in connecting a large number of wells together to maximize the output from the project to bring down the payback period."

GlobalData identifies TechnipFMC, Subsea 7, Schlumberger, Saipem, DOF ASA, Oceaneering, McDermott, Aker Solutions, National Oilwell Varco, Halliburton and Baker Hughes among the leaders in the subsea section of the oil and gas industry.

Puranik concludes: "The COVID-19 pandemic, and the subsequent oil price crash, has affected project economics for many oil and gas fields. The impact is even more pronounced in the offshore sector, where operators are forced to defer several greenfield projects to manage their cash flows such as the Barossa Gas Project in Australia. New orders for subsea equipment are likely to slow down, while the execution of existing orders might also be delayed due to supply chain disruptions. However, subsea technology and services could find increased relevance in offshore projects that are likely to go ahead as they enable in lowering the costs."

*Information based on GlobalData's report: 'Subsea Technologies for Oil and Gas Offshore Exploration and Production (E&P)'*



» The eNovus is a compact work class ROV powered by an environmentally-conscious electric propulsion system that includes state-of-the-art control electronics and intelligent diagnostic system. (Photo credit: Oceaneering)



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# SEAMOR MAKO ROV ASSISTS CANPAC MARINE SERVICES DIVE TEAM

Commercial diving contractor CanPac Marine Services used the SEAMOR Mako ROV to monitor conditions and assist CanPac's dive team as it replaced damaged diffusers on a stormwater outfall in a high current area offshore of Victoria, British Columbia, at a depth of 60 meters (200 feet).

"The depth and current created challenging conditions for the CanPac team, but the Mako ROV allowed the diving supervisor to survey the site beforehand then closely monitor the divers during the repair operation," said Mr. Robin Li, President of SEAMOR Marine. "The Mako can cover lots of ground, ascending and descending without issue even in current, to look at different angles."

CanPac's diving supervisor used the Mako to check the condition of the work site and scan for any potential hazards before deploying the dive team. The Mako also helped identify areas to focus on ahead of time so that divers could address them more directly.

During the operation, the Mako served as a second set of eyes enabling the supervisor to monitor the divers and the worksite in real time to safely manage any developing hazardous situations. In the event of an emergency, the supervisor could have used the Mako to oversee and control the rescue of a diver.

"Our Mako ROV once again proved to be an extremely valuable asset enhancing our productivity and safety during this project."



said Ryan Anderson, Director of Operations at CanPac Marine Services. "We chose the Mako for this project mainly because of its proven efficiency in high current."

High current can jeopardize safety in a commercial diving situation, but the Mako ROV was designed to mitigate the risk.

"The Mako runs on DC power supplied from the surface," says Li. "Other vehicles of the same size run AC power directly to the vehicle, which could pose a significant risk to the divers if they come in contact with stray current."

CanPac, with a spotless safety record over its 40+ years of operations, has used the Mako ROV for dozens of inspections over the last months.

"It's a versatile, reliable workhorse that can handle a heavy payload and operate in challenging conditions," said Anderson. "It does the job that we've had to use much larger work class ROVs for in the past, and it has resulted in a considerable cost savings for us and our clients."

The Mako ROV is the company's largest ROV and can support a payload of up to 22.5 kilograms (50 pounds), working in depths up to 600 meters (2,000 feet). The Chinook is the mid-sized vehicle in SEAMOR's line of ROVs, able to dive to 600 meters (2,000 feet). The Steelhead ROV, SEAMOR's smallest vehicle, is more compact and suited for work in confined spaces in depths of up to 300 meters (1,000 feet).

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## KONGSBERG SIGNS FIRST LARS CONTRACT WITH OCEAN INFINITY

Kongsberg Maritime has signed its first contract for a state-of-the-art launch and recovery system (LARS) specifically designed to handle remotely operated vehicles (ROVs) from unmanned vessels. The contract has been signed with Ocean Infinity who will install the system on their 'Armada fleet' of cutting-edge robotic ships.

KONGSBERG's LARS is an essential component in a system designed to ensure that no people are required at sea while carrying out subsea operations. This innovation enables the deployment of remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) by teams based onshore.

The system uses a pure electric drive system, making it more environmentally sustainable and significantly reduces the need for maintenance. Launch and recovery will happen through the moon pool, with the release and capture of the ROV occurring beneath the sea surface. This eliminates the possibility of damage to the ROV from impact with the vessel's hull. Another benefit is that launch and recovery can be carried out in higher sea states.

### Subsea Expertise

"The new LARS solution is developed in close collaboration with the Ocean Infinity team. It benefits from a unique combination of our advanced subsea technologies, reinforced with years of accumulated offshore expertise," says Lisa Edvardsen Haugan, Executive Vice President, Deck Machinery & Motion Control, Kongsberg Maritime.

"We believe this will be a game changer. The cost of ROV operations can be drastically decreased through the use of this system. We expect to see more companies transition to more use of unmanned vessels to reduce operational costs and increase safety."



» 3D-images shows the new LARS from Kongsberg Maritime in a single and dual setup.



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# HALLIBURTON AND TECHNIPFMC INTRODUCE NEW SUBSEA FIBER OPTIC SERVICE

Halliburton Company and TechnipFMC have introduced Odassea™, the first distributed acoustic sensing solution for subsea wells. The technology platform enables operators to execute intervention-less seismic imaging and reservoir diagnostics to reduce total cost of ownership while improving reservoir knowledge.

The Odassea service integrates hardware and digital systems to strengthen digital capabilities in subsea reservoir monitoring and production optimization. Halliburton provides the fiber optic sensing technology, completions and analysis for reservoir diagnostics. TechnipFMC provides the optical connectivity from the topside to the completions. Through the collaboration, operators can accelerate full field subsea fiber optic sensing, design and execution.

"We are excited to introduce a new technology platform which allows our customers to monitor reservoir performance in real-time," said Trey Clark, vice president of Halliburton Wireline and Perforating. "By collaborating with TechnipFMC, we can harness our combined subsurface and subsea expertise to deliver differentiated products to the marketplace that provide value for our customers."

"This project enables an enhanced level of reservoir understanding for our customers and expands our unique integrated subsea solution," said Christina Johansen, vice president of TechnipFMC Subsea Product Manufacturing. "We are proving that we can leverage the competencies and know-how to drive the change our industry needs for a higher level of sustainability."

In the field, Halliburton and TechnipFMC are delivering solutions with the technology to multiple subsea projects at all stages from conceptual design to execution and installation.



» Photo credit: TechnipFMC



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See page 26 for our  
Check the Tech article in this issue.

## OCEANEERING WINS CONNECTORS SUPPLY CONTRACT OFFSHORE WESTERN AUSTRALIA

Oceaneering International, Inc. has won a contract to provide a number of monobore diverless connectors for an offshore Western Australia project.

Oceaneering will supply 3-inch M5 connectors, which will be used for Monoethylene Glycol (MEG) and Chemical Inhibitor (CI) service on the field subsea distribution system.

The 3-inch M5 Connector enables the intervention of subsea assets. This ROV-flyable, full bore connector features the Oceaneering® Grayloc® metal-to-metal sealing system and proven M-series latch mechanism. The M5 Connector works for applications such as gas lift, chemical injection, well stimulation, hydrate remediation, flooding and venting operations, acid injection, and scale squeeze.

Nikunj Patel, Director of Engineering and Technology for Oceaneering, said: "We are thrilled to provide our high pressure, high flow ROV-flyable M5 connectors for this project located in Australian waters. The M5 is a versatile, compact, and cost-effective solution ideal for high flow MEG, CI, and other chemical delivery applications. With this win, we continue building our track record with the M5 connectors being used in projects worldwide."

# SAAB SEAEDGE LAUNCHES SEVEN-FUNCTION ALL-ELECTRIC WORK-CLASS MANIPULATOR

Saab Seaeye's first seven-function all-electric work-class manipulator has been developed by the world leader in electric underwater robotic vehicles.

This breakthrough heralds a significant advance in underwater robotic technology in the growing electric tooling and vehicle market.

The all-electric work-class seven-function manipulator introduces an equally powerful, more precise and more intelligent manipulator than the hydraulic equivalent currently being used on work class ROVs today.

Its innovative control system enables both manual and automated control, with the potential for full autonomy in the future.

## More Precise

Millimeter precision comes from each of the seven joint modules having its own self-contained smart distributed microprocessor for intelligent, intuitive and precise arm control.

This brings exacting, repeatable, precision which can predict limb motion paths for self-collision avoidance, adjusts movement requests to meet available power and collates joint data for unified control.

The combined lift capacity and range of motion exceeds that of any manipulator on the market, along with its superior accuracy, precise repeatability, high-resolution force and position feedback for greater arm control and path planning.

Included in the design is an adaptable power input system with advanced power management to limit peaks in power demand and manage regenerative loads.

Tested through many million cycles, the titanium built electric manipulator's planned reliability is set to reduce operating costs.

Although packed with advanced technology, Saab Seaeye engineers have created a work-class manipulator that requires far less maintenance when compared to hydraulic systems.

## Less Maintenance

Reduced maintenance and reliability improvements through electrification have created a system that, in addition to conventional ROV deployment, is ideally suited to onshore control with USV deployment or long-term immersion with resident systems.

The electric manipulator's intuitive control simplifies use of the manipulator by mimicking the movement of the master arm. Algorithms also predict and manage movement at each joint.

Designed to be future friendly—including the potential for interchanging the jaws with other tools—the electric manipulator's advanced technology will enable the transition from manual control to supervised autonomy with



» Saab Seaeye is the world leader in electric underwater robotics—including ROV, AUV, hybrid systems and tooling—and creator of the revolutionary iCON™ ecosystem.

advanced perception systems, towards full autonomy.

As the underwater world moves towards an all-electric future, an ecologically friendly, significantly oil-free, all-electric system is expected to have wide appeal.

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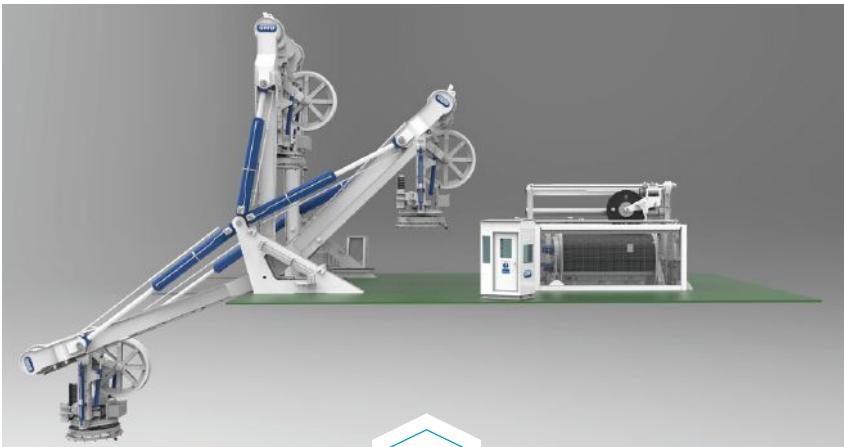
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## SMD SUPPLYING SOLUTIONS FOR ORANGE MARINE GROUP



» The new LARS systems represent an evolution of SMD's specialized Wide Angle A-Frame

Subsea vehicle and launch and recovery systems (LARS) specialists Soil Machine Dynamics (SMD) has won contracts to supply two solutions to marine telecommunications company Orange Marine Group. The new LARS systems will be used to launch custom trenching ROVs for the burial of underwater fiber optic cables.

The solutions are an evolution of SMD's specialized Wide Angle A-Frame, creating a bespoke system to accommodate a high vessel freeboard, allowing the Orange Marine trenchers to operate in higher sea states.

Matthew Woodward, business development manager for handling systems at SMD, who has worked closely on the project, said; "The most dangerous time for an ROV launch is as the vehicle is released from the A-Frame and enters the often rough ocean splash zone, and when it is being raised back onboard.

"SMD's Wide Angle A-Frame has a greater outreach and working arc than that of a conventional A-Frame system. This means that the air gap between the ROV and the water is minimized during launch, which reduces the pendulum effect caused by vessel motions on the vehicle. Limiting these forces is important to ensure a clash between the ROV and vessel structure is avoided, and the vehicle's umbilical

cable is not overstressed. Ultimately this simple solution makes it much easier and safer for operators to launch and recover the vehicle without damage in high sea states."

"At SMD, we pride ourselves on the relationship we foster with our client base. For this project, we have worked very closely with the technical team at Orange Marine and discussed many options to arrive at this preferred solution. The LARS is also supplied with an axial fleeting umbilical winch, which fits within the tight space envelope on deck and we're able to deliver the complete system within the desired timeframe. It's been a great experience collaborating with the team at Orange Marine to a solution that meet their needs, and one that gives them so many operational benefits."

This project consolidates a long-standing relationship between our two organizations. The first system is due for delivery to Orange Marine's Italian subsidiary (Elettra Tlc spa) in Sicily at the end of 2020, with the second system expected to start work near Singapore in mid-2021. SMD will also provide structural assessments on the vessel decks, installation, and commissioning support once the handling systems are onboard to ensure they are fully operational before the trenchers are first launched.

## FUGRO BEGINS SURVEY FOR 2AFRICA SUBSEA FIBER-OPTIC CABLE PROJECT

Fugro has begun their shallow water campaign for the "2Africa" subsea fiber-optic cable project which, once installed, will connect 23 countries in Africa, the Middle East and Europe and deliver more than the total combined capacity of all subsea data cables serving Africa today.

Fugro is supporting the project with offshore and onshore survey expertise, including a geophysical route survey and shallow geotechnical testing to overcome any challenges along the planned route.

Fugro started their survey program for Alcatel Submarine Networks (ASN), which includes a pre-installation and engineering survey, permitting support and desk study consultancy, back in March and work will continue for approximately one year from their multipurpose 70 m vessels Fugro Gauss and Fugro Supporter. By conducting the deep-water reconnaissance survey first, Fugro has already expedited the cable engineering and manufacturing phase by providing multibeam echosounder data to the ASN project team "on the fly" during the first phase of the project.

Malte Cesson, Fugro's Commercial Manager for Marine Site Characterization in Bremen, Germany, said: "We are proud and honored to be selected by ASN for this project, which in its base configuration will be one of the largest of its kind. The challenging scope of work is further complicated by COVID-19 and associated protocols but our unrivaled strategic partnership with ASN means we are confident of successful completion within the required time frame and budget."

The 2Africa cable system is based on the latest fiber-optic technology and will enable resilient and improved low-latency network traffic in times of growing bandwidth demand.

# C-KORE SUBSEA TESTING TOOLS SUCCESSFULLY DEPLOYED OFFSHORE AUSTRALIA

C-Kore Systems has completed a succession of deployments with an operator in offshore WA Australia. The C-Kore units quickly identified and localized anomalies in the subsea infrastructure, saving time and money on the subsea campaign while ensuring the operator gained accurate information to inform the field's maintenance program. With the automated C-Kore units, no additional offshore personnel were needed to perform the testing.

The C-Kore Subsea Testing tools are used by operators and contractors worldwide on both fault-finding operations and new installation campaigns. The tools provide quick feedback, saving customers money by reducing the time needed to perform subsea tests.

A Subsea Engineer for the operator commented, "We were very pleased with C-Kore's excellent service and the quick and accurate data their Cable Monitor and Subsea TDR gave. The results achieved could not be obtained using conventional test equipment. With our most recent mobilisation during the COVID-19 crisis, it was a relief we didn't need to send any personnel offshore with the equipment."

Greg Smith, General Manager of C-Kore added, "It is great to be able to work so closely with this operator. Their repeated business is testimony to the strong working relationships we build up with our customers and the time and money our technology saves. We were delighted that we could successfully perform



» C-Kore Subsea Testing tools are used by operators worldwide

measurements on this campaign that had been unsuccessful with conventional testing equipment. With the difficulties of getting people offshore due to COVID-19, it is an added benefit that our equipment can be used without any extra offshore personnel."

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# SUBMARINE FIBER OPTIC CABLES AS SCIENTIFIC DATA COLLECTORS



» Standard submarine telecom repeaters such as these can be easily turned into devices to collect a wide range of data from the ocean floor. Source: Ocean Systems Inc.

On June 30, a Total Telecom webinar entitled Building the Submarine Networks of the Future with SMART Cables was held in which experts discussed the concept and explain the technology involved in turning commercial submarine telecom cables into ocean data collectors.

SMART stands for Science Monitoring and Reliable Telecommunications. The basic idea is to combine submarine telecom cables and ocean sensing for ocean and climate monitoring and disaster warning by embedding sensors in the repeaters of commercial submarine fiber optic cables. Simultaneous with these cables transmitting Internet traffic, the sensors would be collecting scientific data on the ocean.

Bruce Howe, Chair, SMART Cables Joint Task Force (JTF) and Professor of Ocean and Resources Engineering at the University of Hawaii, provided the keynote address.

"The ocean is the flywheel of the planet," said Prof. Howe. "Submarine cables will make a significant addition to the current observing systems. There are absolute benefits for this kind of ocean observing: disaster warning for tsunamis and earthquakes, studying sea level rise and climate change and societal connectivity enabling progress with

resilient and sustainable telecom infrastructure."

In discussing costs, Prof. Howe noted that the plug-and-play systems are expensive, as are early warning systems with in-line instrumentation. With SMART, there is a sharing of infrastructure with telecom operators that should bring only incremental cost increases. The JTF would pick and choose the systems to work with that make the most sense in many ways.



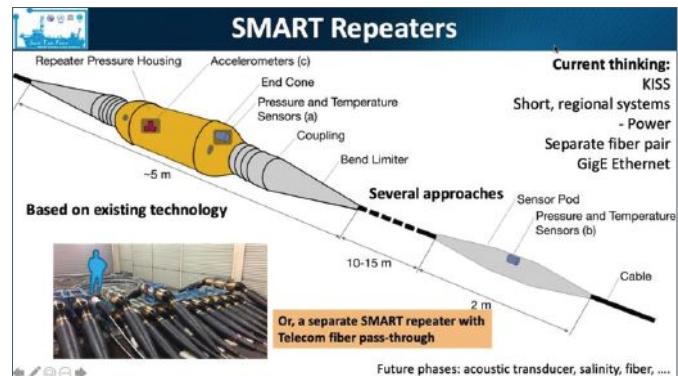
» Conventional submarine telecom repeater being loaded onto a cable ship. SMART repeaters could become standard for future cable installations. Source: Ocean Systems Inc.

He presented data that standard cables cost of between US\$25,000 and \$40,000 per kilometer. In a white paper entitled SMART Cables for Observing the Global Ocean: Science and Implementation, the JTF laid out a scenario where it judged the incremental cost of a SMART addition would be only 10%.

Prof. Howe continued, "The underlying concept of SMART is that submarine cables are shared critical infrastructure. SMART combines telecom with early warning, climate and science with shared benefits for all. We also want to keep it simple initially in all respects; not just technical but programmatically. In that way the countries that want the SMART capabilities for societal benefit can participate. These countries will have significant government involvement to encourage the process and provide funding. We're looking at a situation with a domestic system internal to one country or with facilitating countries to obviate the permitting and security concerns."

In terms of financing, we see very heavy government involvement, as well as multilateral development banks, non-traditional funding and commercial funding. Hopefully there will be incentives, such as tax breaks, expedited permitting and Green Bonds. SMART Cables will bring no loss of utility to the telecom payload. They also provide opportunities to demonstrate Corporate Social Responsibility (CSR)."

Steve Lentz, Director of Network System Science and Engineering, Ocean Specialists Inc. (OSI), is Co-Chair Engineering of the SMART Cables Joint Task Force. He gave a presentation on the technology of the SMART repeater.



» Turning a standard repeater into a SMART repeater. Source: Ocean Systems Inc.

"The image above is a representation of a repeater, showing what needs to be incorporated into it to give it SMART capability," said Mr. Lentz. "The accelerometers for earthquake detection would go inside the repeater housing, along with some additional circuit boards to collect and transmit data. The pressure and temperature sensors obviously need to be exposed to the environment. There are two possible mounting points for those. The first is on the end of the repeater housing, under the end cone."

"The other possibility is to move those sensors away from the repeater," he continued. "This could be done by creating a 'sensor pod,' which could be made by using two bend limiters back-to-back, with the sensors encapsulated in the rubber protection. This sensor pod



## Ocean Sensor Systems

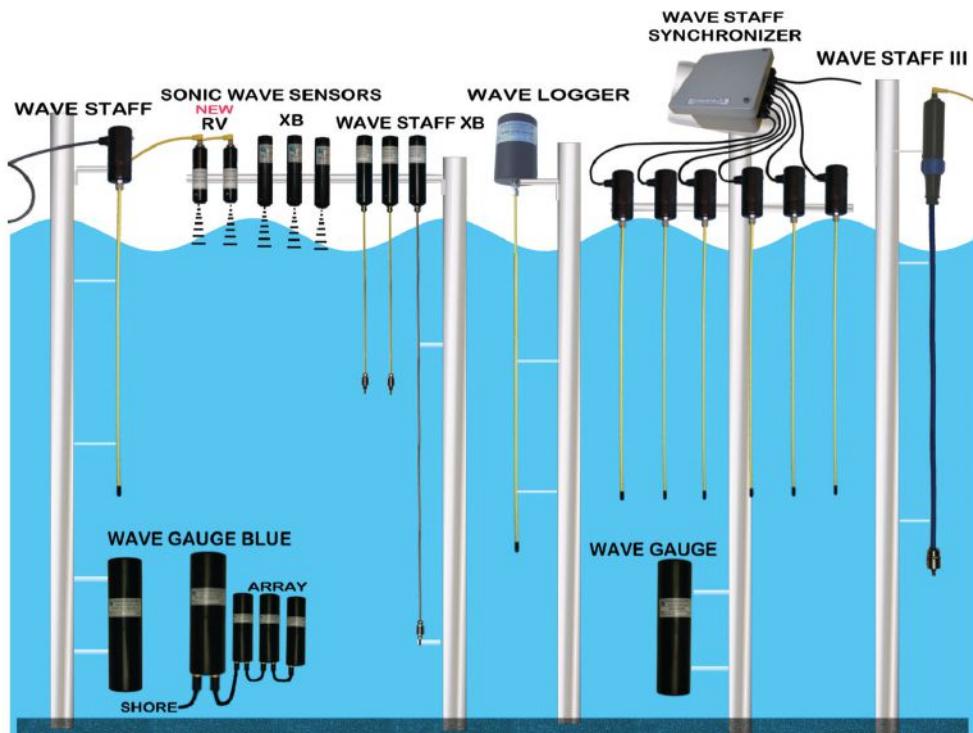
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would be located some distance from the repeater. There is a benefit of moving the sensors away from the repeater. The temperature sensor is trying to detect very small changes in temperature, but the repeater itself generates some heat. Separating the sensors from the repeater would prevent the sensor from recording the heat from the repeater and thus provide a truer temperature reading."

"In the early days of this concept, we anticipate using a separate fiber pair for transmission of the sensor data," Mr. Lentz said. "This is to avoid any complications of integrating with the fiber pairs that are carrying telecom traffic. We hope eventually to evolve to perhaps a WDM or an out-of-band signal so that we can share a fiber pair and not use up as many resources in the cable system."

"Given this, the first set of cable systems using the SMART technology would ideally be regional cables that would be viable with two or three fiber pairs for telecom traffic. Then the fourth pair would support SMART. After that, we can start to look at higher fiber count systems. Right now, we're trying to walk before we run," he concluded.

While the SMART effort is continuing, another approach to turning commercial submarine fiber optic cables into scientific data collectors also has made recent progress.

In a blog post, Valey Kamalov and Mattia Cantono of Google Global Networking announced that a recent experiment using one of its subsea fiber optic cables showed that it could be useful for earthquake and tsunami warning systems around the globe.

Kamalov and Cantono noted that there is a long tradition of using optical fiber for sensing applications. While most of these techniques are effective over distances of up to 100 km, they said that they have developed a technique that works over tens of thousands of kilometers.

Previous approaches require special sensing fiber and special equipment, but the Google researchers use existing fiber to detect disturbances on the seafloor. This technique relies on equipment that is present on the vast majority of the world's existing fiber optic systems, so it is broadly applicable.

The researchers noted that the pulsing light transmitted through optical fibers in submarine cables encounters distortions as it travels thousands of kilometers across the cable. At the receiving end, the light pulses are detected, and the distortions are corrected by digital signal processing. One of the properties of light that is tracked as part of the optical transmission is the state of polarization (SOP). The SOP changes in response to mechanical disturbances along the cable and tracking these disturbances enables us to detect seismic activity.

In 2018, scientists published a paper about early success they had had detecting earthquakes on both terrestrial and subsea links, looking at phase changes using a narrowband ultrastable laser, the researchers note. But the links they used were short (under 535 km for terrestrial and 96 km for subsea) and in relatively shallow waters (~200m deep), limiting practical application of the idea.



## Fifty Years of Ocean Science



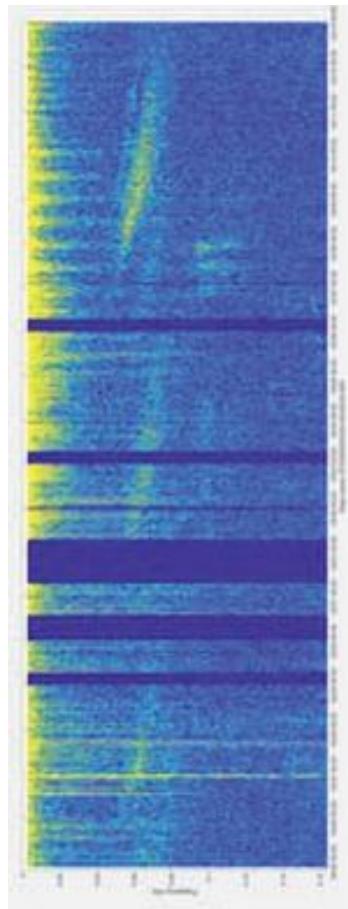
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In October 2019, Kamalov and Cantoro came up with the idea that they could detect earthquakes based on spectral signatures—performing a spectral analysis of Stokes parameters to look at frequencies that are typical of earthquakes.

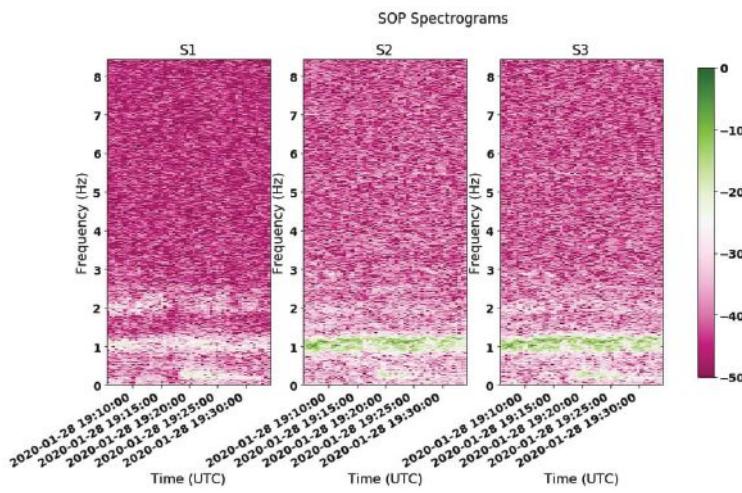
In late 2019, they began monitoring SOP on some of Google's global submarine cables. During the initial field trial, they observed that SOP was remarkably stable, even after the signal traversed 10,500 km. The ocean floor is mostly a quiet place.

Indeed, for several weeks, the ocean floor was perhaps too quiet, showing no SOP changes that would indicate an earthquake. Then, on January 28, 2020, they detected a magnitude 7.7 earthquake off of Jamaica—1500 km away from the closest point of one of Google's cables. A plot of SOP over time showed a pronounced spike at a time stamp approximately five minutes after the earthquake occurred, correlating to the travel time of the seismic wave from Jamaica to the cable, and the duration of the spike was about 10 minutes.

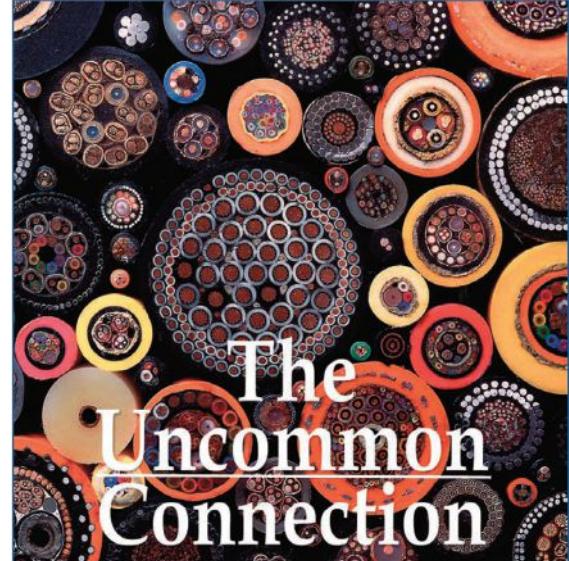
In the image shown below, Stokes vectors S1 (left), S2 (center), S3 (right) generated by the M7.7 earthquake off Jamaica, which provide quantitative analysis of SOP. X-axis time, Y-axis frequency in Hertz, with color code showing intensity of spectral components. Green indicates higher spectral density compared to white and pink. The 7.7M earthquake is barely visible green/white spike below 0.5 Hz. The stronger 1 Hz line is due to environmental oscillations.

Kamalov and Cantoro state that this is just a first demonstration, not a working system, and much work remains to be done. This approach is not for replacement of dedicated seismic sensors but a source of complementary information to enable early warnings for earthquakes and tsunamis.

» Image constructed by Dr. Zhan of the California Institute of Technology Seismological Laboratory, based on Google's data shows ocean waves during storms. X-axis is frequency from 0 to 0.16 Hz, Y-axis time. Ocean waves are seen as yellow angled brushed lines. Source: Google.



» Spectrographic data from Kamalov's and Cantoro's tests during the Jamaica earthquake. Source: Google.



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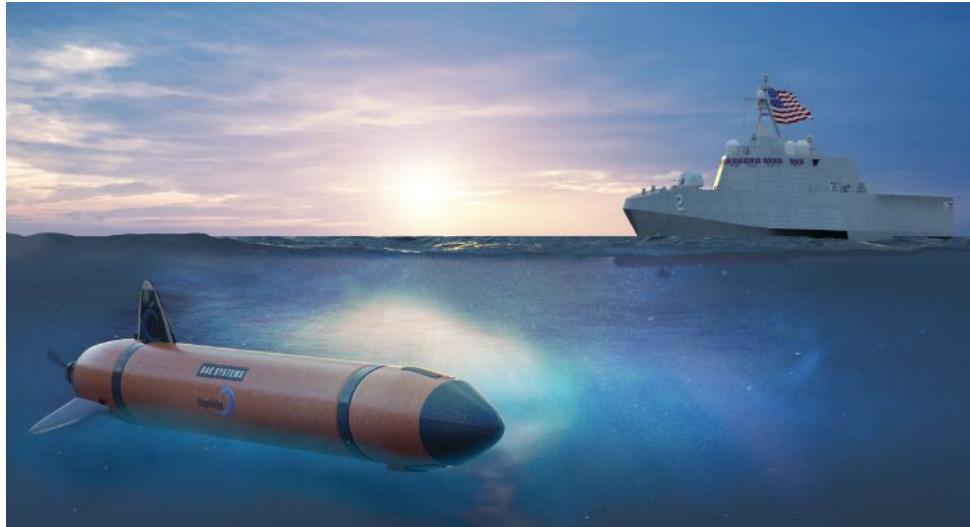


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# FUTURE NAVAL APPLICATIONS FOR UNMANNED UNDERSEA VEHICLES

By Jeff Smith, Chief Scientist, UUV Systems, BAE Systems



» An artist rendering of a BAE Systems' Riptide UUV. The company's mission agnostic, modular system design enables easy modification for various development needs.

## UUV Evolution for Naval Forces

Naval Forces have driven the requirements and demand signals for Unmanned Undersea Vehicles (UUVs) from their earliest days in 1957, with development of the Special Purpose Underwater Research Vehicle (SPURV) by the University of Washington's Applied Physics Laboratory. Although this dual-use technology has long supported commercial and scientific markets in parallel, military needs and development funding have largely been responsible for the advancement of the technology, as well as the advanced sensors and payloads that they employ.

UUVs, like most Unmanned Systems in general, serve as a platform from which the warfighter can extend his sensor range, increasing their area of regard. They serve as a force multiplier in that they perform more monotonous, mundane, or even riskier missions and enable the warfighter to focus on higher priority missions where the human decision-making element is required.

In the mid-to-late 1990s, as more UUVs were entering the market with the increased availability of smaller, and more affordable

computer processing, the U.S. Navy released its first of several periodic UUV Master Plans. The UUV Master Plan provided guidelines for industry to focus vehicle developers to standard common vehicle sizes or classes, along with targeted mission areas for which they were needed. These first few Master Plans listed nine prioritized naval missions; Intelligence, Surveillance, and Reconnaissance (ISR), Mine Countermeasures (MCM), Anti-Submarine Warfare (ASW), Inspection & Identification, Oceanography, Communications and Navigation Network Nodes, Payload Delivery, Information Operations, and Time Critical Strike. The Master Plan and the missions were intended to be guidelines for the vehicle community, shaping requirements and direction for the developers. They effectively drove the UUV community to a certain level of standardization, particularly for 12.75" (Lightweight Class) and 21" (Heavyweight Class) UUVs.

Another advantage of the legacy Master Plans is that they provided industry with supporting technology challenge areas where the U.S. Navy was looking to make advances. These shortfalls were identified as energy, reliability, launch and recovery, autonomy and affordability.

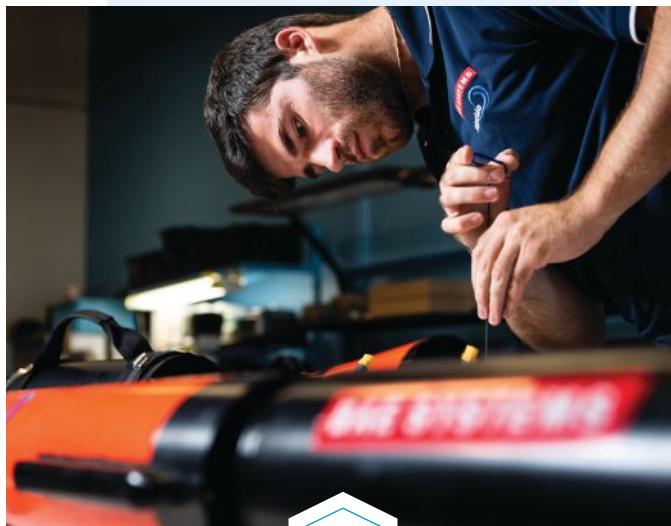
For the past two decades, the UUV development community has focused predominantly on the MCM and the Oceanographic mission areas, supported by various naval development programs in the U.S. and abroad. The MCM mission, highly important to the broad directive of taking the sailor out of the minefield, has a great deal of commonality and overlap with the commercial survey market. The same side scan sonars that can provide sailors with imagery of mines or mine-like-objects of concern can also provide bottom imagery for route clearance, pipeline surveys, salvage, or hydrography. Similarly, various navies use environmental data such as water temperature, depth, and salinity to better understand acoustic propagation in regions of interest for their airborne, surface, and subsurface platforms as well as in some cases for their fixed subsea surveillance systems. Oceanographic researchers and many commercial groups are interested in this data as well as detailed in-situ chemical and biological information.

The dual use nature of these mission areas enabled vehicle developers to efficiently offer largely common platform and payload solutions to multiple end users.

Seeking a tactical advantage, the military applications drove improvements to these capabilities particularly around better sensor resolution and increased endurance as the systems matured. For endurance, early investments were made in better subsea energy storage across a wide range of capabilities from battery chemistries to fuel cells. Discovering truth to the aphorism "the only difference between a battery and a bomb is the rate of discharge," a focus on battery safety became paramount for many militaries. Commercial electric vehicle use started to take off in the same rough timeframe and it became very clear that the commercial development funding for this multi-\$B market would far outpace what militaries could invest. As a system of systems, UUVs started to see many benefits from the commercial markets and the rapid pace of technology development;

micro-electronics is another prime example.

During the last 30 to 40 years, it is also interesting to examine the evolution of the UUV industrial base and how that evolved in parallel with the supporting technologies and market demands. In the late 1980s and early 1990s, several large U.S. defense prime contractors led various early U.S.



» An employee working on a BAE Systems' Riptide UUV. The company's portfolio of UUVs pairs disruptive autonomous undersea platforms with industry-leading sensor and electronic payloads to create an unmatched, highly adaptive UUV offering for any undersea mission.

Navy UUV development efforts. With the military spending draw down starting in the early 1990s, and the commercial market not yet having significant market pull—at least not for these early, higher priced military based solutions—the primes shifted their resources to other pursuits.

As the 2000s opened, UUV technologies from academic labs and research institutions transitioned to small start-up companies. These firms began to deliver UUVs as viable commercial and research products. While volumes were reasonably limited, the market for U.S. and International Defense, Scientific, and Commercial clients enabled these small early phase companies to sustain themselves and grow.

A decade later and the two leading small UUV developers that emerged from this start-up phase saw their acquisitions into larger, primarily defense-oriented prime contractors. And in just the past few years there has been a new flurry of acquisitions of UUV developers and manufacturers

again by large defense primes.

### Rapidly Standing Up and Maturing a New UUV Provider

In 2015, a small team of experienced UUV developers set out to change the dynamics of the industry, founding Riptide Autonomous Solutions. Their challenge was entering an already competitive market and competing against well-established, well-financed, and much larger UUV market incumbents. From the beginning, Riptide's mission was to become the top UUV developer in the market, but to do that they had to be different. They had to be disruptive.

Riptide was aided by its timing related to the state of microelectronics technology and not being locked into a long-standing, established electronics architecture. They were able to fully capitalize on the latest advances in low-power processing technology and start with a very low power, low cost, more efficient architecture. They also took advantage of the latest manufacturing and

rapid prototyping capabilities to rapidly field and quickly evolve their early vehicle offerings. Riptide initially targeted a vehicle size (the 4.875" diameter micro-UUV) that did not have any established competition. Their initial pricing of \$10K for a base vehicle with no payload was also wildly different from the several \$100K to \$M offerings of the legacy competitors. These early \$10K vehicles clearly didn't have the same payloads and capabilities as the higher priced, legacy market solutions, but they opened the UUV market to budget-limited users. This created a rapid demand, particularly in the academic research and development laboratory market. In a short time, Riptide was recognized with numerous awards for becoming a market disruptor—M TR100s, Frost & Sullivans, an R&D100, and more.

Next, responding to end-users' requests to incorporate more and more capabilities and sensors normally found on much larger vehicles, Riptide took what they learned from establishing their micro-UUV product



» An up close view of the nose of a BAE Systems Riptide UUV. The Riptide family of autonomous undersea vehicles provides a sustainable, scalable, and affordable solution for developers of autonomy and behaviors, power systems, subsea sensors, and new payloads.

and scaled it to larger offerings with their Riptide-7 and Riptide-9. They did so while maintaining a high degree of commonality across their new family of UUVs. The larger vehicles enabled more volume for larger, more advanced payloads and the greater energy storage that they typically require.

Riptide's low-power processing architecture, coupled with a focus on high hydrodynamic efficiency, provided an endurance advantage. This enabled these smaller vehicles to post operationally useful endurances even with alkaline batteries—which can be readily shipped on commercial passenger air—and significantly higher endurance, speed, range, and payload power with lithium.

High endurance on small vehicles enables a host of military-critical missions. It also opens up greater depths. A UUV with a 6 – 8 hour run time lacks sufficient endurance to dive to 6000 m and return; to accomplish this, the vehicle must be capable of operating for 24 hours or more. In 2019, Riptide successfully pressure tested their first 6000 m rated micro-UUV. This vehicle utilized 3D-printed titanium hull components in a process that was previously validated in a 1500 m-rated Riptide-7. Although the standard Riptide-UUVs are 300 m rated, this illustrates a depth flexibility not previously demonstrated across a family of small UUVs.

Riptide's vision could not be fully achieved without significantly greater resources and capabilities. In 2019, this came when Riptide was acquired by BAE Systems, and organized under their FAST Labs™ research and development organization. Riptide and BAE Systems' FAST Labs organization is a perfect marriage. The FAST Labs organization's charter is to internally and externally rapidly develop and transition the latest technology for the warfighter. They do this through a highly skilled staff of industry-leading subject matter experts, working internally as well as with external small business and university partners.

Where large primes oftentimes constrain the innovation of small, disruptive acquisitions, the FAST Labs organization itself a technology disruptor, organized to move quickly while providing the necessary processes and safeguards to mature and transition new technologies with low risk.

In the year since the acquisition, the FAST Labs organization has significantly bolstered Riptide with experienced engineering and operations resources, a new custom-built UUV Prototyping Facility, production process maturation and control, supply chain and quality systems, and substantial investments in new vehicles, payloads, and advanced mission level autonomy.

BAE Systems' Riptide family of UUVs have quickly established themselves as a disruptive platform in the undersea market. Under the FAST Labs organization, their capabilities are continuing to rapidly evolve and expand. BAE Systems is a market leader in Signal Intelligence (SIGINT), Electronics Warfare (EW), subsea acoustics, mission-level autonomy development, and more. These capabilities are vital and extremely well-aligned for the next set of major mission demands for UUVs, which was a key contributing factor for this acquisition.

### Future Military Applications

Constant global satellite coverage and the increased range of ballistic missile threats has put surface naval forces at increased risk. Subsea capabilities still maintain a significant advantage for stealth. World events in the South China Sea and the resurgence of the Russian Navy are putting greater and greater demands on allied submarine forces. Unfortunately, these increased demands are coming at a time when the U.S. Submarine Force is retiring submarines faster than it is replacing them. Naval forces are looking to take greater advantage of unmanned systems to "pick up the slack."

Long-standing mission priorities for submarines include ASW, Anti-Surface Warfare (ASUW), ISR, and Mine Warfare (MIW). MIW includes MCM, however for submarines it is primarily referring to offensive mining capabilities. For UUVs to reduce the burden on submarine forces, they need to successfully address as many of these mission areas as possible.

To date, UUVs have not been widely operationally deployed, nor have they demonstrated significant capabilities for these new missions. These more complex missions will require much greater endurance, reliability, and autonomy than has been demonstrated by today's MCM vehicles. The demand for UUV technology that meets these challenges and allows Allied Naval Forces to maintain their technology superiority is expected to drive the market over the next several decades.

This brings opportunity. The challenges faced by submarine forces will drive the innovation needed to usher in new, disruptive capabilities for UUVs. They will enable developers to continue to broaden UUV applications and potential, and significantly increase the vehicles' contributions to our undersea advantage.



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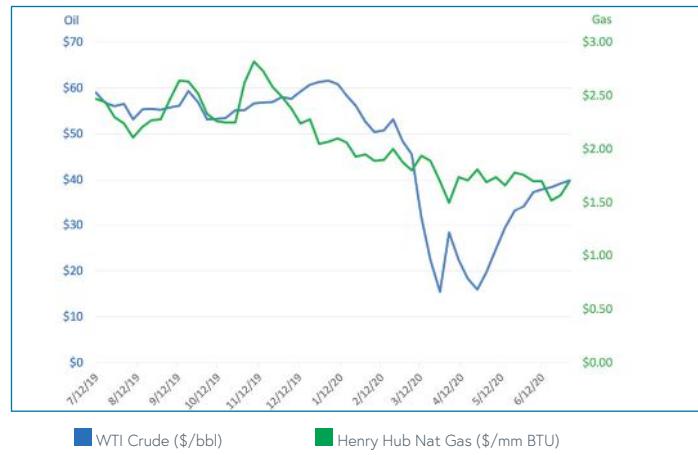
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# CRUDE & NATURAL GAS Spot Prices

PRICES IN US DOLLARS AS OF JULY 10, 2020

As we did not publish our reports on energy prices and equity indexes last month, this report covers the two months since mid-May.

In that eight-week period, oil prices surged by just over \$10 per barrel. On May 15, the most recent data from our previous report, the WTI spot price for oil was \$29.44 per barrel, but prices increased steadily and by the end of the second week of July, the price per barrel passed the \$40.00 mark. An Energy Information Administration (EIA) report for the week ending July 10 noted a significant drop in U.S. crude oil refinery inputs and crude oil imports. It also noted that U.S. commercial crude oil inventories decreased significantly. The lower inventories helped to push up prices.



Meanwhile, natural gas prices remained historically low. The Henry Hub spot price was \$1.66 per million British thermal units (MMBtu) on May 15. Since then, it has risen slightly to \$1.79 on July 10. The EIA reported that in the first half of 2020, the average monthly Henry Hub spot price hit a record low of \$1.81 per MMBtu, while reaching an average low of \$1.63/MMBtu in June, the lowest monthly average since 1989. The warm winter and the economic slowdown induced by mitigation efforts for the coronavirus disease 2019 (COVID-19) contributed to lower demand, further lowering prices. The EIA expects natural gas prices to stay low in the coming months before eventually increasing by the end of 2020.

## WEEKLY WTI CRUDE & NATURAL GAS SPOT PRICES

Last 52 Weeks



# KEY EQUITY Indexes

PRICES IN US DOLLARS AS OF JULY 13, 2020

The Dow Jones Industrial Average (DJIA) and S&P 500 have rebounded in the past two months. The DJIA was up over 2,000 points since mid-May, while the S&P was up almost 250 points. It has been a rollercoaster, however. In the week ending June 1, for example, the DJIA was up over 1,700 points. The following week, however, it was down over 1,500 points. An 856-point loss for the week ending June 22 was followed by an 812-point gain the next week. The S&P 500 saw similar swings during that stretch. The overall surge has been

attributed to hopes for a coronavirus vaccine and strong performances by tech stocks.

The Philadelphia Oil Services Index (OSX) continued an upward trend since mid-March, when it closed below 24 points. The OSX closed at 32.80 points at the end of the second week in July, but had briefly passed the 40-point mark in June. The OSX began 2020 at around the 80-point mark.

## SELECTED EQUITY INDEXES



## CUMULATIVE PERCENTAGE CHANGE

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## HAVE COMMODITY MARKETS HIT THE PAUSE BUTTON?

BY G. ALLEN BROOKS | Author, *Musings From the Oil Patch* | [www.energymusings.com](http://www.energymusings.com)

### CRUDE OIL:

The last time we commented on the state of commodity markets, we discussed the oil market showing signs of improvement following the oil price's journey into negative territory. At the time, we wondered how far the recovery might go. Since then, we watched market forces pushing oil prices higher overwhelm those tugging them lower. The trajectory of oil prices remains uncertain, as everything seems to revolve around the health (pardon the pun) of the coronavirus.

As various U.S. states reopened their economies last May, believing they had "flattened the curve" of infections, economic activity quickly rebounded. The surges in daily road traffic and pickups in air flights convinced refiners to restart operations, drawing from the vast stores of crude oil that had built during the shutdown. Speculation swirled around whether the "V-shaped" oil demand rebound would continue, or possibly falter. The rising activity lifting oil demand also inflated future expectations for growth, pushing oil prices to \$40 a barrel, where they currently sit, but doubts about a further rise are growing.

The surprising June surge in virus infections in many early-opening states has forced pauses or retreats in those openings, choking off activity. The virus surges have undermined optimism about how strongly the U.S. economy is rebounding, as fear of the illness has paralyzed reopening initiatives. The result has been a flattening, and, in some case, actual declines, in traffic data in many of the states rolling back their openings, indicating less oil use.

The oil price recovery emboldened OPEC+ to ease its production cutback. As the organization's members watch U.S. oil production fall, both due to wells being shut-in and the absence of new wells coming into production, OPEC+ seems intent to boost its output in line with anticipated global demand increases. OPEC+ is trying to regain the market share lost to the U.S. in recent years. One wonders how soon internal battles over OPEC+ production quotas erupt, and what that might do to supply growth. Given the precariously balanced market, uncertainty over the pace of oil supply and demand growth in the face of existing high global oil inventory levels makes navigating the future a challenge. We could just as easily see another crushing blow delivered to oil prices, as a spike to \$100 a barrel. Each outlook is associated with wildly different outcomes. Like the three bears story, we're really hoping for: "Ahhh, this porridge is just right."

### NATURAL GAS:

Our last missive stated that natural gas prices were at the mercy of weather and LNG shipments. The latter, a significant natural gas demand driver in recent years, and the impetus for substantial capital investment in the industry, had been in control of gas

prices until the past few days, as hot temperatures have taken over driving gas prices.

The underlying market driver has been the anticipated fall in associated natural gas from shale oil wells. That supply has only recently begun showing signs of decline, something that is anticipated to impact future gas supply and lift prices. According to EIA data, shale output between December 2019 and June 2020 has declined by 4 Bcf/d, or -5.5 percent, probably indicative of the drop in total U.S. gas supply.

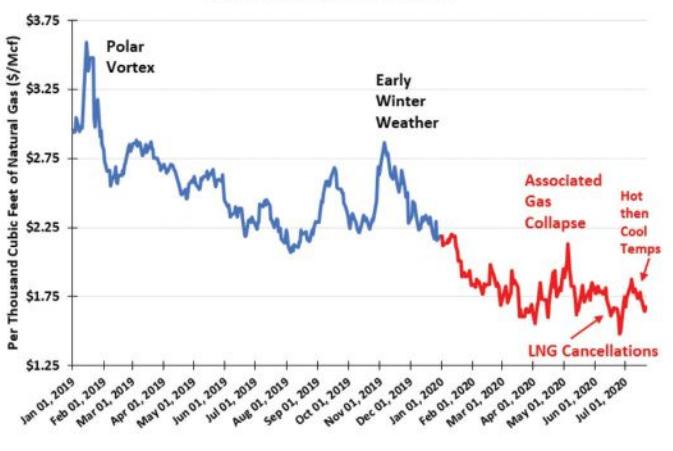
The price recovery from less gas supply has been overwhelmed by the cancellation of a large number of LNG export shipments. The fate of the U.S. LNG business is tied to global natural gas prices. The growth of the LNG business has been keyed to low wellhead prices that made domestic gas highly competitive in the global market. Early in the LNG export era, global gas prices were in double-digits, with U.S. prices in single-digits. The U.S.-global price spread provided substantial profits to cover gas liquefaction and transportation costs. That business model began unravelling when global prices fell into mid-single-digits due to surging international gas supplies. While sub-\$2 per Mcf U.S. wellhead prices continued to support LNG economics, recently, global gas prices converged with Henry Hub prices, destroying those economics.

Global gas prices converged on U.S. prices due to surging supplies. That supply growth, coupled with warm winters, left above-average gas volumes in storage, depressing prices. This has been particularly true in Europe, which was a target market for U.S. LNG cargoes. Europe has new pipeline supplies coming from Russia, a supply source that is anticipated to grow. Last winter, European gas storage reached an all-time peak. As of mid-July, European gas storage is heading towards matching last year's record. It is already at levels comparable to the peak volumes reported during the 2016-2018 winters. In other words, Europe is swimming in natural gas.

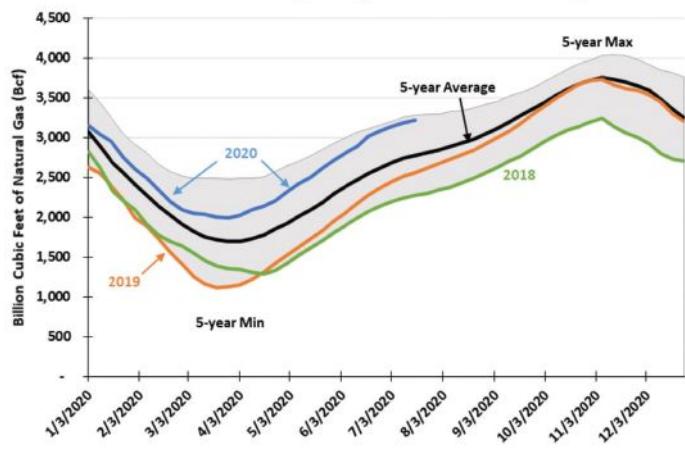
The convergence of global gas prices has pressured U.S. LNG sellers to cancel cargoes. From May through September, nearly 150 LNG cargoes have been cancelled. Encouragingly, the number of September cargo cancellations is half the average monthly cancellations of June to August. Fewer cancellations reflect the recent uptick in natural gas futures prices for the early months of 2021 in Europe and Asia. The increase in international gas prices is outpacing the rise in U.S. gas futures, widening the price spread, which will restore LNG profitability.

Optimism for higher natural gas prices is growing, based on expectations for falling gas supply and rising demand due to more power generation use and increased LNG exports. Both price drivers need to be watched closely, as they are likely to be more volatile than in the past.

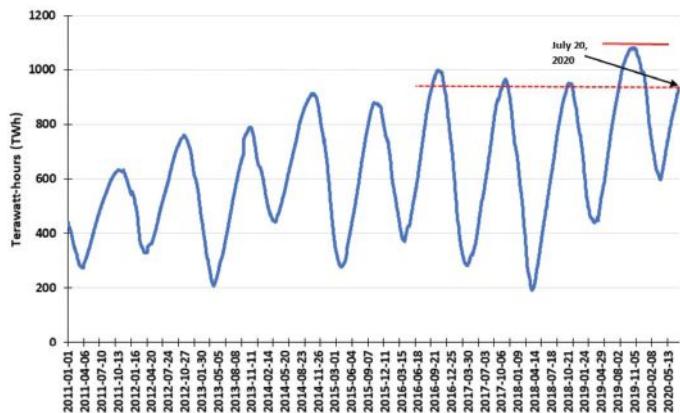
From Distressed to Euphoric to Confused:  
2020 Natural Gas Prices



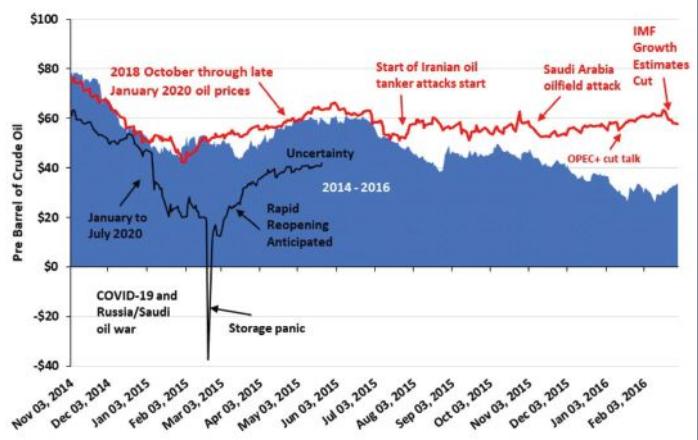
Low Prices and High Output Rebuilt Gas Storage



Natural Gas Storage Volumes In Europe - 2011-2020



2020 Oil Prices Are Mirroring 2014-2016 and 2018-2020



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# SeaState

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SEASON 1 / EPISODE 3

## THE MARINE TECHNOLOGY SECTOR—A PERSPECTIVE

Join us on our next episode of SeaState: The Marine Technology Sector—A Perspective. In this episode we talk with Justin Manley and get his thoughts on our industry, where it is now, and where it is going in the future. Justin is an innovative technologist and executive with experience in startup, public corporation, academic, and public sectors. He is a recognized leader in unmanned systems development and operations. Mr. Manley has been working with marine technology and robotics since 1990. He was a principal in the development of unmanned marine vehicles at the Massachusetts Institute of Technology from 1993 to 2002. Between 2002 and 2009, Mr. Manley provided marine technology consulting services, primarily to the National Oceanic and Atmospheric Administration (NOAA) where he was the founding Chair of the NOAA-wide AUV Working Group.

In 2009, Mr. Manley transitioned to the private sector, joining Liquid Robotics during its startup phase. There he was responsible for developing new commercial and scientific programs based on the Wave Glider. In 2011, Mr. Manley joined Teledyne Benthos as Senior Director of Business Development where he managed a diverse product portfolio and led the development of a networked systems strategy across Teledyne Marine Systems (Benthos, Webb Research, Gavia, and SeaBotix).

Drawn back to entrepreneurial endeavors, Mr. Manley founded Just Innovation Inc. in mid-2015. He supports clients from startups to multi-national corporations with core technical specializations in unmanned vehicles, robotics, sensors, and undersea systems. Mr. Manley offers clients support with strategy and innovation, business and product development, evangelism, and marketing.

Mr. Manley is extensively involved in the marine technology profession through a variety of leadership roles. He is a Senior Member of IEEE, a Life Member of the Marine Technology Society (MTS), a Fellow of the Institute for Marine Engineering Science and Technology (IMarEST) and was a founding member of the U.S. Integrated Ocean Observing System (IOOS) Advisory Committee. He is also dedicated to innovation, serving as an advisor to startup companies and a judge for the XPRIZE Foundation. He holds two patents in the area of unmanned systems oversight and security. So tune in and do not miss the next episode of SeaState, ON&T's official podcast!

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# FUGRO ADDS ADDITIONAL VESSELS FOR ATLANTIC SHORES OFFSHORE WIND PROJECT

Fugro has mobilized two additional vessels off the coast of New Jersey to support their ongoing site characterization work for Atlantic Shores Offshore Wind, a joint venture between Shell New Energies US LLC (Shell) and EDF Renewables North America.

Operating in the Atlantic Shores lease area since May, Fugro now has three vessels on site with a fourth to be added later this month.

The project involves collection of high resolution geophysical, benthic and shallow geotechnical data within the lease area and along two proposed export cable routes. These data will be processed and analyzed to characterize site conditions, including bathymetry, seafloor morphology, subsurface geology, environmental and biological sites, seafloor obstructions, soil conditions and archaeological resources. Atlantic Shores will use this information to safely design, permit and install future wind farm facilities, which could generate up to 2500 MW of renewable energy for residents along the mid-Atlantic.

Ed Saade, Fugro's Group Director for the Americas, said: "Not only is Atlantic Shores a sizeable project that highlights our ability to manage a comprehensive work scope in a single field season, but it also demonstrates our ability to evolve alongside our long-time client, Shell. Together, we are adapting decades of

site characterization experience developed through oil and gas projects worldwide to serve a new energy market in the US and a more sustainable future."

Weather permitting, the field program will continue through the autumn and winter. To provide deliverables to Atlantic Shores as efficiently as possible, Fugro is performing near-real-time geophysical data processing, made possible by Fugro's Back2Base™ data packaging and transfer technology.



» Fugro's vessels will support the collection of high resolution geophysical, benthic and shallow geotechnical data

## REVER OFFSHORE COMPLETES NORTH SEA PROJECT FOR SERICA ENERGY

Rever Offshore, a leading subsea project delivery and execution provider to the offshore energy industry, has announced the recent completion of a contract awarded by Serica Energy.

This is the second campaign Rever has undertaken for the independent North Sea operator within a framework agreement which commenced in November 2018. The workscope, which took place in the North Sea's Rhum field, was completed in late May.

Throughout the 14-day campaign, the company deployed the multi-purpose dive support and offshore construction vessel, the Rever Polaris, to carry out electrical diagnostics as part of a multi-year campaign of preventive maintenance on the subsea cable network. Subsequent testing took place via the Polaris and Serica's Bruce platform.

Barry Macleod, Rever Offshore CEO, commented: "As we complete our second campaign for Serica Energy within the current framework agreement, so our knowledge and understanding of the client continues to grow.

"Completed on schedule and, most importantly, safely during these operationally challenging times, this complex IRM workscope is illustrative of the benefits an established client relationship can bring—and one which we look forward to building on in the future."

This campaign represents one of several undertaken by Rever Offshore since the introduction of stringent social distancing measures, implemented during the global COVID-19 pandemic. The company has developed and adhered to strict protocol specific to the situation, working closely with its clients to ensure all staff remain safe, regardless of location.



» Barry Macleod,  
Rever Offshore CEO



# JOINT VENTURE TO UNLOCK VIETNAM'S OFFSHORE WIND POTENTIAL

Airswift, a global workforce solutions provider for the energy, process and infrastructure sectors, has formed a joint venture (JV) with Source of Asia (SOA) in Vietnam as it targets growth in the offshore wind sector. The partnership is part of Airswift's ongoing growth strategy to diversify its business and enhance its global reach.

Based in Ho Chi Minh City, SOA will provide on-the-ground support to Airswift's candidates and clients working in the region's burgeoning offshore wind market, which has an estimated capacity potential of 160GW.

Together, the companies will offer unrivalled knowledge and expertise on the local area and immigration policies, as well as a global mindset and extensive candidate pool.

## Offshore wind represents a big opportunity for Vietnam

Charles Pfauwadel, VP Asia at Airswift comments: "Vietnam's 3,200 km long coastline means there's huge potential for the country to be a leader in offshore wind. With more than 70 projects slated for development, there is a significant opportunity to develop the local economy and decarbonise its electricity supply. Together

with SOA, we believe our local knowledge and extensive network can help wind developers and the country achieve these goals."

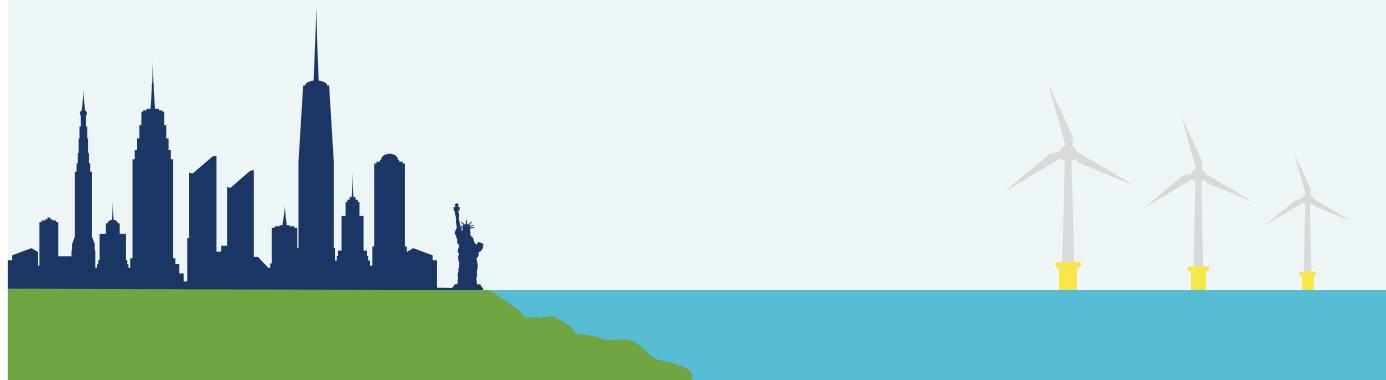
Thierry Mermet, CEO at SOA adds: "Vietnam is a booming market, but it can be increasingly complex for companies to navigate how to operate here – from visas and immigration to relocation services. From working with Airswift on projects over the last 18 months, we believe we can be a catalyst to ensuring the country has the very best talent to unlock the value of offshore wind."

The JV marks another milestone in Airswift's global expansion and will form a launchpad for further growth in Asia as they establish their presence in Vietnam.



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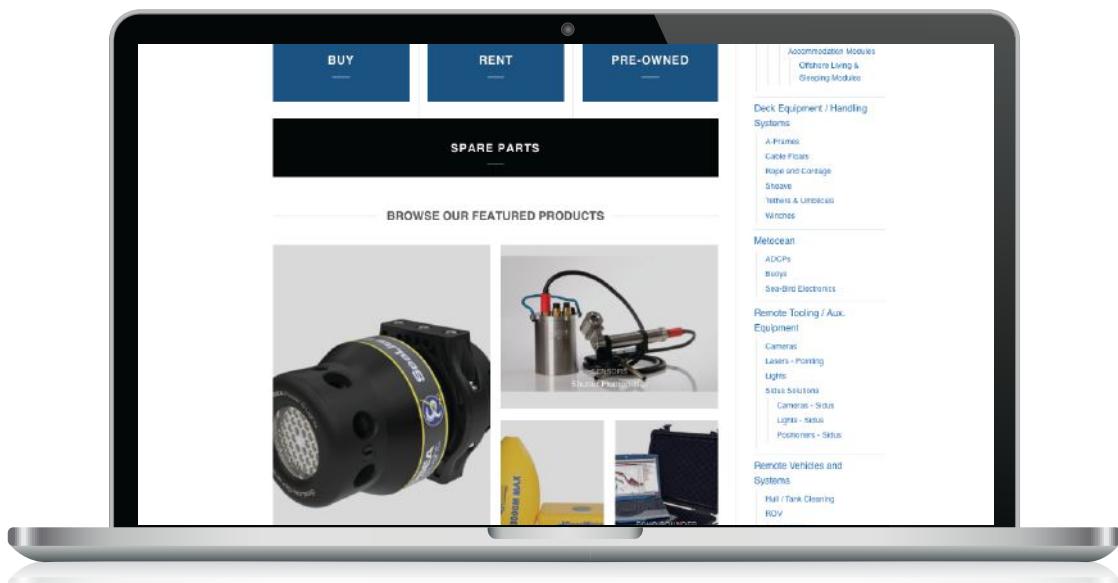
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The range includes the Hunter system (AUV Imaging and Laser), the Scout system (Observation Class ROV Imaging and Laser Profiling), the Pathfinder system (Work Class ROV Imaging and Laser Profiling) and the Prowler I & II systems (Towed Vehicle Imaging Range and Scale Measurement).

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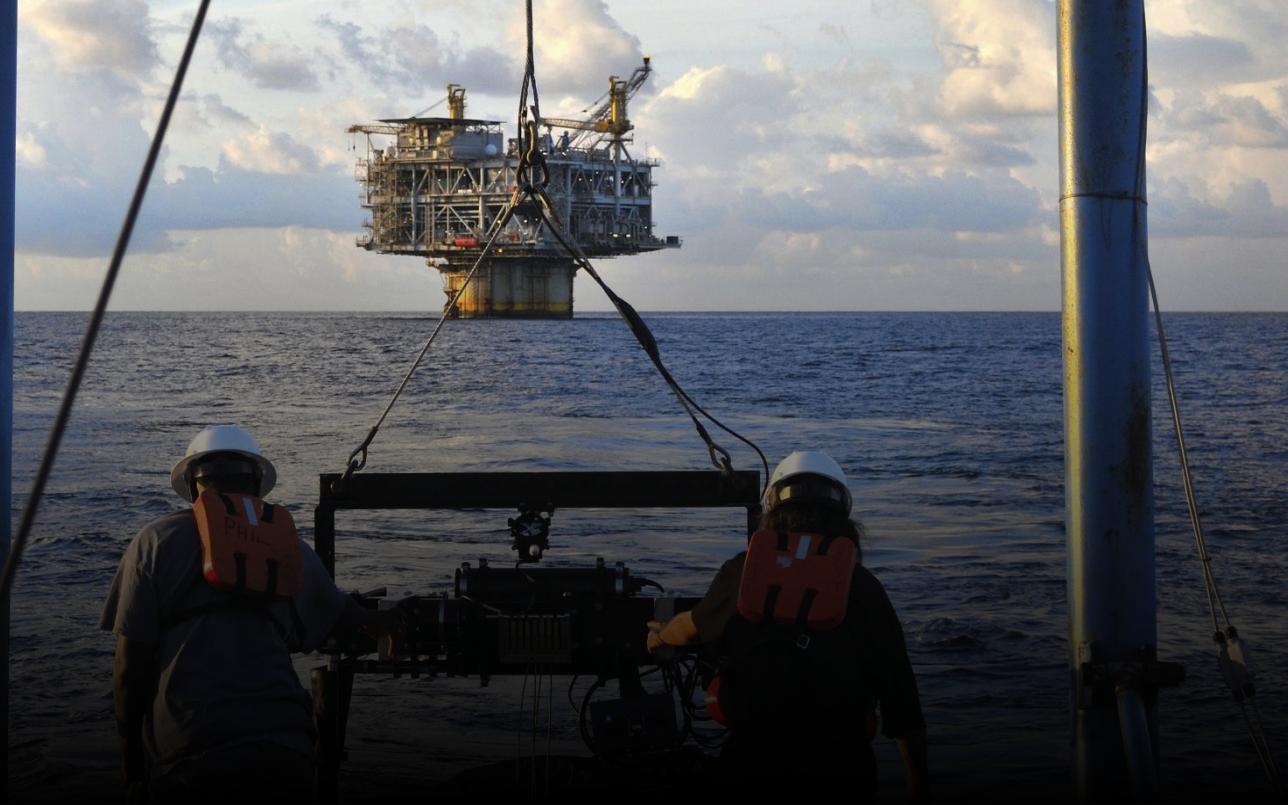
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