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Our 2020 Rising Tide Awards pg. 10

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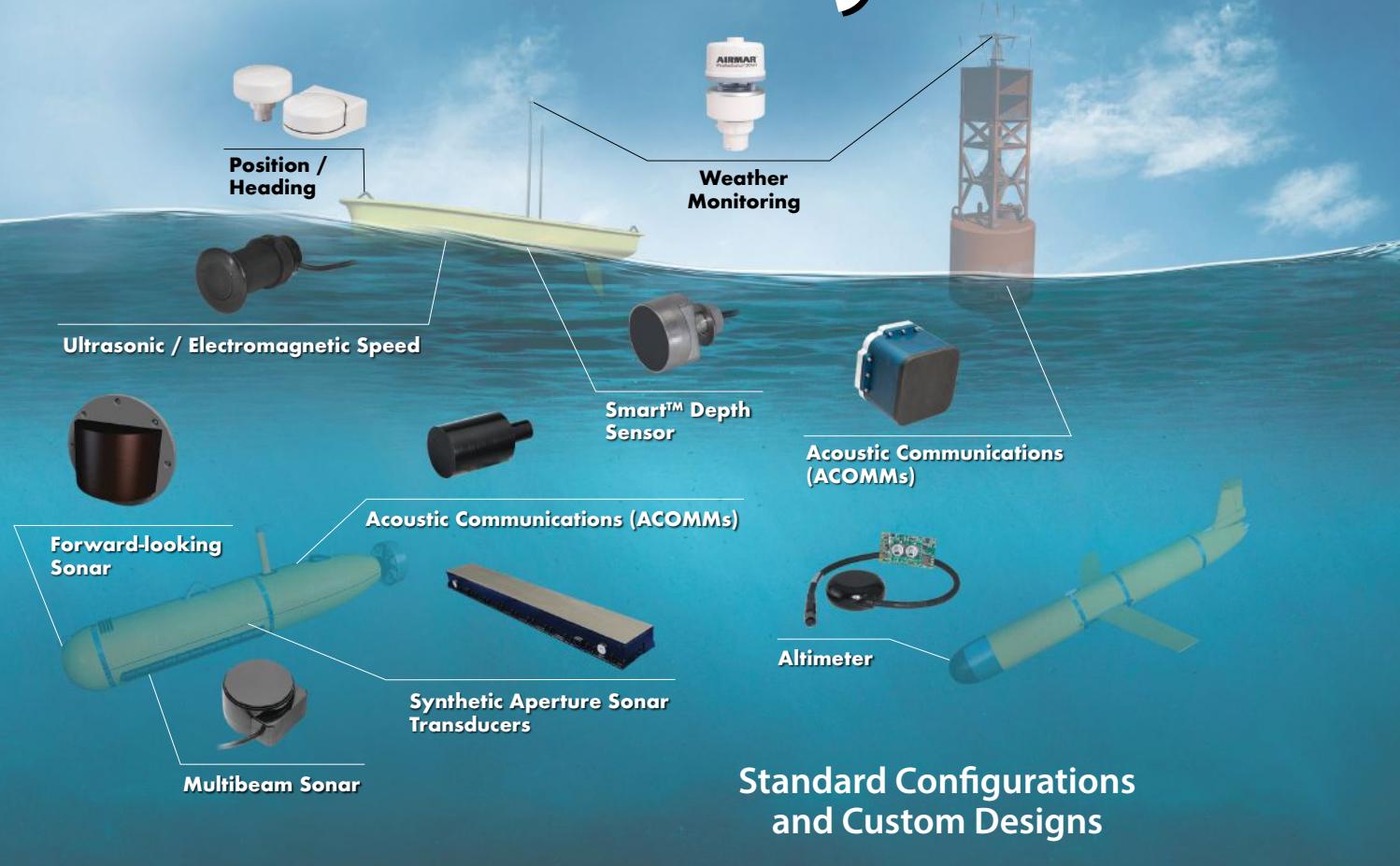
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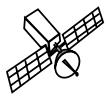
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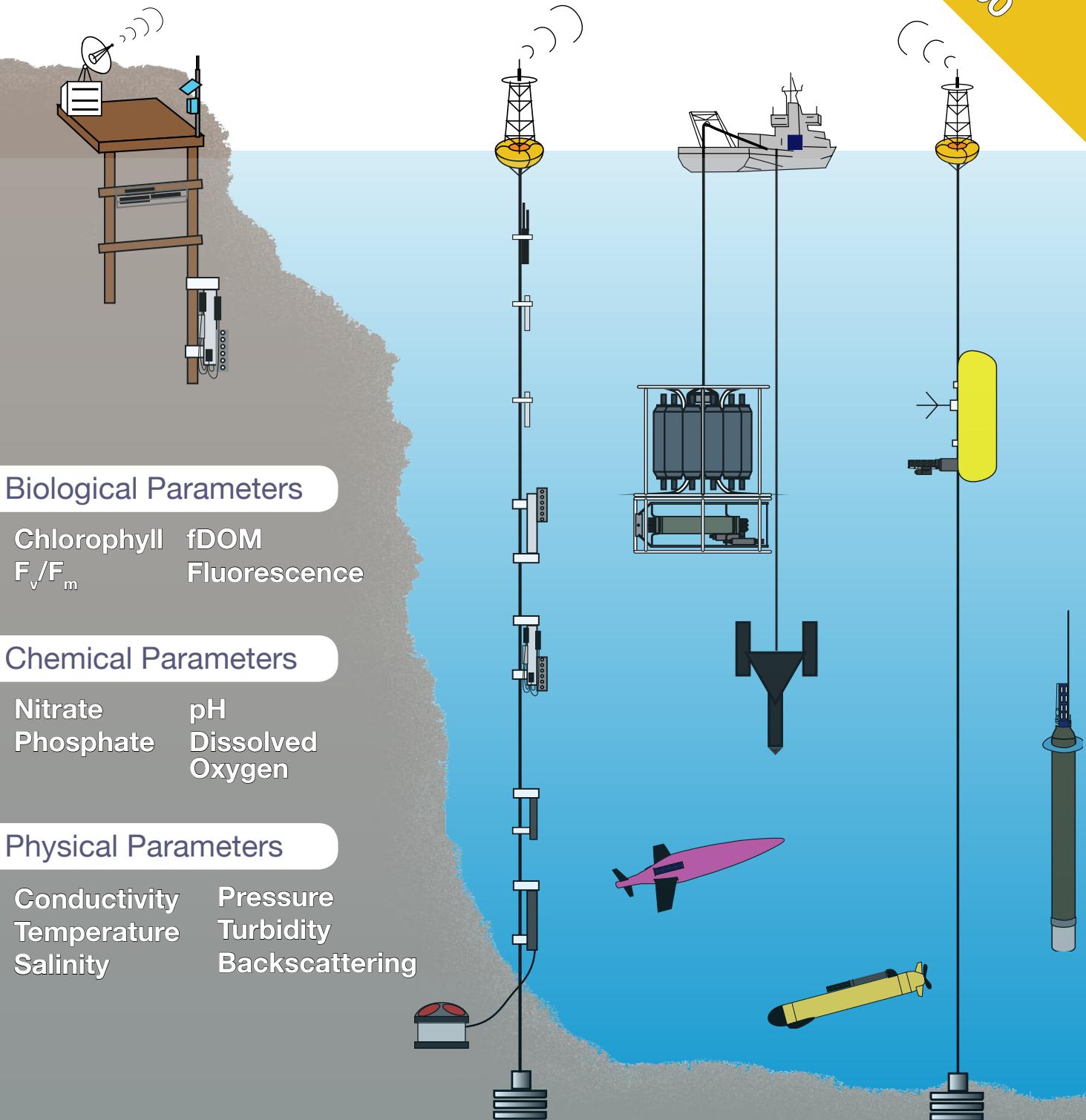
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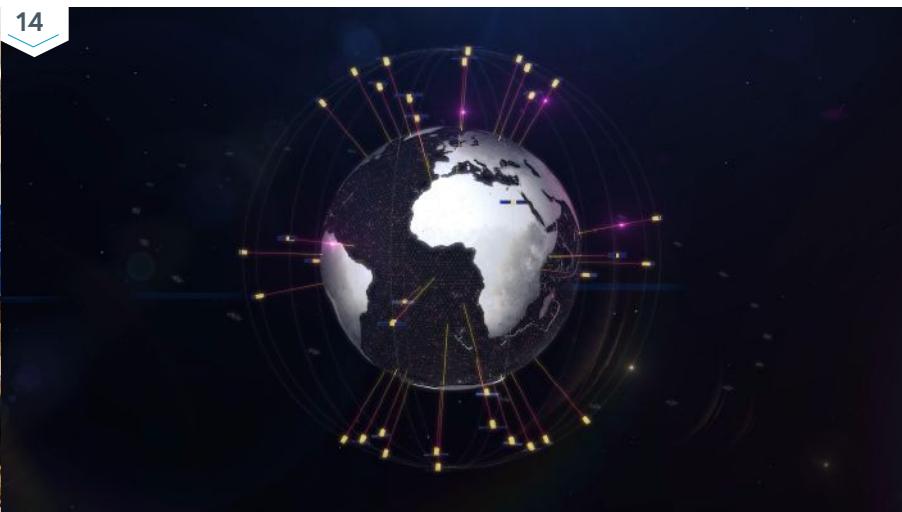
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ON THE COVER:

A buoy used for weather and oceanographic observations floats in the Gulf of Trieste off the coast of Italy.



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THE OCEAN, DATA AND YOU

BY GREG LEATHERMAN,
Editor in Chief, ON&T

For people who live in a coastal area, oceanographic sensors are not just products we see while flipping through a magazine. They are essential tools that can help save lives, boost our economy, and sustainably manage ocean and coastal resources.

For example, when the USGS deployed hundreds of storm-tide sensors in the Florida, Georgia, and the Carolinas during 2019's Hurricane Dorian, they gained valuable knowledge about improving storm surge predictions for coastal erosion and flooding, which could help someone like myself (with a home barely above sea-level) better prepare for the next major storm.

Of course, extreme weather events are not the only phenomena sensors measure. From marine mine detection and port management to offshore oil exploration and fisheries optimization, sensors are essential tools for working safely and sustainably. Experts tell me that what we are seeing now is just the beginning. As more states seek to expand their renewable energy portfolios, sensors will support site exploration and characterization in order to determine where new infrastructure—such as wind farms and subsea cables—can be located in order to minimize their impacts on coastal ecosystems, as well as other blue businesses.

The value of conferences for networking around these prod-

ucts and capabilities cannot be overstated. Global challenges require that scientists, product developers, investors, academia, and government network about everything from emerging technological capabilities to long-term sustainability goals.

The **Blue Innovation Symposium**, held in Newport, Rhode Island in January 2020 was a great example of high-level networking. The event brought together established and start-up marine technology companies alongside leading oceanographic and defense institutions. You can read more about what went on at that event in pages 10-13.

Another event with a major sensors and data focus will be held on the first two days of April: **The Marine Technology Society's 2-Day TechSurge Conference on Florida Estuary and Coastal Monitoring and Water Quality**.

Among other water quality topics, the event will feature content on remote sensing, data analytics and management, autonomous vehicles, and sensors for long-term deployment. These topics hit home for me, because I live in a coastal area prone to harmful algal blooms, and I know that we need to improve our capability to monitor the sources and impacts of such blooms. So, I invite you to join MTS and their partners—the Indian River Lagoon National Estuary Program, and Florida Atlan-

tic University's Harbor Branch Oceanographic Institute—in April. Guidance and outcomes from this meeting will directly influence monitoring network planning for the Indian River Lagoon and may even feed into the United Nations Ocean Decade Implementation Plan (2021-2030). To register, visit <https://florida.mtsociety.org/>.

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| EDITORIAL FOCUS |

BLUE INNOVATION SYMPOSIUM WRAPS SUCCESSFUL 2020 EVENT

THE SYMPOSIUM FEATURED BREAKING INDUSTRY NEWS AND THE INTRODUCTION OF COMPELLING NEW TECHNOLOGY



The Blue Innovation Symposium, a premier networking event for the Blue Economy, was held in January 2020, in Newport RI. With nearly 300 attendees and 40 sponsors, the event was a rousing success. From the quality of the speakers and presenters to breaking news from the Governor of Rhode Island's office, as well as the presentation of the first-ever Rising Tide awards, the level of excitement at the event reflected the robust agenda.

"This was the most successful Symposium to date," says Dr. Tobias Stapleton, Dean of Graduate and Continuing

Education Programs at Salve Regina University and co-founder of the event. "The expertise of the presenters and the detail shared by them was remarkable. The event provided an incredible opportunity for learning about the state-of-the-art in sensor technology and, with ample time built-in for networking, making critical business and organizational connections."

During the symposium, three recipients were named for the inaugural Rising Tide Awards: Dr. Jim Bellingham, director of the Center for Marine Robotics (CMR) at the Woods Hole Oceanographic Institution

(WHOI), was presented a Rising Tide Award in recognition of his ongoing contribution to the booming blue technology community. Dr. Tobias Stapleton presented the award.

Boston Engineering of Waltham, Massachusetts and GeoSpectrum Technologies of Dartmouth, Nova Scotia were also presented Rising Tide Awards in recognition of their contributions to the industry. Greg Leatherman of Ocean News & Technology (ON&T) presented both company awards.

Dr. Bellingham delivered the event's keynote address,

where he discussed the communication challenges faced by the ocean community in communicating with the rest of the world, the societal drivers changing the ocean industry, and the new ocean industries rapidly emerging. He also touched upon the rapid technological advances that are giving us unprecedented access to the ocean.

A surprise announcement was made by Stefan Pryor, RI Secretary of Commerce. He announced that Rhode Island Governor Gina Raimondo worked with the leadership of offshore wind developer Ørsted, to bring its United

States Innovation Hub to Providence, Rhode Island. The Innovation Hub will officially open in spring 2020.

This announcement coincided with Governor Gina Raimondo's state of the State address delivered the previous evening where she announced that Rhode Island will become the first state in the union to use 100% renewable, sustainable energy by 2030.



Other notable speakers included Alan Leonardi, NOAA Director of Ocean Exploration and Research, David Shea, Vice President of Engineering, Kraken Robotic Systems Inc., and Eivind Alling, VP QHSE & Integration, Americas, Kongsberg Maritime, Inc.

Sponsors included Boston Engineering, WHOI, L3Harris, FLIR, Hydroid, Innovate Newport, and GeoSpectrum Technologies, among others.



The 2020 event was organized by Salve Regina University, The Consulate-General of Canada in Boston, and TSC Strategic, an ocean industry marketing and media agency whose portfolio of publications includes Ocean News & Technology (ON&T).

To find out more, visit:
www.blueinnovationsymposium.com.

RISING TIDE AWARD: DR. JAMES G. BELLINGHAM

Dr. James G. Bellingham is winner in the individual round of the inaugural Blue Innovation Symposium Rising Tide Award, sponsored by ON&T Magazine.

While his accomplishments are many, he is recognized with this award for one reason above all others: Dr. Bellingham is forging a new path when it comes to revolutionizing the way people and machines work together in the marine environment.

Many ON&T readers already know Dr. Bellingham as the founding Director of the Center of Marine Robotics (CMR) at the Woods Hole Oceanographic Institution (WHOI). Indeed, his presentation during the symposium was among the most anticipated of the event.

"Technology is really revolutionizing ocean access," he commented during his presentation. "Oceanography, of course, has always been a technological enterprise. A ship is a technological device, as are submarines, bathyscaphes, CTDs... All of these fundamentally allow you to operate in environments which are hazardous or simply not survivable for humans. But today, the technology rate of acceleration is increasing. The kinds of tools that we are bringing to bear are increasingly sophisticated, and we can see the need for systems that we don't currently have in our arsenal."

WHOI is speeding the development of such an arsenal, including robotic technologies, by collaborating with industry sponsors, academic partners, and key government agencies in order to change the way people and machines work together to surmount the unique challenges presented by the marine environment.

Under Dr. Bellingham's leadership and guidance, CMR helps join scientific, commercial, and military users and developers in creating the next generation of autonomous ocean systems. Members of CMR gain unique access to experts and resources devoted to creating breakthroughs in autonomous systems. As a result, recent advances in robotics are improving efficiency, lowering costs, and reducing the risks of marine operations.

Dr. Bellingham joined WHOI from the Monterey Bay Aquarium Research Institute (MBARI), where he was first Director of Engineering and then Chief Technologist. Prior to MBARI, Jim founded the Autonomous Underwater Vehicles Laboratory at MIT Sea Grant (1988) and co-founded Bluefin Robotics (1997). Bluefin is a Massachusetts-based company that develops, builds and operates autonomous underwater vehicles (AUVs) and was acquired by Battelle in 2005.

Dr. Bellingham pioneered the development of small, high performance Autonomous Underwater Vehicles (AUVs), resulting in a class of systems which are now widely used within the military, industry and scientific communities. He was instrumental in developing and demonstrating distributed system approaches to ocean observing, leading the Autonomous Ocean Sampling Network program which coupled fleets of AUVs to ocean models to observe and predict ocean conditions.

Dr. Bellingham has led over 20 AUV expeditions in locations such as the Antarctic, North Atlantic, Mediterranean, South Pacific, and the Arctic. He has served on numerous advisory committees and boards, including Chairing the Naval Research Advisory Committee and serving on several National Academies studies. His awards include the Lockheed Martin Award for Ocean Science and Engineering and the MIT Fourteenth Robert Bruce Wallace

lecturer. Dr. Bellingham received an B.S., M.S., and Ph.D. in physics from the Massachusetts Institute of Technology.

» Judson Poole, a WHOI engineer assistant, works on a REMUS autonomous underwater vehicle in the Dunkworks lab within the CMR. Photo credit: Tom Kleindinst, Woods Hole Oceanographic Institution.



RISING TIDE AWARD: BOSTON ENGINEERING

A winner of the inaugural round of the Blue Innovation Symposium Rising Tide Award in 2020, Boston Engineering has an unmatched record of technical innovation across a quarter of a century.

Making a meaningful impact drives the staff at Boston Engineering. From designing advanced products and technologies to accelerating time to market, Boston Engineering thrives on solving tough client challenges and improving the way that people work and live. Clients benefit from their deep product development capabilities, focused industry expertise, and ISO-certified quality management system. As a dedicated extension of their clients' teams, Boston Engineering applies focused creativity and relentless determination to turn pipe dreams into pipelines, wishful thinking into measurable results, and process complications into progressive solutions. Together, they help companies and organizations make meaningful impacts.

Boston Engineering not only won a Rising Tide Award, the company was also major sponsor of the Blue Innovation Symposium. They exhibited at the show and Jose Vazquez, the company's Defense & Security Director, served as the moderator for a panel focused on Defense Sensors and Data.

Asked about Boston Engineering's business case for attending the Blue Innovation Symposium, Michael Rufo, director of Boston Engineering's Advance System Group, replied, "We know all of the organizers here. We work with a lot of folks here. We also knew that this would be one of the first times that our collaboration with the Canadian company Dartmouth Ocean Technologies would be publicly announced. For us, the Blue Innovation Symposium was a good fit."

Michael Rufo says that the company continues to innovate:

"In 2019, we worked with the U.S. Navy on combining biomimetic swimming with

biomimetic sonar and sensing. Sort of a replica of how bats do it, except that it operates under the water. It really provides a good opportunity for better obstacle detection and avoidance, sensing, and the close-up inspection of things based the way biology does it."

Another recent innovation from Boston Engineering is in the field of ocean profiling. The company has built several tailor-made, handheld devices for profiling in the water column, with each device sensing different things.

ON&T asked Michael Rufo how Boston Engineer approaches the diverse requirements of their clients. He explained that for the typical small business grants from the Navy or the Marine Corps, for example, "They have a capability gap and we'll propose a solution to fill that, and then we iterate through that with them."

Because of this persistent approach to expanding the boundaries of what's possible, Boston Engineering attracts engineers who thrive on solving tough challenges.

"Because our work is so dynamic, our people need to have not only a wide breadth of knowledge, but also an interest in solving a wide range of problems. Our staff is made up of people that have really high work ethics, and in my group, are interested in advancing the greater defense of United States. That's a motivating factor."



» Boston Engineering president Bob Treiber shares how biology served as a model for his company's innovative unmanned under water vehicle robotics. Recorded at the PTC Live 2015 keynote sessions.

**BOSTON
ENGINEERING™**



» Boston Engineering exhibits at the Blue Innovation Symposium.

RISING TIDE AWARD: GEOSPECTRUM TECHNOLOGIES INC.

Canadian stars GeoSpectrum Technologies Inc. (GTI) of Dartmouth, Nova Scotia won one of our inaugural Rising Tide Award at 2020 Blue Innovation Symposium.

The award celebrated their innovative products, including their family of C-Bass very low frequency (VLF) units. These electrodynamic sound projectors of differing sizes and capabilities are less expensive, lighter, smaller, more efficient, and have a broader bandwidth than their peers. As a result, C-Bass makes possible applications that were previously impractical.

The omnidirectional C-Bass can be used individually or in arrays to produce high-power sources with or without directivity. The VLF sound sources are already proving their value in supporting environmental science in arctic waters, and the buzz from the Blue Innovation Symposium suggests that GTI's clients foresee many future applications.

Speaking to ON&T, Matt Dempsey of GTI explained that the C-Bass line was born out of a project with a marine seismic company. As part of that project, GTI has been developing a replacement for seismic air-guns.

"The device that we're designing and manufacturing for this marine

seismic company doesn't make use of any piezoelectric ceramics. It's like a pneumatic sound source. A large bank of them, using compressed air, will create a pressure wave in the ocean. So, through our work on that, which has been going on for close to ten years, we developed a piezoelectric-free sound source that uses linear motors to actuate. The linear motor within the sensor will move both sides of the sound source and create a pressure wave in the water. These sounds are very low frequency, allowing them to travel across longer ranges than higher frequencies. And with these sound sources you get higher power, too."

GTI also made the devices portable, said Dempsey: "We've taken something that used to be the size of a van and have made it fit in a trunk in the back of the van."

Asked if that means the device is one-man portable, Dempsey explained, "There are four different flavors. The largest one is 1200 millimeters in diameter and the smallest one is 225 millimeters in diameter. What that means for the industry is that it allows researchers—as well as people that will use this sound source for calibrating zooplankton acoustic profilers (ZAP), sonar, and so forth—to deploy a very



» Deployment of a C-BASS VLF from GeoSpectrum Technologies. Photo: GeoSpectrum Technologies.

low frequency sound source using a wider range of vessels. No longer do you need a large winch and handling system. The smaller devices can be over-boarded by hand and, even for the largest ones, you only need a gantry crane."

Asked why FTI attends the Blue Innovation Symposium, Dempsey highlighted the shared goals of technology innovation in Atlantic Canada (where GTI is headquartered), and in New England, as well as his company's export of products to the United States.

"We have a lot of existing relationships with companies and organizations here, like the Woods Hole Oceanographic Institution and the Navy groups that are here, such as the Naval Research Laboratory. Being able to get in front of existing and potential customers is very important to us, because fostering such relationships is how we like to do business."



» GTI is based in Dartmouth, Nova Scotia. Founded in 1994, the company designs and manufactures integrated, end-to-end acoustic systems for defense and commercial applications.



THE METAMORPHOSIS OF THE ARGOS SYSTEM IS ON ITS WAY

» With the support of France's National Center for Space Studies (CNES), CLS is working to develop a completely new generation of dedicated satellites called Kinéis. The constellation of 25 nanosatellites is planned to launch by early 2022.



On December 18, 2019, the French Space Agency, CNES, launched the first Argos nanosatellite, marking the beginning of a revolution in the Argos system as we know it. This nanosat is the prototype mission for Kinéis, a constellation of 25 nanosatellites with Argos instruments onboard that will be launched in 2022. This new constellation will receive data from around the globe with only 10-15 minutes between satellite passes and is fully backward compatible with existing Argos beacons. It will also allow for more data transmission and for the first time two-way communication. This constellation represents a revolution in satellite telemetry. CLS has served the oceanographic community for more than 30 years, offering dedicated satellite-based solutions for all in-situ metocean observations. CLS provides daily data, positioning, backup tracking, geofencing, and monitoring solutions. The company also hosts, distributes, and provides satcom equipment. Kinéis is the ultimate constellation for space IoT and will revolutionize data collection and tracking, covering a wide-range of environmental applications.

ANGELS: A PROMISING SUCCESS FOR METOCEAN OBSERVATIONS



» ANGELS satellite. Photo credit: David Ducros.

In order to prepare for the Kinéis constellation, CNES embarked upon the ANGELS project. ARGOS Neo on a Generic, Economical and Light Satellite (ANGELS) will fill one of the orbital planes of the Argos constellation from 2020 and beyond. The first ANGELS has been launched by Arianespace on December 18, 2019. The data from ANGELS will be available to users after the in-orbit commissioning process is complete, which will take at least three months' time.

ANGELS will perform an in-orbit demonstration of a miniaturized Argos instrument (TAS-Syrlinks), onboard a 12U nanosatellite (HEMERIA). It is a revolution for the Argos system because it is the first satellite to carry such a small Argos instrument. The full satellite weighs a mere 20 kg. Miniaturization of the space segment opens the door to the Kinéis constellation, of which ANGELS is the precursor. With smaller nanosatellites, it is possible to launch a larger number of satellites gaining a faster revisit time that will encompass the globe. During the in-orbit lifetime, the data generated by ANGELS will be provided to users by CLS for scientific and environmental monitoring applications.

On Friday, January 10, 2020, CNES communicated with the first message received from an Argos beacon thanks to ANGELS. This first signal came from a Japanese fishing boat present off the Australian coast. With its subsidiary Kinéis, CLS is revolutionizing the historic Argos system.

ARGOS, 30 YEARS PARTNER FOR OCEANOGRAPHIC COMMUNITY

With more than 6000 ocean devices and 8000 animals tracked each month and more than 30 years of leadership, CLS has always been a partner to the oceanographic community. Thanks to Argos, CLS provides ocean data telemetry services for a broad spectrum of applications including ocean modeling, moored buoy monitoring and more.



» Soys Flight SV23 – launching Angels first nanosatellite in orbit. Photo credit: Arianespace.

COLLECTING OCEANOGRAPHIC DATA IN-SITU

In all of the world's oceans, drifting and moored buoys, and profiling floats transmit environmental data via the Argos system for operational programs such as the World Weather Watch (WWW), and the World Meteorological Organization (WMO). Argos is an essential tool of the Global Ocean Observing System (GOOS) for collecting oceanographic measurements and their geographical location, particularly for the Argo program, the Ship Observation Team (SOT) program, and the Data Buoy Cooperation Panel (DBCP).



» Metocean buoy. Photo credit: Woods Hole Group.

Locating Instruments At Sea

Argos transmitters, which are both robust and energy efficient, are used to locate expensive oceanographic instruments. Due to its global coverage, its accurate Doppler positioning (to within 250m), and in concert with the Goniometer for retrieval of assets in the field, Argos is the ideal satellite system for locating and recovering instruments at sea. Several tracker options exist, with varied manufacturers: different shapes, sizes, attachment options, and depth ratings exist. In addition, CLS is developing its own backup tracking device, to cater to the oceanography community.

ARGOS REVOLUTION: IMPROVING OCEAN INFORMATION & FORECASTING

The Argos constellation will continue to expand in the coming years, with the Argos-4 instrument launched on several satellites by international space agencies. In 2022, the Kinéis constellation, which is fully backward compatible with existing Argos beacons

will be revolutionary for the end -user community. This new system will open the door to many new applications to better protect and understand our environment.

In 2022, with the new Argos constellation, Argos users will benefit from up to 35 operational satellites, which means a much faster revisit time. In addition, the new generation of Argos instruments will provide two-way communication and more data transmission.

NEW OPEN-SOURCE REFERENCE DESIGN, EASY TO USE FOR MAKING ARGOS SATELLITE TRANSMITTERS

CLS and the Arribada Initiative are proud to announce the release of a new open-source reference design by Icoteq, Ltd for building an Argos transmitter. The venture started with an ESA project named SHARC and aimed to develop a new low-cost, next generation tag equipped with the ARGOS ARTIC R2chipset that is Argos compatible and Kinéis ready and dedicated to track migrating marine animals and oceanographic instrumentation.

This miniaturized chipset (7mm x 7mm) allows the use of new Argos-3 & 4 capabilities like the two-way communication capacity, and new modulations. The new modulations increase the volume of data that can be collected by the Argos satellite constellation. This new open-source reference design represents a huge opportunity for the oceanographic community, giving the community accessible innovation and a ready-to-use reference design.

CLS, a subsidiary of the French Space Agency, CNES, ARDIAN & IFREMER, is a worldwide group of companies and pioneer provider of monitoring and surveillance solutions for the Earth since 1986. Its mission is to deploy innovative space-based solutions to understand and protect our planet, and to manage its resources sustainably. CLS employs 750 people, at its headquarters in Toulouse (France) and in its 26 other sites around the world. In North America, CLS Satellite Telemetry Services are provided by the Woods Hole Group. Headquartered in Massachusetts, Woods Hole Group is an international metocean and marine environmental services organization, with offices in Delaware, Maryland, and Texas. Woods Hole Group offers a range of offshore and coastal measurement, monitoring, and consulting services, including the collecting of ocean data, ocean forecasting, tracking assets and wildlife with satellite communications, and fishing vessel monitoring systems.



» This miniaturized chipset (7mm x 7mm) allows the use of new Argos-3 & 4 capabilities like the bidirectional communication capacity, and new modulations. Photo credit: CLS.

NOAA LAUNCHES ATOMIC

MAJOR WEATHER AND CLIMATE PREDICTION FIELD CAMPAIGN EXAMINES AIR-SEA INTERACTIONS



» January 2020: Deploying a CTD rosette station, which measures temperature and salinity of sea water at different depths. Photo credit: Richard Marchbanks, CIRES/NOAA.

NOAA has launched a six-week scientific campaign from the island of Barbados in the Caribbean, using multiple human-piloted and autonomous vehicles, buoys, radar, and computer modeling to investigate how the ocean, atmosphere, and shallow clouds work together to create the weather and climate we live in.

Called ATOMIC, or the Atlantic Tradewind Ocean-Atmosphere Mesoscale Interaction Campaign, the mission is the U.S. component of a collaborative effort that includes Germany, France, United Kingdom, United States, and Barbados called EUREC⁴A (Elucidating the Role of Clouds-Circulation Coupling in Climate). ATOMIC will involve experts from three NOAA Research labs, NOAA pilots and crew, the Caribbean Institute for Meteorology and Hydrology, several universities, and other partners to address this complex problem.

"The atmosphere is like a crazy squirrel going nuts running on top of the slower-

moving ocean — air-sea interactions are complicated," said Chris Fairall, ATOMIC Chief Scientist and NOAA Earth System Research Laboratory scientist.

"ATOMIC will advance our scientific understanding of how the ocean and atmosphere including clouds work together to create weather," added Brian Gross, NOAA's National Weather Service Environmental Modeling Center Director. "We'll use this to enhance our models to improve the guidance they provide National Weather Service forecasters, and ultimately service to the public."

Collecting Data For The Caribbean and Beyond

From January 7 through February 13, 2020, the research team will travel east and south of Barbados to take measurements of different variables in the air and the sea.

"This region in the heart of the trade winds is like a real-world laboratory," said Fairall.

"It represents other areas across the global ocean where air-sea interactions make the same shallow convective clouds."

By studying the region in the winter, researchers can observe the ocean, air, and clouds in near isolation from the impacts of storms and hurricanes. This will help them acquire a better understanding of how the ocean makes shallow clouds, and how these clouds, the basic building blocks for storms, affect larger weather and climate patterns.

NOAA's scientists will focus on two sites. One is where Earth's largest circular ocean currents (or eddies) spin off from the Amazon and Orinoco Rivers, and drift into the study region. These eddies are potential heat reservoirs, providing energy and moisture to create shallow convective clouds. However, the origin of eddies, their properties, and their interaction with the lower atmosphere to drive cloud development are poorly understood. The



» January 2020: Science team members monitor the display information as the CTD rosette makes its way down to a depth of 2,000 meters. Photo credit: Richard Marchbanks, CIRES/NOAA.

second site is in the trade-wind region, where winds consistently blow along the ocean surface. Observations from this region will help scientists understand how wind-ocean interactions provide moisture and heat to the atmosphere.

"We know very little about how these processes vary across fields of clouds and eddies because they have never been measured concurrently in one focused region, and satellites cannot measure them all at the same time," said Elizabeth Thompson, ATOMIC and NOAA ESRL scientist. "Yet, they hold immense power in controlling our climate-weather system."

To measure all of these processes simultaneously, scientists will use instruments aboard NOAA Ship Ronald H. Brown, NOAA WP-3D Orion aircraft, several autonomous vehicles, as well as ocean surface floats. Launched from the Brown, wave gliders (autonomous sea vehicles) and SWIFT (Surface Wave Instrument Floats with Tracking) will drift along the sea surface. The research team will also compare measurements from these autonomous systems to long-term data from two NOAA ocean observing sites: The Northwest Tropical Atlantic Station (NTAS) buoy and the Meridional Overturning Variability Experiment (MOVE) mooring site.

Types of Autonomous Instruments Deployed

Wave gliders: These are wave-propelled, solar-powered autonomous surfboards capable of sustained deployment over multiple seasons that convert the energy of waves into thrust. Each wave glider is made up of a 7-foot long surfboard-like float tied to a submerged glider that controls speed and direction along a programmed or remotely-piloted path. Wave gliders measure wave properties, currents, ocean temperature and salinity, exchanges between the air and water, along with surface weather. Data are transmitted to shore via satellite.

Seagliders: Five of these small, streamlined, free-swimming vehicles will repeatedly dive and climb to make measurements of the upper ocean traditionally collected by research vessels or moored instruments, but for months at a time and at a fraction of the cost. They can survey a transect, hover at a fixed location, or receive remote directions to follow a set course.

Saildrones: Five of these autonomous, solar-powered sailboats will operate in the larger ocean area around Barbados in January and February. It's a unique instrument package that provides simultaneous measurements of the lower atmosphere and upper ocean: waves, ocean temperatures, salinity and currents, along with surface weather and ocean chemistry. Two NOAA-funded saildrones will be on extended operation from February through July, while the original saildrone fleet will return to Barbados for recovery.

SWIFT buoys: Six SWIFT buoys—SWIFT stands for Surface Wave Instrument Floats with Tracking—will drift along the sea surface measuring ocean turbulence, wave properties, salinity, water, surface meteorology, and capture images of clouds.

Argo floats: These battery-powered autonomous floats spend most of their time drifting at a depth of about 1.2 miles measuring temperature and salinity, then rise to the surface on a set schedule to transmit data in real-time via satellite. Argo floats cycle through these dives, or "profiles" for four to five years on battery power. Since its inception in 1999, the Argo Program has grown to include almost 4,000 floats and participation from 26 countries across the globe.

Ocean Drifters: Ten enhanced drifting buoys will also aid in collection of ocean data. "Drifters" are composed of a surface float, which includes a transmitter to relay data via satellite, and a thermometer that reads temperature a few centimeters below the air-sea interface. The floats were also equipped with salinity sensors for this experiment. The surface float is tethered to a holey sock drogue (a.k.a. "sea anchor"), centered at 15 m depth. The drifter follows the ocean surface current flow integrated over the drogue depth.

In the skies: Unmanned aerial vehicles or UAVs can fly slower and lower than larger piloted aircraft, making UAVs ideal for probing the marine boundary layer that connects clouds with the ocean surface, from 100 to 10,000 feet of elevation. The ability of these small craft to fly grids at different elevations offers the opportunity to obtain measurements unavailable with larger, faster aircraft. The UAVs can collect needed information on turbulence and its impact on the transfer of heat, mass, and momentum across the cloud base.

NOAA scientists will deploy the RAAVEN UAV, carrying the miniflux sensor package developed by NOAA, CIRES and University of Colorado scientists in Boulder, Colorado, in flights just offshore, where ships and other ocean-based platforms can't operate. The measurements will explore the interactions between the ocean surface and the overlying atmosphere, as well as the interface between that boundary layer and the clouds that are generated.

These roaming autonomous platforms significantly enhance the coverage of data available across space and over time compared to that from one location. These datasets will complement the intensive data collection also taking place at the ships, aircraft, and buoys during ATOMIC.



» Wave gliders measure wave properties, currents, ocean temperature and salinity, exchanges between the air and water, along with surface weather. Photo courtesy of NOAA.

THE LIMITING FACTOR: TRELLEBORG DEVELOPING NEW MATERIALS FOR ULTRA-DEEP-WATER VEHICLES

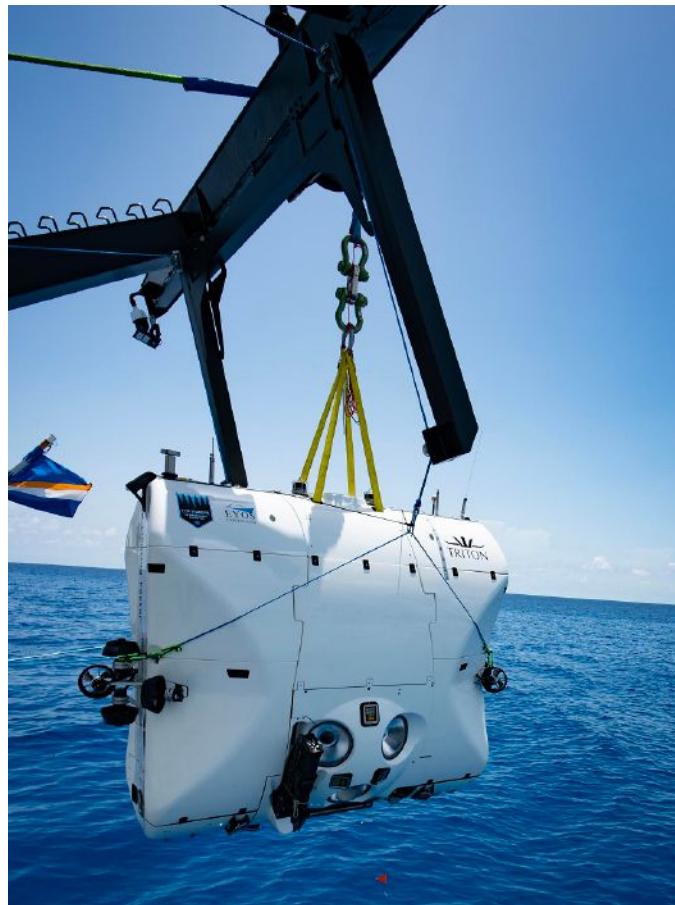
The Five Deeps Expedition, the world's first successful manned expedition to the deepest point in each of the world's five oceans, covered 47,000 nautical miles in just 10 months, with its submersible vessel completing 39 dives including depths of over 10,000 m.

The manned submersible vessel, the *Limiting Factor* was not only being used for technical capability verification and scientific missions, but also exploring places never visited before, including the deepest point on planet Earth: Challenger Deep within the Mariana Trench in the Pacific Ocean.

The development of the *Limiting Factor* required a huge amount of collaboration to support the overriding aim for the manned submersible to undertake repeated dives to full ocean depths. Integral to the development, Trelleborg's applied technologies operation worked with the submersible builder to create unique buoyancy modules specifically for ultradeep high pressure environments. They were manufactured from full ocean depth material TG-11500, a 11,500 m rated low density high performance syntactic foam which made up some 70 percent of the overall body of the vessel.

Each block of raw material underwent extensive in-house testing in Trelleborg's recently upgraded laboratory for water absorption and Hydrostatic Crush Pressure testing at its facility in Rochdale, England. Completed modules were then successfully tested at the Krylov test centre in St. Petersburg and signed off by DNVGL.

Three years of intensive efforts from some of the world's leading oceanographers, submarine engineers and scientists were necessary to make Victor Vescovo's, an American extreme explorer and the initiator and sub pilot of the Five Deeps Expedition, project possible. The design, manufacture and engineering capabilities, and the combined efforts of the development team, have produced something truly world class, enabling the vessel to make five dives in the Mariana Trench in just 10 days.



» Photo courtesy of Caladan Oceanic, Triton Submarines, and the Five Deeps Expedition.

Learning from The Five Deeps Expedition has set Trelleborg on course to further develop a range of materials purely for ultra-deep-water high-pressure environments. Trelleborg's research and development team have been investigating the effects of long-term immersion of syntactic foam in ultra-deep waters and are now collaborating on new projects. It is working to expand its product range and develop new materials for use in the manufacture of resident ROVs (Remotely Operated Vehicles). These are no longer deployed from surface vessels but instead remain garaged on the sea bed in ultra-deep waters for long periods of time and operated from safe on-shore control rooms.

CGG EXITS FROM SEABED DATA AQUISITION BUSINESS

CGG has announced that it is completing its exit from the seabed data acquisition business and has terminated the Seabed Geosolutions' joint venture agreement effective December 31, 2019.

In line with its strategy to exit the data acquisition business, CGG has agreed to transfer its 40% shareholding

in Seabed Geosolutions to Fugro before the end of the first quarter of 2020 and to conclude before year-end 2019 the remaining matters related to Seabed Geosolutions' financing and non-competition provisions by paying \$35 million to Fugro.

Including this payment, CGG anticipates in 2019 significant positive net cash flow above its expectations.

WWW.CGG.COM

SEAVIEW WAVE SENSOR NOW PROVIDES SHIP STRIKE ALERTS

As more oceanographic buoys are deployed around the world, incidents of ships striking buoys are increasing. The impact of such strikes can be severe enough to damage a buoy or even knock it off its mooring and set it adrift. Without a clear timeframe of when the strike occurred, there has historically been no way to determine the cause of costly (and oftentimes hazardous) buoy damage; until now.

SeaView Systems' SVS-603 wave sensor has been enhanced with ship strike detection capabilities which can trigger an alert based on buoy motion parameters that indicate a ship strike (or other anomalous conditions). The alert allows prompt response to assess potential damage. The date and time associated with the alert can then be matched to nearby ships at the time of a strike based on Automatic Identification System (AIS) data.

"The addition of the SVS-603 wave sensor's ship strike alert capability is a very useful tool in monitoring harbor buoys that are damaged all too frequently," said Captain Pete Dolan of eProNav, a provider of expert consulting and system design services for marine navigation.

"Connecting the alert information from the SVS-603 with readily available



» Buoy damaged by a ship strike and acceleration data from the SVS-603 wave sensor delineating day and time of strike (sharp peak).

AIS information makes it possible to connect a strike with local vessel traffic, information that is extremely useful in determining conditions (and potentially responsibility) for costly buoy damage."

SeaView's Systems Development Manager Ed Celkis sees this sort of enhancement as a natural extension of the platform of capabilities in the SeaView wave sensor and a reflection of the way that microelectronics is dramatically changing traditionally mechanical systems.

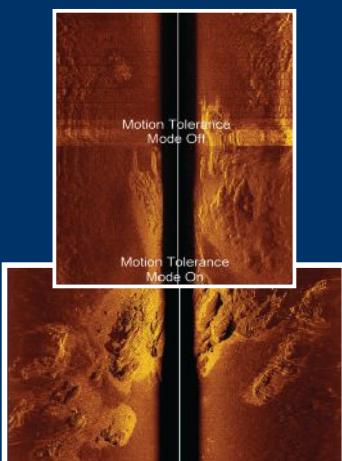
"With the fast micro-controller and onboard electronics which are central to the SVS-603's algorithmic capabilities, we have a platform which can readily be extended to add these kinds of features," said Celkis.

SeaView's SVS-603 wave sensor is widely used to add wave sensing capabilities to legacy buoys, as part of various buoy networks for weather and environmental data collection, as well as being used to add wave sensing to various autonomous surface and submersible vehicles. Ship strike detection is just one of several enhancements included in the latest updates.

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» WHOI's robot, *Nereid Under Ice* (*NUI*), samples a patch of sediment from the mineral-rich floor of Kolumbo volcano off Santorini Island, Greece. This is the first known automated sample taken by a robot in the ocean. Photo credit: Richard Camilli, © WHOI.

WHOI UNDERWATER ROBOT TAKES FIRST KNOWN AUTOMATED SAMPLE FROM OCEAN

A hybrid remotely operated vehicle developed by Woods Hole Oceanographic Institution (WHOI) took the first known automated sample performed by a robotic arm in the ocean. In December 2019, an international team of researchers used one of WHOI's underwater robots, *Nereid Under Ice* (*NUI*), to explore Kolumbo volcano, an active submarine volcano off Greece's Santorini island.

"For a vehicle to take a sample without a pilot driving it was a huge step forward," says Rich Camilli, an associate scientist at WHOI leading the development of automation technology as part of NASA's Planetary Science and Technology from Analog Research (PSTAR) interdisciplinary research program. "One of our goals was to toss out the joystick, and we were able to do just that."

As with self-driving cars, handing the wheel over to a computer algorithm can be unsettling. The same goes for ocean robots, especially when they need to work in tricky and hazardous environments. Camilli was part of an international team of researchers on an expedition aimed at learning about life in the harsh, chemical-laden environment of Kolumbo, and also exploring the extent to which scientists can hand over the controls to ocean

robots and allow them to explore without human intervention.

Slightly smaller than a Smart Car, *NUI* was equipped with Artificial Intelligence (AI)-based automated planning software—including a planner named 'Spock'—that enabled the ROV to decide which sites to visit in the volcano and take samples autonomously.

Gideon Billings, a guest student from the University of Michigan whose thesis research focuses on automated technologies, got the honors of using his code to collect the very first automated sample, which was of a patch of sediment from Kolumbo's mineral-rich seafloor. He issued a command to the autonomous manipulator and, moments later, a slurp-sample hose attached to the robotic arm extended down to the precise sample location and sucked up the dirt.

Billings says this level of automation will be important for NASA as they develop technologies to explore ocean worlds beyond our solar system. "If we have this grand vision of sending robots to places like Europa and Enceladus, they will ultimately need to work independently like this and without the assistance of a pilot," he says.

Moving forward, Camilli will continue working with Billings and colleagues at the University of Michigan, as well as the Australian Centre for Field Robotics, Massachusetts Institute of Technology, and the Toyota Technological Institute at Chicago to push the automation technology forward. The work will include training ocean robots to see like ROV pilots using "gaze tracking" technology, and building a robust human-language interface so scientists can talk directly to robots without a pilot go-between.

"We can eventually see having a network of cognitive ocean robots where there's a shared intelligence spanning an entire fleet, with each vehicle working cooperatively like bees in a hive," Camilli says. "It will go well beyond losing the joystick."

 WWW.WHOI.EDU

» *NUI* is lowered into the Aegean Sea before plunging to a depth of 500 meters to explore Kolumbo volcano. Photo credit: Evan Lubofsky, © WHOI.

NOAA AND OCEAN INFINITY TO DEVELOP DEEP-WATER AUTONOMOUS TECHNOLOGIES

NOAA's Office of Ocean Exploration and Research and the ocean data and technology company Ocean Infinity have announced a new agreement to develop deep-water autonomous technologies that can gather ultra-high-resolution ocean information.

The four-year Cooperative Research and Development Agreement (CRADA) between NOAA and Ocean Infinity will also focus on advancing telepresence or the transmission of ocean video and information in real-time to public and academic audiences as well as new data collection and processing methods to increase the value and relevance of deep-ocean data.

"This new partnership will help us more efficiently execute NOAA's mission to advance unmanned drone systems and artificial intelligence to explore and map the United States Exclusive Economic Zone," said Neil Jacobs, Ph.D., acting NOAA administrator. "Data and information about the ocean help our nation advance our Blue Economy, including maritime commerce, domestic seafood production, healthy and sustainable fisheries, coastal resilience, energy production, tourism and recreation, environmental protection and national security."

The collaboration will support the recent Presidential Memorandum on Ocean Mapping in the U.S. Exclusive Economic Zone and Shoreline and Near Shore of Alaska and the goals announced at the November 2019 White House Summit on Partnerships in Ocean Science and Technology.

Developing New Robots To Rapidly Characterize The Deep Ocean

"This is an exciting step for Ocean Infinity as we combine our leading deep-water exploration technology with NOAA's prominent authority in ocean science," said Sean Fowler, director of business development for Ocean Infinity. "Perhaps greater than technology is the collaboration between leading engineers and scientists to ultimately improve our understanding of earth-ocean systems in remote environments."

Craig McLean, assistant NOAA administrator for research, added, "Together, we'll accelerate how we deliver important ocean information to those who need it most from ocean areas we know the least. This work will enhance our mission in science, operations and engineering."

Only 43 percent of the 3.4 million square nautical miles of U.S. territory underwater is mapped to modern standards. "The NOAA-Ocean Infinity partnership will play a key role in helping NOAA reach its goal of fully mapping the U.S. EEZ and characterizing ocean environments to support their conservation, management, and balanced use," said Alan Leonardi, Ph.D., director of the NOAA Office of Ocean Exploration and Research.

Ocean Infinity is a world-leading

technology company that uses innovative state-of-the-art sensor technology to acquire and analyze ocean data. By leading national efforts to explore our ocean and making ocean exploration more accessible, the NOAA Office of Ocean Exploration and Research is filling gaps in the basic understanding of U.S. deep waters and seafloor, providing critical deep-ocean data, information, and awareness that is needed to sustain and accelerate the economy, health, and security of our nation. NOAA's mission is to understand and predict changes in the Earth's environment, from the depths of the ocean to the surface of the sun, and to conserve and manage our coastal and marine resources.

For more information visit:
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CHECK THE TECH: LAB-ON-A-CHIP SENSORS DEVELOPED FOR DEEP OCEAN AUVS

During the recent Blue Innovation Symposium in Newport, Rhode Island, professor Dr. Vincent Sieben of Dalhousie University (Dal) presented lab-on-a-chip technology. Sieben has spent the better part of fifteen years developing this technology, and since March of 2018, he has worked with Dal's Ocean's Engineering Hub to utilize the technology in developing tiny in-situ microfluidic sensors to monitor nutrients, metals, hydrocarbons and microbes in the ocean.

In collaboration with other researchers, including Dr. Mae Seto who was recently appointed the Irving Shipbuilding Chair in Marine Engineering and Autonomous Systems, and Dr. Douglas Wallace from Dal's Department of Oceanography, Sieben plans to integrate his sensors onto underwater vehicles. The miniature chips are housed on a portable power system and then strapped onto Autonomous Underwater Vehicles (AUV) and deployed into the ocean. The sensors are intended to collect data within environments often too dangerous or too expensive for human exploration. From there, the chips allow researchers

to instantly measure valuable characteristics of the ocean's chemistry including nitrate, nitrite, ammonium, phosphate, silicate and iron.

Sieben says one of the main challenges in developing lab-on-chip devices for the deep sea is the design and fabrication of the device on a very small scale. These tools must be both cost efficient and functional, and of course, small enough to fit onto a small robot.

"The focus of our lab-on-a-chip program is to develop sensors that are better suited for long-term deployment at sea without having scientists themselves go out to collect the data," he says. "So if we have miniature sensors that are small enough to integrate onto these AUVs, and that consume very little power, then we can conceivably collect much more ocean data over space and time."

A SEA OF KNOWLEDGE

Traditionally, advances in lab-on-a-chip technology have focused mainly in the area of healthcare and recently in oil and gas. However, in 2008, a group of scientists at the National Oceanography Center in Southampton, UK

conducted research on the first lab-on-chip nutrient and microbiology sensors for the deep ocean. Their team of researchers included Dr. Vince Sieben. Their chip, powered by a support system roughly the size of a large drinking bottle, was dropped into the ocean at a depth of 1,600 m and used to measure the temperature and salinity of the water.

"The professors who recruited me at the time had a vision of utilizing microfluidics in harsh environments. When it came to this type of technology, the work was a change in complexity that really excited me," says Sieben. "The thought

of throwing a lab-on-a-chip system in the deep blue put butterflies in my stomach. So, I joined their group."

Sieben says lab-on-a-chip integrates many areas of technology including microfluidics and nanofluidics. The devices incorporate several laboratory functions on a chip that ranges in size from a few millimeters to a few square centimeters. Sample analysis occur on location rather than being transported to a larger laboratory. He says the process, which helps achieve thorough automation, also reduces the risk of human error and interpretation.



» Dr. Vincent Sieben of Dalhousie University is working to utilize lab-on-a-chip technology in developing tiny in-situ microfluidic sensors to monitor nutrients, metals, hydrocarbons and microbes in the ocean. Photo courtesy of Dalhousie University.





» The lab-on-a-chip integrates many areas of technology including microfluidics and nanofluidics.



» The miniature chips are housed on a portable power system and then strapped onto AUVs and deployed into the ocean. Photo credit: Dartmouth Ocean Technologies Inc.

"Many of the biogeochemical measurements performed on marine water still rely on wet-chemistry protocols. When scientists perform these finely-tuned and sensitive processes in a laboratory, there can exist slight variations that yield dramatically different results," he says. "When we string these processes together on-chip, the sample never leaves our closed channels. It is treated the same as the 1000 other samples before it had been. This leads to unprecedented repeatability across a wide-range of users."

Following his work in Southampton, Sieben was a senior scientist at Schlumberger, the oil field service provider. He was the lead scientist on the team that delivered MazeTM, the first commercialized microfluidic sensor in the oil and gas industry. The technology coupled novel microfluidic chip technology and spectroscopy for precise measurements, and fully automated well over 400 step process for testing geographically diverse oil samples for saturates, aromatics, resins, and asphaltenes (SARA).

While at Schlumberger, Sieben also developed expertise in AUVs and Robotics for subsea

inspection and maintenance.

"What became apparent to me while working there was the fact there's a lot of infrastructure that humans have deployed throughout the ocean, but it can be quite costly to continuously monitor those structures," he says. "Ultimately, both the oil and gas industry and oceanographers are looking to reduce the cost of going out and gathering chemical and biological measurements at sea, and lab-on-chip technologies are well suited to address these challenges when coupled with autonomous vehicles."

A NEW WAVE OF OCEANS RESEARCH

In the Spring of 2017, Faculty of Engineering Associate Professor, Dr. Mae Seto, was appointed the Irving Shipbuilding Chair in Marine Engineering and Autonomous Systems. Part of her research focuses on intelligent autonomous systems, and marine robotics, particularly for deployment in difficult environments such as marine and under-ice.

"One of the reasons I like working with Dr. Seto is because she always says that her robots

are there for a reason, and that reason is for the sensors," says Sieben. "Whether you're looking for nutrient trends like we're doing here at Dal, or monitoring infrastructure as we were doing at Schlumberger, there's always some type of question you want answered, and those answers require sensors, and those sensors require robots."

In 2018, Sieben and his team (Andre Hendricks, Cesar Rodriguez, Sean Morgan, Eddy Luy) created and tested Dal's first lab-on-chip sensor for the deep ocean. Deployment occurred in the heart of Halifax's Bedford Basin.

The chip, coined by Sieben as "Generation Zero," was housed in a self-powered system that included all of the off the shelf components required in developing a sensor, including tubing and wires. The box however was the size of a carry-on piece of luggage, and substantially too large to strap onto one of Seto's small underwater vehicles.

In the summer of 2019, Sieben removed all of the original off the shelf components to his model, and engineered a smaller and sleeker sensor that attached onto a Riptide AUV, developed by BAE Systems'

Riptide Autonomous Solutions. Ultimately, he sees the chip becoming much smaller.

"I want to see the evolution of the chip," said Sieben, "I want to go from the big piece of carry-on luggage which we built last year, to the smaller tube we're creating now. Then I want to create an even smaller sensor hockey puck sized, and finally build something that's the size of a credit card."

Sieben says, "What excites me about applying lab-on-a-chip technologies for ocean monitoring is the cross generational impact that it can have. When I look at my children's children, I'm hopeful that we will have figured out a way to either measure our impact on the ocean ecosystem or at least be aware on how we're disturbing them. Our sensors are at the core of that solution."

For more information, visit www.siebenlab.com.

A NEW LOW-COST WAY TO CONNECT DEEP-SEA INSTRUMENTS

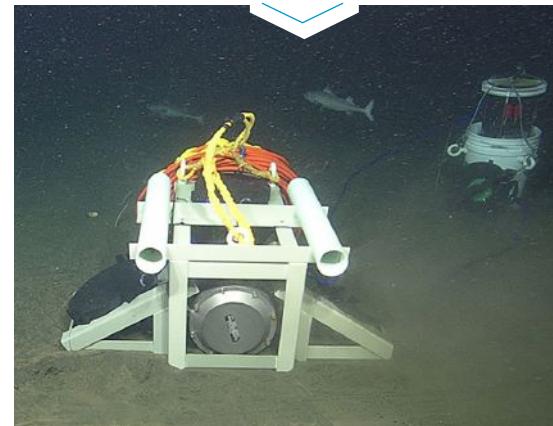
By Kim Fulton-Bennett,
Monterey Bay Aquarium Research Institute

Hoping to attract new users to their MARS undersea observatory, Monterey Bay Aquarium Research Institute (MBARI) engineers have developed a wireless device called Deep-Sea Connect, a relatively inexpensive system for supplying data and power to instruments in the deep sea. In December 2019 they demonstrated the system.

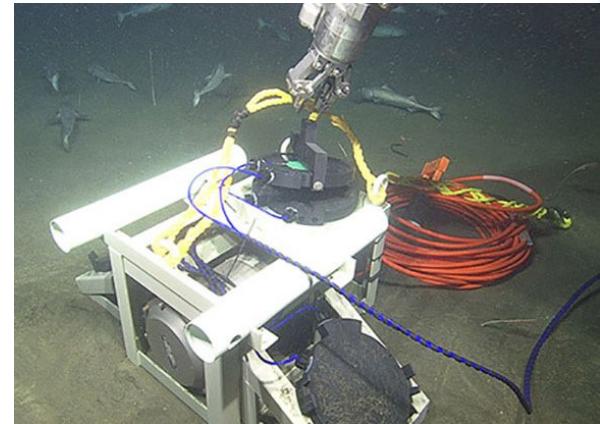
The MARS observatory is connected to shore through a 52-kilometer seafloor cable that acts as a giant extension cord. At the end of this cable is a "science node" with eight ports that provide electrical power and a high-speed data connection between the observatory and instruments on the seafloor. Unfortunately, the waterproof power and data connectors used on MARS can cost up to \$50,000 dollars each. This means that, historically, only well-funded researchers have been able to use the observatory.

Engineers Craig Dawe and David French developed Deep-Sea Connect, which they hope will allow additional researchers, and perhaps school groups, to take advantage of the observatory. Deep-Sea Connect consists of a small fiberglass frame with a titanium pressure housing that holds the "brains" of the system. On the sides and top of the frame are black plastic "paddles" that use radio waves to transmit power and data wirelessly underwater.

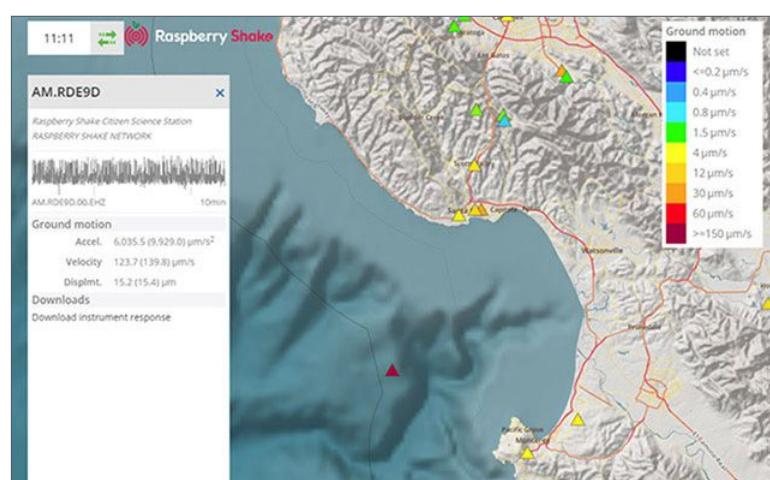
As an initial test, the engineers hooked up a small, inexpensive seismometer called a "Raspberry Shake," which can provide earthquake data comparable to that from professional short-period seismometers. For their test deployment, the MBARI researchers packaged a Raspberry Shake inside a waterproof housing and added a wireless connector paddle to connect the unit to the main Deep-Sea Connect system. After using remotely operated vehicle (ROV) Ventana to carry the instruments 900 meters down to the seafloor, the ROV pilots simply placed the paddle from Raspberry Shake on top of one of the paddles on the Deep-Sea Connect system and data from the Raspberry Shake began flowing into the observatory network. Within a matter of hours, the data was visible on the Raspberry Shake website.



» Deep-Sea Connect system (foreground) and the Raspberry Shake seismometer (background) just before the instruments were connected to the MARS observatory. Image: © 2019 MBARI.



» The manipulator arm on ROV Ventana placing a wireless connector "paddle" from the Raspberry Shake on one of the paddles on the Deep-Sea Connect system. Image: © 2020 MBARI.



» The red triangle offshore of Monterey Bay shows the approximate location of the Raspberry Shake seismometer on the MARS observatory. Live data from the seismometer appears on the left. Image courtesy of Raspberry Shake.

MIROS RANGEFINDER ACHIEVES ATEX ZONE 1 CERTIFICATION

The Miros RangeFinder sea state monitoring sensor is now available with Atex IEC Ex certification for use in Zone 1, clearing it for use in explosive atmospheres. This breakthrough opens for unrestricted use of RangeFinder in offshore oil and gas production environments. The motion compensated version of the Miros RangeFinder, WaveFinder, is also certified for use in Zone 1.

Offering up to 15% higher operational availability and increased operational safety, the Miros sensor is a high-frequency vertical microwave radar that provides sea level, tide, non-directional wave monitoring, ride control and air gap measurements.

"There is a constant need for accurate and real-time knowledge of the sea state in the offshore oil and gas industry," says Miros CEO Andreas Brekke. "The RangeFinder can

now be employed whenever and wherever needed on platforms and service vessels. This will provide operators with even better access to highly accurate sea state data that can help them plan and execute safer and more efficient marine operations."

Unlike laser sensors, the RangeFinder is undisturbed by fog, rain and water spray, giving measurements with +/- 1-millimeter accuracy in all weather conditions. The sensor is dry-mounted, meaning no parts are submerged in water, eliminating problems with wear and fouling associated with submerged equipment.

RangeFinder is available as an IoT-based sensor, needing only power and an internet connection to provide secure local and remote real-time ocean state data to any device. The sensors can also be complimented with cloud services from



Miros, such as web displays, database integration, data processing and device management services, making historical weather data available to all stakeholders.

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THE RICH NORTH SEA: LOOKING FOR A SUSTAINABLE BLUEPRINT

A new covenant called 'The Rich North Sea' (De Rijke Noordzee) brings together several companies working to connect two of the major challenges of our time: ensuring sustainable energy and enhancing underwater biodiversity. Tennet, Eneco, van Oord, Blauwwind, Ørsted, Nature & Environment and De Noordzee Foundation all signed The Rich North Sea covenant at the Norwegian office of the National Postcode Lottery.

The parties, who all have an important relationship with the North Sea, share a common goal: a healthy North Sea, a source of sustainable energy, with robust natural habitats full of life. Under the agreement, wind farms in the North Sea would be used as nurseries for underwater life.

The first demonstration project will provide know-how and contribute to a blueprint for underwater nature restoration at all offshore wind farms, so that this can soon become standard when constructing new wind farms. Numerous big new wind farms are planned for the Dutch sector of the North Sea in the coming years. The partners aim to show that nature conservation and sustainable energy generation can be mutually beneficial. The Parties support the program by, among other things, setting up nature enhancement projects, installing artificial reefs, making ships available, or conducting or enabling scientific research.

"A strong collaboration between the wind sector and nature organizations will stimulate innovation on the seabed in wind farms with the ultimate goal of a healthy North Sea," said Erwin Coolen, Director De Rijke Noordzee.

The Rich North Sea: Where Wind And Nature Reinforce Each Other

The Rich North Sea program aims to strengthen natural ecosystems in and around North Sea wind farms on a large scale for the first time. Natural reefs have virtually disappeared there due to human intervention and diseases. But fishing is not allowed on the bottom of the wind farms in the North Sea. By developing new living reefs right there, places are created for shellfish to attach to. This creates habitat that can give nature in the North Sea a "kickstart". The Rich North Sea will implement such nature projects in both existing and yet to be built wind farms in the coming years.

The Rich North Sea is supported with a contribution of € 8.5 million from the Dream Fund of the National Postcode Lottery.

FUGRO AND COLOMBIAN MARITIME AUTHORITY TO COMPLETE SEEP HUNTING STUDY

Fugro and the Colombian Maritime Authority (Dirección General Marítima, DIMAR) have completed a joint environmental seep hunting study to help assess the country's resource potential in the Caribbean Sea. The study involved shallow water seabed sediment coring, geochemical analyses, and seabed heat flow measurements. Fugro also provided classroom and vessel-based training to DIMAR personnel.

"This project and training were carried out to support DIMAR's strategic objectives, including developing the skills of our personnel, and producing technical and scientific information to support Colombia's maritime authority," stated Petty Officer First Class Luis Olarte, project manager for DIMAR.

The field programme was conducted in two phases onboard DIMAR's new multipurpose hydrographic vessel, the ARC Roncador. Fugro mobilized specialised equipment for the testing, including two self-contained laboratories and a state-of-the-art heat flow probe. The ability to perform preliminary geochemical analyses at sea is unique to Fugro and results in the rapid identification of high-potential cores. This service can significantly reduce project delivery schedules: on this DIMAR project, our offshore analyses shortened the project by approximately 2 months.

"We are grateful for this opportunity to have partnered with DIMAR and provided training to their personnel in our areas of expertise," said Dr. Jim Gharib, Fugro's Global Manager for Seep Hunting and Geochemical Exploration. "Operations were carried out safely and successfully, and Fugro appreciates this opportunity to create a partnership with DIMAR and to demonstrate our commitment to Colombian scientific and business objectives now and in the future."

WWW.FUGRO.COM



» Fugro and DIMAR personnel onboard the ARC Roncador

TCARTA DEVELOPING COMMERCIAL ICESAT-2 BATHYMETRIC PRODUCT

TCarta Marine, a global provider of marine geospatial products, is commercializing a new technique to derive highly accurate shallow-water bathymetry measurements from NASA's ICESat-2 satellite data. The new methodology is being developed by TCarta with funding from the National Science Foundation (NSF).

In 2018, NSF awarded TCarta a Phase 1 Small Business Innovation Research (SBIR) grant to commercialize new satellite-derived bathymetric (SDB) measurement technologies. Referred to as Project Trident, the research focused on leveraging Artificial Intelligence (AI) - machine learning and computer vision - to determine shallow-water seafloor depth in variable water conditions.

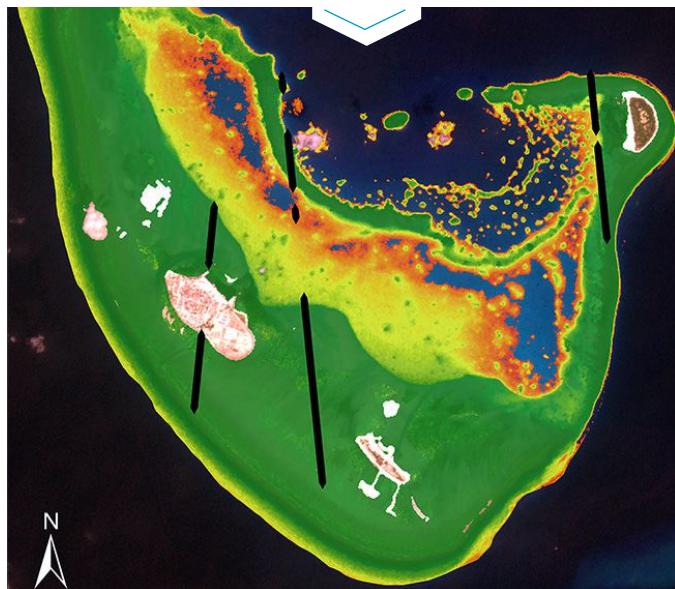
"As participants in NASA's Applied Users Program, we incorporated laser data from ICESat-2 as a validation tool for the enhanced SDB technologies under development," said TCarta President Kyle Goodrich. "The results were so impressive we plan to introduce a stand-alone ICESat-2 bathymetric data extraction tool as one of several commercial products from our NSF work."

NSF awarded TCarta a Phase 2 grant in late 2019 to incorporate the new ICESat-2 research into the project's original objective of enhancing existing SDB technologies with AI capabilities to measure seafloor depths in diverse water conditions.

"The breakthroughs we made with NSF funding will enable us to apply SDB technology in geographic areas and water conditions not previously possible," said Goodrich. "The results will have commercial impacts on marine operations related to oil & gas exploration and production, coastal infrastructure engineering, environmental monitoring, and geospatial intelligence (GEOINT) activities."

TCarta pioneered the application of high-resolution optical satellite imagery for seafloor depth measurement in 2014 with commercialization of a proprietary technique. This SDB technology, however, was limited to the relatively calm and clear waters of shallow coastal areas. In 2018, TCarta teamed with jOmega and DigitalGlobe of Maxar Technologies on Project Trident.

The team added ICESat-2 space-based laser data to the project shortly after the small satellite's launch in 2018. Developed by NASA and the University of Texas, ICESat-2 (Ice, Cloud & Land Elevation Satellite) was designed primarily for polar ice elevation and tree canopy measurements, but the green laser altimeter onboard has proved remarkably accurate at gauging seafloor depths down to 100 feet below the surface. TCarta is developing a software tool incorporating AI algorithms to automatically extract bathymetric measurements



from ICESat-2 data sets. Parties interested in serving as beta testers for the ICESat-2 tool or other Project Trident software components should complete the online Project Trident survey at www.tcarta.com/blog/survey.

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ØRSTED TO OPEN INNOVATION HUB IN RHODE ISLAND



As part of Ørsted's commitment to building an offshore wind industry supply chain in the U.S., the company is establishing its Innovation Hub team in Rhode Island. To facilitate its mission, the Hub team will leverage Ørsted's industry-leading expertise across the company's offices in U.S. and Europe. Ørsted expects its seven workstations at Providence's CIC will be regularly filled with dedicated innovation team leaders as well as rotating team members from the company's global headquarters in Denmark and its regional headquarters in North America. The Innovation Hub will officially open early spring 2020.

The purpose of this team will be to identify, foster, and, where appropriate, finance enterprises related to offshore wind, with a focus on next-generation technology and related innovation in the offshore wind energy field. The Innovation Hub will serve as the physical location for this team as they investigate U.S.-based companies interested in deploying next generation technologies to advance offshore wind deployment. As a key part of this process the hub team will leverage Rhode Island's existing innovation ecosystem.

"Innovation has been the key to the success of the offshore wind industry in Europe, so committing time and resources to foster new technology growth here in the U.S. was an obvious step for Ørsted," said Thomas Brostrøm, President for Ørsted North America and CEO for Ørsted U.S. Offshore Wind. "Locating this operation in Providence was an equally obvious move for us. The state has shown time and time again that it is home to one of the best innovation economies in the country and we look forward to becoming a part of that community."

"I'm thrilled that Ørsted has decided to open its United States Innovation Hub here in Providence, further cementing our status as America's offshore wind capital," said Governor Gina M. Raimondo. "We're making record investments in education and job training, and the results speak for themselves. As we continue working to ensure Rhode Islanders are prepared for high-skill jobs in the modern economy, I'm confident that more and more companies like Ørsted – leaders in 21st century industries – will continue to look to Rhode Island."

Rhode Island Secretary of Commerce Stefan Pryor said, "Ørsted will join companies such as GEV Wind and Boston Energy at CIC as the industry continues to flourish in Rhode Island."

Ørsted and the CIC-based cadre will host meetings and larger gatherings of entrepreneurs and pioneers in the offshore wind energy field. As a result, this will be a dynamic team that draws upon new local talent as well as worldwide expertise in order to conduct its work and catalyze progress in this field.

"We believe that there is great value to be gained by working with the booming blue tech ecosystem," said Jens Patrik Edvardsen, Head of Innovation at Ørsted Offshore. "As small nimble players can provide significant benefit and new solutions to Ørsted, so can Ørsted provide a fantastic platform for maturation and growth to companies with unique and relevant solutions. We look forward to increasing our collaboration with the innovation ecosystem."

For more information, visit us.orsted.com.

THE NORWEGIAN PRIME MINISTER OPENS THE JOHAN SVERDRUP FIELD

Norway's prime minister Erna Solberg performed the official opening of the Johan Sverdrup field center on January 7, 2020, and the Minister of Petroleum and Energy, Sylvi Listhaug, also attended the opening.

Since Equinor and the Johan Sverdrup partners Lundin Norway, Petoro, Aker BP and Total started the field on October 5, last year, production has increased to a level well above 300,000 barrels per day. Johan Sverdrup is expected to yield a total production revenue exceeding NOK 1 400 billion and more than NOK 900 billion in revenue to the Norwegian state. Expected recoverable Johan Sverdrup reserves are 2.7 billion barrels of oil equivalent. Two thirds of the oil from Johan Sverdrup are expected to be produced before 2030.

The field is setting a new standard for CO₂ efficiency. Land-based power supply leads to record-low CO₂ emissions of well below 1kg per barrel, compared to a global average of around 18kg.

"Johan Sverdrup offers both high value creation and record-low emissions, making Johan Sverdrup a future-oriented oil field and part of the solution for reduced emissions. Electrification is an important tool for reaching Norwegian and international climate goals, aiming to reduce our greenhouse gas emissions in Norway by 40% by 2030, and close to zero emissions in 2050," says Eldar Sætre, CEO of Equinor.

Johan Sverdrup is based on a long history of valuable experience and expertise. The field is also a pioneer in using technology and digitalization.

"Digitalization offers new opportunities that few people



deemed possible only a few years ago. It is necessary to secure the transformation we need to succeed in our future industrial activities and value creation on the Norwegian continental shelf," says Arne Sigve Nylund, executive vice president for Development and Production Norway.

Digital solutions are integrated on the field—as an example we are monitoring the reservoir and optimizing production thanks to huge amounts of data transmitted from the wells. A "digital twin" provides a virtual real-time version of what is happening on Johan Sverdrup. This analytical tool helps improve safety, increase revenue and reduce emissions.

The field is expected to produce up to 660,000 barrels of oil per day in full production. Plateau production for phase 1 is up to 440,000 barrels of oil per day and is expected to be reached in the summer of 2020.

"We are working systematically on creating higher value from the field and achieving an optimal recovery rate. The field ambition is to reach a recovery rate above 70%," says Nylund.

In the operating phase Johan Sverdrup may also create jobs corresponding to an average of more than 3,400 man-years per year.

For more information, visit
WWW.EQUINOR.COM



» Equinor CEO Eldar Sætre marking the official opening of the Johan Sverdrup field, together with Norwegian Prime Minister Erna Solberg and Oil and Energy Minister Sylvi Listhaug. From left: Eldar Sætre, Erna Solberg, Kari Nessa Nordtun (Mayor Stavanger), Sylvi Listhaug and Elin Marie Halvorsen (Platform Manager Johan Sverdrup) Photo credit: Arne Reidar Mortensen.

BSEE SAFETY INITIATIVES SUPPORT RECORD OIL PRODUCTION

The Bureau of Safety and Environmental Enforcement announced in January that for the first time in history, oil production from the Gulf of Mexico exceeded 2 million barrels per day in August 2019. This record average daily production in the Gulf of Mexico followed on the heels of a record-setting 2018 for the entire Outer Continental Shelf (OCS), when a total of more than 640 million barrels were produced in federal waters. Additionally, a number of BSEE initiatives that began in 2017 are driving offshore safety performance and environmental improvements.

The increase in production in 2019 led to \$2.34 billion more offshore royalty revenue for the Federal Treasury and, according to a U.S. Energy Information Administration report, U.S. Gulf of Mexico oil production not only increased, but will continue to set records through 2020.

"This is incredible news for the Nation," said BSEE Director Scott Angelle. "Under the Trump Administration, BSEE is stressing safety and environmental sustainability while at the same time promoting robust energy production offshore, and it's paying off."

BSEE implemented initiatives beginning in 2017 to improve Bureau performance in response to three of President Trump's Executive Orders: 13795, 13868 and 13783. These efforts have targeted all three of BSEE's mission areas: safety, environmental sustainability and resource conservation.

BSEE has made important advancements in ensuring resource conservation. Recognizing that collaboration with industry spurs innovation, BSEE formed a strike team to better manage high pressure and high temperature (HP/HT) operating conditions. The significant efforts of this team led to clear directives being published in three 2019 guidance documents, known as Notices to Lessees, which set a path for HP/HT projects in the Gulf of Mexico to gain BSEE approval.



Shell's Appomattox project, located in the Gulf of Mexico about 80 miles south of New Orleans, was the first high temperature project to gain BSEE approval and began production in May 2019. The permitting work for the Appomattox project helped define and clarify the safety requirements in BSEE's recently published HP/HT related guidance documents.

On 12 December 2019, Chevron sanctioned the first ultra-high-pressure project at Anchor in the Gulf of Mexico approximately 140 miles off the coast of Louisiana. The project represents the industry's first deepwater high-pressure development at 20,000 pounds per square inch (psi) to win a final investment decision. The BSEE strike team met with Chevron to discuss the guidance.

Chevron subsequently awarded Schlumberger OneSubsea a contract to provide the industry's first fully integrated subsea production-rated system to handle up to 20,000-psi. Chevron relied upon BSEE's safety requirements to incorporate the guidance into its operations. Defining the processes, procedure and standards has ensured additional energy resources are not abandoned unnecessarily.

BSEE also partnered with the Bureau of Ocean Energy Management to conduct research into the health of energy production in the Gulf of Mexico Shallow Water Province. That research is detailed in a joint research report that evaluates the contributing factors for the decline in shallow water production and recommends operators use updated considerations in their royalty relief applications.

Ongoing BSEE initiatives are driving safety performance and environmental stewardship improvements, including:

- Risk Based Inspection Protocol: Using data and trend analysis to identify higher-risk operations and facilities, BSEE is able to focus inspection resources on these targets as a supplement to BSEE's existing schedule of inspections on production facilities and active drilling operations. This systematic approach led to performance-based risk inspections on 67 facilities in 2018, resulting in two safety alerts issued and 19 safety recommendations. In 2019, BSEE conducted

performance-based risk inspection on 57 facilities, resulting in two safety alerts issued and 20 safety recommendations. BSEE also conducted three facility-based risk inspections in 2018 and four in 2019.

Risk Analysis Committee: Established in December 2018, the Risk Analysis Committee advances BSEE's policy to ensure that risks to human health and the environment related to offshore activities are properly identified and reduced. This formalized effort addresses gaps identified in a 2011 report produced by a National Commission on the BP Deepwater Horizon Oil Spill and Offshoring Drilling.

Vital Statistics Program: Led by BSEE subject matter experts, vital statistics teams measure and track more than 80 unique statistics in order to identify areas needing improvement. Committees review quarterly data and meet to discuss findings from their analysis, and then recommend action steps.

Text Messaging Service: The BSEE!Safe messaging service, launched in May 2019, is a first-of-its-kind direct communication between a safety regulator and front-line workers. BSEE has used the service to send 28 safety alerts and bulletins to offshore workers, via more than 51,470 text messages, sharing lessons learned and recommendations from incidents and near misses. BSEE is currently the only safety regulator in the world

that delivers critical safety information directly to several thousand workers through text messaging.

Regulatory Reform Effort: As directed by Executive and Secretarial orders, BSEE undertook a review of the Production Safety Systems Rule and the Well Control Rule with a view toward the policy direction of reducing regulatory burden without sacrificing safety. The resulting revised rules provide an undiscounted ten-year savings of \$1.67 billion dollars compared to a cost of \$3.2 trillion for the rules promulgated in 2016. BSEE believes in smart regulations that lead to risk reduction without unnecessarily encumbering energy production, constraining economic growth or preventing job creation.

Information Sharing: BSEE has worked to enhance safety by increasing information sharing between the Bureau and the industry. The number of Safety Alerts and Safety Bulletins issued by BSEE rose 214% from 2016 to 2018, demonstrating BSEE's commitment to proactively analyzing information and sharing knowledge to reduce risk. The current administration also energized efforts to increase participation in the voluntary near-miss reporting program known as SafeOCS. Through dedicated outreach, participation has grown from the inherited rate of 4 percent to 86 percent as of June 2019, a 2,766 percent increase.

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» Photo credit: Noble Energy

FIRST GAS FROM THE LEVIATHAN FIELD OFFSHORE ISRAEL

On 31 December 2019, Noble Energy, Inc. announced the commencement of natural gas production from the Leviathan field, the largest natural gas field in the Eastern Mediterranean.

David L. Stover, Noble Energy's Chairman and Chief Executive Officer, stated, "This is a historic day for Noble Energy. The safe and successful execution of the initial phase of Leviathan development has been world-class, continuing our exceptional track record of major project delivery. First gas is online less than three years from project sanction and capital expenditures were \$150 million under budget. Combined with Tamar, our Israel assets provide a differential production profile and cash flow outlook for Noble Energy far into the future."

J. Keith Elliott, the Company's Senior Vice President, Offshore, commented, "The supply of natural gas from Leviathan will enhance Israel's energy resilience, enable further reduction of coal usage for electricity generation, significantly improve air quality and ensure long-term affordable energy for Israel. Leviathan natural gas provides redundancy in supply domestically and helps transition Israel to become a significant exporter of energy to regional and global customers for the first time."

The Leviathan field was discovered in 2010, and the initial development phase was sanctioned in 2017. The first phase of development consists of four production wells producing through two 18-inch, 73-mile subsea tiebacks to a processing platform offshore northern Israel. Located approximately 80 miles offshore in 5,500 feet of water, the field is estimated

to have recoverable resources of 22 trillion cubic feet (Tcf) of natural gas from 35 Tcf of in-place resource. The first phase of development has a designed production capacity of 1.2 billion cubic feet of natural gas per day.

Noble Energy holds a 39.66 percent working interest in the Leviathan project. Other interest owners include Delek Drilling LP with 45.34 percent and Ratio Oil Exploration LP with 15 percent interest.



» Photo credit: Noble Energy

For more information, visit
WWW.EQUINOR.COM

TOTAL AND APACHE MAKE SIGNIFICANT OIL DISCOVERY OFFSHORE SURINAME

Total and Apache have made a material oil discovery with the Maka Central-1 well on Block 58 offshore Suriname, on trend with the prolific discoveries in the adjacent Stabroek block in Guyana.

The Maka Central-1 well was drilled by a water depth of about 1,000 meters and encountered more than 123 meters net pay of high-quality light oil and gas rich condensate net pay, in multiple stacked reservoirs in Upper Cretaceous Campanian and Santonian formations. Further drilling and testing will be carried out to appraise the resources and productivity of the reservoir.

"We are very pleased with this first significant oil discovery, made just after our entry into Block 58. The result is very encouraging and proves the extension of the prolific world-class Guyana Cretaceous oil play into Suriname waters," said Kevin McLachlan, Senior Vice President Exploration at Total. "We are optimistic about the large remaining potential



of the area still to be discovered and will test several other prospects on the same block."

The Maka Central-1 exploration well was drilled by Apache as operator with 50% working interest and with Total as the JV partner with 50% working interest. The next exploration well will be drilled on the Sapakara West-1 prospect and the operatorship will be transferred to Total after completion of a third exploration well.

For more information, visit
WWW.TOTAL.COM



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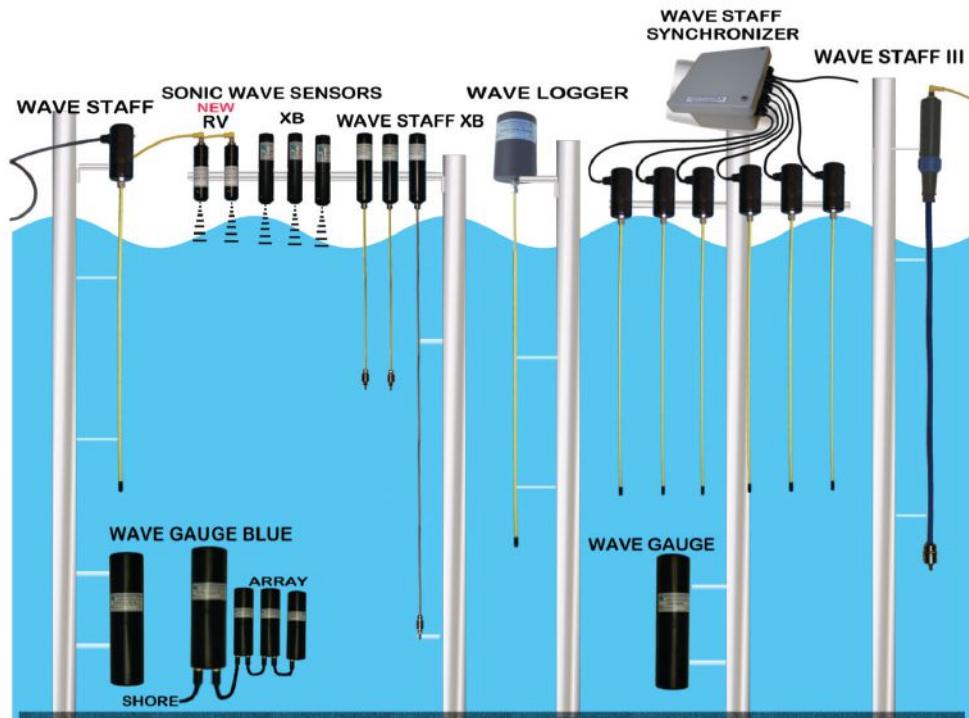
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OCEANTECH DEVELOPS INSPECTION ROBOT PROTOTYPE



» Inspection robot prototype.

OceanTech has been awarded a Subsea Research Project "ANDWIS" (Automated Non-Destructive Weld Inspection Robot) within the Petromax 2 program.

Inspection Robot

Project Manager Geir Ingar Bjørnsen explain the new Robot to be a game-changer in detecting fatigue cracks in Jacket Structures subsea and in the Splash Zone. The major challenges in the Splash Zone for such inspections are the forces from the current and waves, as well as the complex geometry to follow. Divers have a huge HSE challenge working in this zone, and ROV's have major challenges in positioning due to the movements. Different types

of crawlers also have problems with the positioning and being able to do efficient inspection in this zone.

To solve these challenges, OceanTech has developed a robot prototype which holds on to the structure and can move along the welds to be inspected. The research project will develop brand new technology to make the control easier, and with new sensoring to make the robot autonomous.

Inspection Robot Also For Subsea Use

In addition to being able to do efficient inspection in the Splash Zone, the robot can be used in deeper water and be deployed by ROV's. The Robot will be

connected to the ROV's control system and powered from the ROV. It is also likely that the ANDWIS robot can bring other sensors and NDE equipment for wall thickness measurements, CP or FMD inspection.



» OceanTech Vertical Access Tool (VAT) will deploy the new system in the Splash Zone.

Many of the older offshore installations have major issues related to corrosion and structural damages, especially in the Splash Zone (+5 to -10 meters). There are cases where Jacket Structures have large cracks, which can be critical for the structure integrity. Most oil-companies are today choosing to inspect and monitor these structures (which is very costly) or to repair it using different kinds of clamping solutions. In cases with Life Time Extension, such inspections are also an important input to the calculation related to remaining lifetime.

Since 2007, OceanTech has developed robotized access tools for operations in the Splash Zone on offshore installations. This work was started under Linjebygg Offshore, where the Splash-Zone division was bought by OceanTech in 2017. By utilizing robust and flexible access tools, OceanTech has successfully completed mechanical work, inspections and maintenance that require a high degree of precision.

For more information, visit
WWW.OCEANTECH.NO

SUBSEA INTEGRATION ALLIANCE AWARDED MAJOR CONTRACT OFFSHORE SENEGAL

Subsea 7 has been awarded a very large contract by Woodside to Subsea Integration Alliance for the Sangomar Field Development Phase-1 project located in the Sangomar Offshore and Sangomar Offshore Deep oil blocks, offshore Senegal. This contract was initially awarded in December 2018 subject to final investment decision, which has now occurred. Subsea 7 defines a very large contract as being between \$500 million and \$750 million. This value range refers to Subsea 7's share of the consortium contract and will be included in Subsea 7's order intake for the first quarter 2020.

The project work scope covers the engineering, procurement, construction, transportation and installation of the SURF system and associated subsea production systems (SPS). The development will include 23 wells, 107 km of rigid flowlines, 28 km of flexible risers and jumpers, and 45 km of umbilicals in water depths between 700 m and 1,400 m.

Offshore activities will take place from 2021 to 2023 using Subsea 7's reel-lay, flex-lay and light construction vessels.

The Subsea Integration Alliance team established during the Front End Engineering Design (FEED) phase will now transition into the full EPIC phase based at Subsea 7 Global Projects Centre (GPC) in Sutton, UK. SURF engineering will be performed by Subsea 7 GPC centers in Sutton and Suresnes, France. A base in Senegal will support the



offshore campaign and conduct site receipt testing and equipment storage.

Woodside is operator of the Rufisque Offshore, Sangomar Offshore and Sangomar Deep Offshore (RSSD) joint venture comprising Capricorn Senegal Limited (a subsidiary of Cairn Energy PLC), Woodside Energy (Senegal) B.V., FAR Ltd and Petrosen (the Senegal National Oil Company).

Subsea Integration Alliance is a non-incorporated strategic global alliance between Subsea 7 and OneSubsea®, the subsea technologies, production and processing systems division of Schlumberger.

For more information, visit
WWW.SUBSEA7.COM



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CANADIAN GOVERNMENT AWARDS KRAKEN ROBOTICS SEAVISION® CONTRACT

Kraken Robotics Inc. announces that its wholly owned subsidiary, Kraken Robotic Systems Inc., has been awarded a contract valued at \$524,720 with the Government of Canada for Kraken's SeaVision® 3D laser scanner. SeaVision® was initially pre-qualified under the Canadian government's Build in Canada Innovation Program (BCIP). Effective April 1, 2019, BCIP became the Innovative Solutions Canada—Testing Stream (ISC-TS), delivered by Innovation, Science & Economic Development's Innovation Canada Sector. Kraken expects to deliver SeaVision® to its test partner, Parks Canada Underwater Archaeology Team (UAT) during Q3 2020. Parks Canada and Kraken plan to conduct at-sea testing and evaluation of the SeaVision® system at a variety of archaeologically significant sites including the HMS Erebus and HMS Terror at the National Historic Site of Canada, Nunavut. Kraken was previously involved in Parks Canada's discovery of the HMS Erebus during the Franklin Expedition in Summer 2014.

About SeaVision®

SeaVision® is an underwater 3D laser imaging system designed to be fitted to remotely operated and autonomous underwater vehicles. The system delivers real-time, full color 3D point cloud images of subsea infrastructure with millimeter accuracy. These datasets create highly detailed models for 3D visualization to support complex machine learning and artificial intelligence algorithms used for analytics. SeaVision® simplifies creating dynamic digital models of subsea physical assets and systems. This helps build and operate digital twin applications to gain knowledge and insights about performance of future operations.

Karl Kenny, Kraken President & CEO said, "In subsea inspection applications such as offshore wind, subsea oil and gas and underwater archaeology, we believe that a self-contained, motion-corrected 3D laser scanner on a small powerful ROV offers a significant competitive advantage to what currently is available on the market. It is also a significant quality improvement to purely optical inspection. Existing underwater laser products require



a combination of a high-grade navigation payload for motion correction and require a larger stable ROV. Other market solutions for subsea 3D asset reconstruction are based on photogrammetry and inherently have less precision and range than Kraken's SeaVision® 3D laser system. We are confident that SeaVision® offers a superior price and performance value proposition."

About Parks Canada Underwater Archaeology Team (UAT)

Parks Canada's Underwater Archaeology Team (UAT) conducts comprehensive scientific diving and remote-sensing surveys to identify, inventory, evaluate, and interpret submerged cultural resources within the Parks Canada mandate. This includes an expanding system of National Historic Sites, National Parks, National Park Reserves, National Marine Conservation Areas, National Marine Parks, and Heritage Rivers. The UAT is also a recognized Federal Authority for the evaluation of submerged cultural resources under the provisions of the Canadian Environmental Assessment Act. As such, the UAT is called upon to conduct archaeological site investigations throughout Canada in both marine and fresh-water environments (including the Pacific, Atlantic, and Arctic Oceans, as well as the Great Lakes).

The detailed documentation and analysis of submerged archaeological structures such as wharves, cribs, fish weirs, and shipwrecks is the main operational focus of the UAT. In the course of its archaeological survey operations across Canada, the UAT has increasingly enlisted 3D imaging technologies to locate and document complex cultural features and to situate these features in a precise geo-referenced bathymetric context.

For more information, visit

[HTTPS://KRAKENROBOTICS.COM/PRODUCTS/SEAVISION](https://KRAKENROBOTICS.COM/PRODUCTS/SEAVISION)

TERRASOND AWARDED HYDROGRAPHIC SURVEY CONTRACT FROM NOAA

TerraSond, an Acteon company, has been awarded a five-year IDIQ contract by the Hydrographic Surveys Division of NOAA's National Ocean Service, Office of Coast Survey, to provide hydrographic surveying services. The new contract was effective January 1, 2020 with a maximum value of \$250 million over 5 years, subject to

appropriation by Congress. Under previous contracts with NOAA, TerraSond has surveyed more than 7,120 square nautical miles of U.S. waters in Alaska and the Gulf of Mexico since 1998, providing data for use in creating and maintaining nautical charts. During this period, it carried out task orders for NOAA in every year with a total value of about \$90 million; almost 200 individual survey areas have been completed to date during 28 separate projects in Alaska and the Gulf of Mexico.



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JFD HAVING A BUSY FIRST QUARTER

Acquires Ansti Test Systems

JFD, a world leading underwater capability provider serving the commercial and defense diving markets and part of James Fisher and Sons plc has announced the acquisition of the business, including all intellectual property rights and assets, of Ansti Test Systems Ltd, an independent global designer and manufacturer of test facilities for performance measurement of underwater breathing apparatus. The acquisition, which significantly enhances JFD's global product testing capabilities and services, is part of the company's long-term ambition to provide underwater diving equipment with unparalleled safety and performance, protecting and preserving life in the harshest marine environments to define the limits of product performance under a variety of conditions.

Ansti Test Systems provides turnkey packages which utilize computerized data acquisition techniques to display the performance of breathing apparatus under test, in real time. The systems can be configured to meet bespoke requirements for any diving equipment and life support systems, ensuring a wide range of equipment can be tested to a varied selection of British, European and Worldwide standards and

regulations. All services are delivered in the strictest confidence. As part of the acquisition both Ian Himmens and Stan Ellis, the co-founders of Ansti Test Systems Ltd, will work with JFD on a consultancy basis to assist during the transition period and beyond.

Giovanni Corbetta, Managing Director, JFD, said, "Ansti Test Systems comes with a strong track record in underwater diving testing including a global client base spanning over 60 organizations, more than 5,000 regulator tests for SCUBA manufacturers worldwide, and technical consultancy for various diving related projects. This extensive experience complements JFD's existing subsea support operations and will provide a significant contribution to our long-term ambition of protecting and preserving lives in the commercial and defense industries."

Named as Finalist for Offshore Achievement Awards

JFD has also been named as a finalist in the Health, Safety and Environmental (HSE) Innovation category for the Offshore Achievement Awards 2020. The shortlisting showcases JFD's commitment to providing safe and effective capabilities for divers working in the world's most

challenging underwater environments, demonstrated in the COBRA (Compact Bailout Rebreathing Apparatus) set.

The Offshore Achievement Awards encourage innovation and collaboration in the oil and gas and renewables industry in the North Sea. The winner of the HSE Innovation Award will be selected based on several factors, including how the technology supports business, industry health, safety or sustainability and creates new business opportunities as a result.

Until now, the industry standard for the provision of emergency breathing gas has been limited to just a few minutes through use of conventional bailout cylinders. As a direct response to the urgent need to drive significant improvements in safety standards, JFD developed the COBRA rebreather set, which provides an advanced emergency bailout provision. This greatly extends the supply of emergency breathing gas, providing a supply of up to 33 minutes at a depth of 120 meters, compared with approximately 7.5 minutes on conventional bailout at the same depth.

For more information, visit
WWW.JFDGLOBAL.COM

UNIQUE GROUP INVESTS IN INDIAN DIVING AND LIFE SUPPORT FACILITY

A multi-million-rupee investment to enhance its Diving and Life Support division in western India will see Unique Group company Unique Hydra strengthen its infrastructure and increase customer accessibility in the region.

The 10,000 sq. ft facility in Vadodara, Gujarat, will offer assembly and manufacturing services along with a dedicated engineering and design team to support customers' diving requirements. The state-of-the art manufacturing facility will be equipped to manufacture integrated saturation and air diving solutions, HBOT systems, diver launch and recovery systems (LARS), and decompression chambers, as well as containerized air and mixed gas diving systems. Complying with international standards including IMCA, Lloyds Register, ABS and DNV, the facility will also manufacture Unique Group's Oceanwide S.a.S brand of Self-Propelled Hyperbaric Lifeboats (SPHL), bringing the Group's global expertise to the Indian marketplace.

The new and upgraded facility in Gujarat is a valuable addition to the Group's "Make in India" initiatives and will provide a base from which to support contractors and the Indian defense sector's diving equipment and support needs. Products and



» Saturation dive system, produced by Unique Group.

services from Unique Group's partner companies, Kirby Morgan and Cortland Fibron, will also be delivered from the new location with a dedicated service team to provide after sales support to clients.

Dr. Sharad Kumar, Director of Sales at Unique Hydra (India) said: "Unique Group has established a strong presence in India across our various divisions: survey equipment, on-site engineering, marine and subsea and buoyancy and ballast. Through this new facility in Gujarat, we aim to service our strong customer base while also empowering the local economy and workforce. We have already received an order for a mini-saturation diving system from a reputable client in India, which is an excellent start to 2020."

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HYDRONIQ'S COOLERS FOR NEXANS SUBSEA CABLE INSTALLATION VESSEL



» The CLV Nexans Aurora. Illustration Skipsteknisk

Norwegian shipyard Ulstein Verft has contracted Hydroniq Coolers to deliver the seawater cooling system to a cable lay vessel it is constructing for Nexans Subsea Operations.

The CLV Nexans Aurora will play a vital role in installation of Nexans' HV submarine cables that will connect offshore wind farms to the grid, supporting electrification of offshore petroleum installations and creating interconnectors between countries.

Under the contract, Aalesund-based Hydroniq Coolers will supply its Pleat seawater cooling system for the CLV Nexans Aurora. The Pleat coolers will provide cooling of the vessel's main engine and auxiliary systems through the use of seawater. Hydroniq Coolers has not disclosed the value of the contract. The patented Pleat is a module-based titanium cooler for seawater to freshwater, with

design pressure 6 bars and design temperature of 0-95°C.

"Users of the Pleat benefits from long service intervals, which is an advantage for vessels that operate offshore for long periods at a time. Further, one crew member can easily maintain and clean the Pleat within one hour, because compared to a traditional heat exchangers one Pleat cooling element is equal to approximately 15 plates," says Hans Robert Almestad, vice president of sales and marketing at Hydroniq Coolers.

Marine cooling systems are utilized to reduce temperatures in the ship's engines and other auxiliary systems through use of seawater to avoid overheating of the engine and other critical systems. Hydroniq Coolers will manufacture and assemble the Pleat cooler at its headquarters in Aalesund, Norway, and deliver it to Ulstein Verft in Ulsteinvik, Norway.

For more information, visit
WWW.HYDRONIQ.COM

CLV Nexans Aurora is a DP3 cable laying vessel that will be outfitted for power cable laying, including bundle laying, cable jointing and repair and cable system protection and trenching. The vessel is developed for operations in rough weather and has high manoeuvrability and station keeping capabilities.

The advanced cable laying vessel has a turntable with a large cable capacity of 10,000 tons, and the fibre optic basket holds 450 tons. The vessel is 31 m wide, 149.9 m long, with a deadweight of 17,000 tons, and she can accommodate 90 people. The vessel is scheduled for delivery in 2021.

"This is an impressive cable layer which will support both energy interconnections worldwide, as well as offshore wind. We are proud to be chosen as supplier to CLV Nexans Aurora," says Hans Robert Almestad.

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SUBSEA CABLES: THE MISSING LINK IN THE US OFFSHORE WIND SUPPLY CHAIN?

EXECUTIVES GATHER IN HOUSTON TO DISCUSS THE CRITICAL ROLE OF SUBSEA POWER CABLES

By Ed Freeman, ON&T Features Writer

Houston Aquarium was the venue for *Subsea Cables: A Critical Connection*, a one-day workshop hosted by the Business Network for Offshore Wind (Network) and SubCableWorld (SCW) on January 23, 2020. Over 120 delegates participated in a program of technical presentations and panel discussions about the critical role of subsea power cables regarding the prospects of the U.S. offshore wind sector.

The agenda was organized into three sections: lessons from the past, challenges of the present, and prospects for the future. Shortly after Network CEO Liz Burdock's opening remarks, proceedings kicked off with a word of caution from the world of insurance, and the growing need for developers to mitigate against unforeseen capital expenditure and risk exposure.

REDUCING RISK

The audience was reminded of the haunting statistic that over 80% of project insurance claims are attributed to array or export cable problems. Learning from these issues is,

therefore, a priority for the entire supply chain and not just the subsea cable sector. Another concern was the seeming overreliance on traditional cable laying methods—a technique that has barely changed over the last 100 years—for such a specific type of cable, laid in such potentially volatile environments. In short, we must incorporate a "fit for purpose" approach to the design, manufacture, and installation of subsea power cables to cap the cost of renewable energy and safeguard networks against failure.

STAGGERING NUMBERS

John Manock, editor of SubCableWorld.com, ushered us into the present with an overview of an exclusive demand forecast for wind power cables over the coming decade. The numbers are staggering. His report outlines three possible scenarios, the most aggressive of which suggests that procurement pledges will require nearly 14,000 km of new cable.

This volume of demand poses pressing questions for cable manufacturers, like Nexans, one of the event's headline

sponsors. There are still no manufacturing plants in the U.S. and while two plants are in the process of being modified to produce offshore wind cable, capacity is limited and clearly remains an issue. The panel discussion that followed explored some of the other expected challenges, but most hinged on the need for cable design and delivery to be a front-end consideration of any project scope.

A SUSTAINABLE VISION

Setting sights on the future, cable innovation was a consistent theme. A rally cry to develop a self-sufficient industry—not just meet spiraling demand—and look beyond the horizon of 10GW emerged. That shared sense of responsibility became evermore palpable as the afternoon progressed; this is our opportunity to build a prosperous and sustainable industry that seeks to decarbonize the 21st century and create U.S. jobs. It is worth noting, in fact, that cable laying vessels are not restricted by the Jones Act, a federal decree that goods shipped between U.S. ports may only be transported by ships built, owned, and operated by U.S. citizens or permanent residents. Suffice to say, we are not required to employ Americans in the construction of U.S. wind farms. However, our mission goes beyond infrastructure; our goal is to build a U.S. industry that establishes legacy and delivers opportunity in equal measure.

COOPERATION IS KEY

These broader societal considerations naturally led to discussions about how to educate and engage wider public, and more specifically how to navigate public policy, dilute community concerns about shore crossings, and engage high-school kids as the pioneers of tomorrow. Shore landings are often more a matter of political motivation than technical concern and that's why policy makers need to look beyond projects in isolation, and instead address the challenges of wind farm interconnectivity on both U.S. coasts.

Grid integration, both in terms of the various technologies and models deployed, must further consider the prospects for deep-sea wind generation, floating turbines, and high-power cables. Again, cable innovation—including the next generation of dynamic cables—will prove critical, but more than this, these questions will require ongoing collaboration between stakeholders: between developers and cable manufacturers; between policy makers and local communities; between the energy companies themselves.

And perhaps that was the key takeaway of the day: cooperation will be fundamental in defining the next phase of market development. As Europe sets course for 450GW by 2050, there is much to be done and to that

end, events like *Subsea Cables: A Critical Connection* will prove instrumental.

The Network and SCW will continue the critical connection dialogue at the International Partnering Offshore Wind Forum (IPF), April 22-24. A series of workshops on this important topic will be held.



» Executives meet in Houston to discuss the critical role of subsea cables to the US offshore wind industry.

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THE U.S. NAVY WANTS TO PUT ITS HEAD IN THE CLOUD

By Christian H. Heller
via the Center for International Maritime Security (CIMSEC)

The Navy is pushing toward an IT future based on cloud computing that promises enormous benefits and can set the foundation for a future force shaped by emerging technologies. The incremental adoption of cloud services by the Department of the Navy (DON), other services, and private industry already holds much promise, but the stakes are high. Getting the cloud migration right can underpin revolutionary developments like artificial intelligence and give the Navy the advantage it needs for the coming decades.

Benefits of the Cloud

The Navy demands extensive requirements from its cloud adoption. The naval services conduct a vast array of missions in diverse global environments. Naval platforms gather information from dozens of sensors and communications systems at any given second. Command and control networks facilitate effective fleet management

and direction. The Navy can disperse its needs between organic cloud networks onboard deployed ships which then forward information to larger shore-based clouds whenever bandwidth and operations allow.

For a scale comparison, the Navy collects new data equivalent to the Library of Congress—approximately 200 terabytes—every day. This number is increasing faster every year, and any cloud system must be able to accommodate the variety and velocity of this data collection.

A major benefit of cloud computing for the Navy is the ability to combine disjointed information systems spread amongst various units. The integration of these networks in the cloud is necessary for the DON to harness the benefits of big data and machine learning. In effect, the transition to the cloud is the first step of many in the DON's transition to the future of warfare and technology.

This cloud infrastructure must not only be widely implemented, but optimized for data processing and proper use.

Cloud computing can allow departments to do more with less by supporting greater speed for administrative and technological processes (such as audits and inventories), all the while occupying fewer personnel. It also facilitates quicker access to and reconciliation of data between distant units which supports expeditionary operations and better coordination. These more efficient information transfers will increase commanders' situational awareness both locally among squadrons or distantly between fleets.

Other militaries have already had success migrating to the cloud. The United Kingdom has implemented a "cloud-first approach" which mandates that all purchases of IT products and services must first be considered through the cloud. Private firms helped

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the Australian Department of Defense move various systems to the cloud, including its non-material procurement, material procurement, and other acquisition programs. This process involved linking 13 different, non-interacting systems into a transparent and interlinked procurement program accessible by all users.

Amazon Web Service (AWS), one of the largest cloud service providers in the U.S., already supports other government entities, such as the intelligence community. The CIA spent \$600 million migrating to the cloud in what former Principal Deputy Director of National Intelligence Sue Gordon called, "one of the best decisions we made." AWS created its own "secret region" to support government needs across the full range of classifications, an offering which the Navy also would require. U.S. Air Force Special Operations Command saved \$3.5 million in 2019 by transitioning to the cloud. Additionally, the National Oceanographic and Atmospheric Administration (NOAA) provides an example of how the Navy can benefit from cloud-based weather systems for more accurate research and forecasts.

The government has laid out four critical requirements that cloud services must meet to support operational units. Any cloud system must support all classification levels, must have a global

reach, must be synced and interoperable with other government cloud initiatives, and, most importantly, must support the future needs of artificial intelligence and machine learning programs. The current steps by the Navy meet these requirements and promise substantial return on investment.

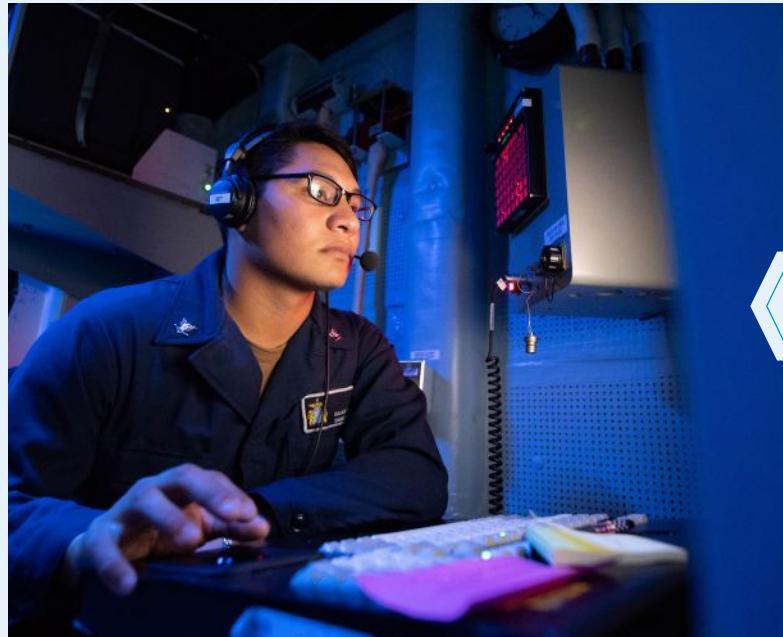
Current Steps Forward by the Navy

The DON has pursued cloud computing services over the past decade. Its Chief Information Officer (CIO) issued guidance in 2015 on the acquisition of commercial cloud services for the Navy's various branches and commands. Some units like the Space and Naval Warfare Systems Center (SSC) Atlantic embraced the cloud and have pushed forward under Department of Defense (DoD) instruction to accelerate cloud migration. Its pilot programs involved multiple major cloud service providers like Microsoft and Amazon.

Last year the Navy awarded \$100 million for commercial cloud service contracts as a preliminary step towards future cloud adoption. Earlier last summer, the Navy completed its largest cloud migration to date. The DON migrated its Enterprise Resource Program (ERP), its financial system of record, this past August in one of the largest cloud transitions in North American history. The program, which tracks over \$70 billion annually and maintains half of the



» Information Systems Technician 2nd Class Jeffrey Bennett, left, and Information Systems Technician 2nd Class Joseph Camino observe the proper configuration of a high-frequency radio aboard the amphibious command ship USS Mount Whitney (LCC/JCC 20). Photo credit: Mass Communication Specialist 2nd Class Felicito Rustique Jr., U.S. Navy.



» Operations Specialist 3rd Class Isaiah Daniels conducts Tomahawk Exercise procedures inside the Command Information Center aboard the Arleigh Burke-class destroyer USS Thomas Hudner (DDG 116) as part of a joint force exercise. Photo credit: Mass Communication Specialist 3rd Class Marianne Guemo, U.S. Navy.

DON's financial and logistics dealings and involves 72,000 users, took ten months to complete and paved the way for future large-scale naval IT conversions.

The Navy also operates one of DoD's only two cloud computing access points to transfer high-impact unclassified data to and from the commercial cloud, a bottleneck which the Defense Innovation Unit seeks to overcome.

An early cloud transition for logistics programs makes sense as a proven method for quick benefits. The Defense Logistics Agency (DLA) upgraded its educational systems to the cloud as an early test of large-scale cloud-hosting for sensitive information. U.S. Army Logistics Activity (LOGSA), which manages 40 million different data points daily, transitioned to the cloud to implement better analytics tracking cost-saving benefits. Data-driven maintenance is an additional area where the Navy stands to benefit in the near-term from moving to cloud-based management systems. The DON also employed an early cloud transition for its Fleet and Family Readiness Division. The Navy's GovCloud system only maintained unclassified information but demonstrated the benefits of a cloud enterprise through its maintenance of 95 websites, 10 regional content management systems, and 113 mobile phone applications, delivering more than six terabytes of data every month.

Another major goal for the Navy's cloud evolution is to establish a digital environment for rapid software development, testing, and implementation. This "Cloud-to-Edge" (CTE) environment could be employed on either individual ships or entire strike groups and allow the navy to adapt more rapidly

to changing environments. One key component of the CTE was successfully tested last year with the AEGIS system on the USS Arleigh Burke, USS Ralph Jonson, and USS Thomas Hudner which developed and deployed software updates within 24 hours.

Bureaucracy Gets a Vote

Bureaucratic decision-making has already played a major role in the Navy's cloud transition and will likely lead to additional changes in the future. In 2015, the Navy decided to consolidate cloud-leadership within its Program Executive Office for Enterprise Information Systems (PEO-EI). Two years later, it divided that authority between eight functional community commands. The DON intends to pursue its primary cloud enterprise contract for 95 percent of the naval services' needs. These eight other commands—including Navy Installations Command and Military Sealift Command—will be allowed to establish individual cloud networks for mission-specific needs and will oversee their units' transitions and readiness for the cloud implementation. The preparation of commands and systems to migrate to the cloud will be vital in facilitating the DON's goal of a total cloud migration by 2021.

Overlapping strategic guidance will require deft navigation by DON leaders. DOD officials issued strategic guidance in February 2019 to provide some cohesion and direction to the various cloud processes currently underway amongst the services. The Director of Naval Intelligence (DNI) issued its own Cloud Computing Strategy which, if naval intelligence units are to utilize the full assets of the intelligence community, the DON will need to adopt (at least on a select basis).

The DOD and the services have knocked heads over cloud implementation throughout this period of change. Despite the DOD's push for an overarching, large-scale cloud under the JEDI program, individual services and departments will continue operating their multiple clouds already in place. In total, DOD already spends more than half a billion dollars on cloud technology every year, and the department will continue working on new ways to integrate service-specific clouds with DOD enterprise clouds.

Inspector General investigations and reviews by the Secretary of Defense will also likely alter the path forward for the Navy's cloud adoption in the coming years. In October, DOD announced it awarded the JEDI contract to Microsoft. The contract has a potential period of 10 years and the total payments could range from \$1 million to \$10 billion. A single-source contract with such potential has sparked significant backlash from other competitors. Oracle is suing the federal government for a third time. Amazon announced a challenge soon after. The impact upon the Navy from such developments is unclear for now, though they will certainly affect cloud developments over the coming years.

Conclusion

The current transition is only the latest example of the difficulties faced by the DON as it adopts major projects for the next era of warfare. Similar challenges accompany every major change in naval technology. Future administrative battles over artificial intelligence, unmanned vehicles, and advanced weapons like hypersonic missiles will inevitably ensue, but the cloud will be the link which enables their effective application. The Navy cannot afford to get it wrong.

About the Author: Christian Heller is a graduate of the U.S. Naval Academy and the University of Oxford. He currently works as an officer in the U.S. Marine Corps, and can be followed on Twitter @hellerch.

Editor's Note: The above article was edited for length. Ocean News & Technology is partnering with the Center for International Maritime Security (CIMSEC) to increase awareness of defense technology topics. ON&T reprints this article, which first appeared on the CIMSEC website, with permission. CIMSEC is a 501(c)3 non-partisan think tank with over 800 members in more than 30 countries. CIMSEC does not take organizational positions and encourages a diversity of views in the belief that a broad range of perspectives strengthens our understanding of the challenges and opportunities in the maritime domain.



» Utilitiesman 2nd Class Robert Erlich, from Glenview, Illinois, attached to Underwater Construction Team (UCT) 1, Construction Dive Detachment Charlie (CDDC), processes sonar data while UCT is conducting surveys in Lisbon, Portugal, Oct. 15, 2019. Photo credit: Mass Communication Specialist 3rd Class Colbey, U.S. Navy.

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NORWEGIAN AUTONOMOUS-SHIP PROJECT RECEIVES NOK 200 MILLION IN EU FUNDING



» *Eidsvaag Pioneer, which will be equipped for remote-operated and autonomous maritime transport.*

Kongsberg Group (Kongsberg) is going to install and test autonomous technology on two vessels in different operational environments. This project is receiving funding of almost NOK 200 million (Euro 20.1 million)—one of the largest grants ever given to Norwegian players—from Horizon 2020, an EU research program. Kongsberg announced the news on January 21, 2020.

"The Norwegian maritime cluster, of which Kongsberg is a part, is the world leader in autonomous shipping. Now we are further strengthening our position through the AUTOSHIP project, which will accelerate the realization of next-generation autonomous ships and create a roadmap for commercializing autonomous shipping in the EU in the next five years," says Egil Haugsdal, CEO of Kongsberg Maritime.

AUTOSHIP, a four-year Horizon 2020 project, is a collaboration between Kongsberg and Norway's leading research organization, SINTEF, as well as several European partners. The Research Council of Norway is also providing support.

Two autonomous vessels will be demonstrated for use, especially in short sea coastal shipping and Europe's inland waterways.

"The AUTOSHIP project gives Northern Europe, with Norway, a leading edge in developing the next generation of autonomous vessels. The race is underway internationally. The technology contributes to safer, more efficient and sustainable operations at sea, both in transport and aquaculture. The project will now receive one of the largest allocations ever made from the EU's Horizon 2020 program to a Norwegian player. This is a NOK 200 million mark of quality," said Iselin Nybø, Norway's Minister of Research and Higher Education.

Maritime Growth Market

The *Eidsvaag Pioneer* is one of the two vessels that will now be equipped for remote-operated and autonomous maritime transport. This ship is owned by the Eidsvaag shipping company and operates along the Norwegian coast and in vulnerable fjord areas where it carries fish feed to fish-farms. The markets for both short sea coastal shipping and transport on inland waterways are expected to expand in the next few years, both in Norway, Europe, and worldwide.

"We will demonstrate that it is possible to remotely operate several ships from land and over large geographical areas. The

technology is used in different ways on the vessel to show that the solutions can be applied widely. This is a market with a significant potential," says Haugsdal.

The aim of the project is to test and further develop key technology linked to fully autonomous navigation systems, intelligent machinery systems, self-diagnostics, prognostics and operation scheduling, as well as communication technology enabling a prominent level of cyber security and integrating the vessels into upgraded e-infrastructure.

Takes 7,500 trucks off the roads

The other vessel to be equipped with autonomous technology is a Belgian pallet shuttle barge owned by Blue Line Logistics NV. This operates on canals, transporting goods to and from large container ports. Europe's inland waterways can achieve major environmental gains by using new technology. An autonomous barge in operation is expected to take around 7,500 trucks off the roads each year and will result in reductions in both traffic congestion and emissions.

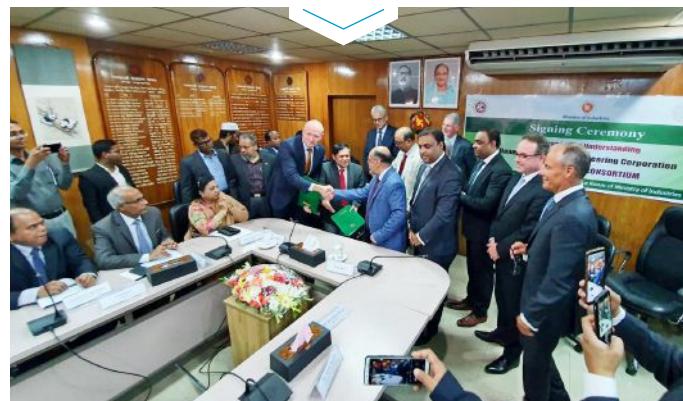
DAMEN SIGNS MoU FOR DEVELOPMENT OF BANGLADESH SHIPBUILDING INITIATIVE

On January 14, 2020, Gentium and Damen Shipyards Group signed a memorandum of understanding (MoU) with the Ministry of Industry of Bangladesh in Dhaka. Also present at the signing ceremony were representatives of the Netherlands Embassy in Bangladesh, who are supporting Gentium-Damen in their undertaking.

The goal of the MoU is to establish and develop a shipbuilding and ship repair industry in the Bangladesh. The aim is to build ships in Bangladesh, for Bangladesh, with a long-term view of serving export markets. The partners in the MoU will undertake a number of tasks in this direction. First amongst these will be the establishment of a shipbuilding and repair facility built to globally recognized environmental and building standards. The standard of the facility will be sufficient for the construction and delivery of seagoing vessels able to compete in the global marketplace.

As part of their role in the MoU, Gentium-Damen will facilitate a transfer of technology and knowledge to help Bangladeshi personnel develop the skills required to serve the international maritime industry. As a result of this, the MoU will create training and employment opportunities within Bangladesh.

Area Director Asia Pacific of Damen Shipyards Group, Roland Briene, who signed the MoU on behalf of Damen, said, "It is our philosophy and practice to help develop the shipbuilding and maritime industries in the countries in which we operate. This includes investing in the establishment of high-quality facilities and equipment and the training of local personnel. Time and again we have witnessed this leading to the establishment of sustainable shipbuilding initiatives able to serve the global marketplace. We are very much looking forward to applying our experience, along with our partners Gentium and the Ministry of Industry, here in Bangladesh."



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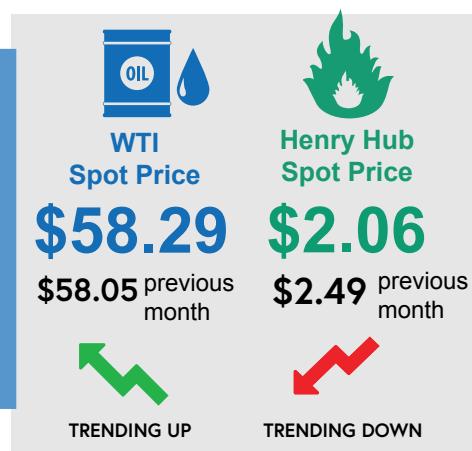
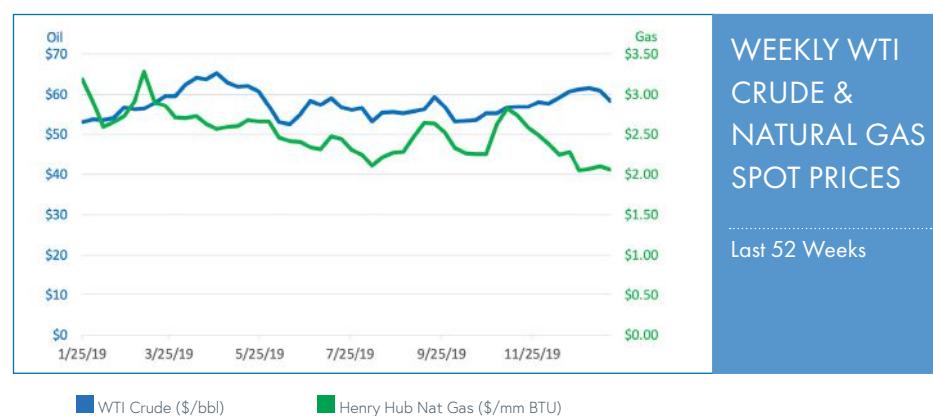
CRUDE & NATURAL GAS Spot Prices

PRICES IN US DOLLARS AS OF JANUARY 17, 2019

Oil prices spiked past the \$60 per barrel mark in the past month, before settling back at \$58.29 per barrel on the WTI Spot Prices in mid-January. Prior to January, oil prices were on a generally upward trend since the beginning of October, moving from approximately the \$53.00 mark and peaking at \$63.27 on January 6 with announcements of OPEC production cuts and Persian Gulf tensions. As tensions eased, the market responded to rising crude production in the United States, South America and the North

Sea, driving prices down once again, according to the Houston Chronicle.

The Henry Hub natural gas spot price have been plummeting since November, dipping briefly below the \$2.00 per million British thermal units mark before closing at \$2.06 on January 17. An unusually warm winter in the United States and oversupply in the U.S., Europe and Asia are providing significant downward pressure on prices.



KEY EQUITY Indexes

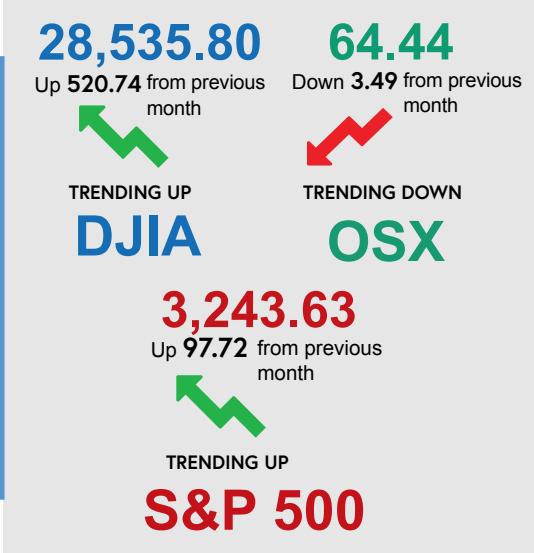
PRICES IN US DOLLARS AS OF JANUARY 27, 2019

EQUITY INDEXES CONTINUED to show volatility in the past month

Equity indexes in the past month continued their upward march into record territory before dipping back a bit by the end of January. The Dow Jones Industrial Average (DJIA) closed at 28,535.80 points on January 27, which is just slightly above the 28,551.53-point mark that it stood at on December 17. In the interim, however, the DJIA passed the 29,000-point mark for the first time in history, closing on January 13 at 29,348.10 points. The recent drop was attributed by CNBC, CNN and other sources to fears of the coronavirus. The S&P 500 saw a similar trend, peaking at over 3,300 points, again a new record, in the second week of January before dropping to levels near those of a month earlier on coronavirus fears.

The Philadelphia Oil Services Index (OSX) suffered significant losses in the past month, closing in the mid-60s by the end of January. The OSX had been showing some strength, pushing past the 80-point mark in early January, but saw a downturn late in the month, again attributed to fears about the coronavirus.

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BEGINNING A NEW DECADE WITH INCREASED COMMODITY UNCERTAINTY

BY G. ALLEN BROOKS | Author, *Musings From the Oil Patch* | www.energymusings.com

Crude Oil:

Too much oil. Not enough oil. Peak oil demand on the horizon. Oil will be needed for decades. Climate change will destroy the industry. The oil industry is the best equipped to solve our carbon emissions challenge. Are you confused about the outlook for the oil market, and, in turn, oil prices? You are not alone. All one needs do is watch the daily price volatility of oil futures trading on the NYMEX to appreciate how unsettled the view is about the commodity's future. But is that the real story of where oil prices are likely headed during 2020 and for the balance of the decade? We doubt it.

It is fascinating to watch the daily oil price moves and listen to the commentary of commodity traders about what is making prices move up or down on any particular day. The reality is that most people in the industry, and most buyers of oil, are more concerned about the trend in prices and what that might mean for their pocketbooks. If you are a producer, you'd love to know what oil prices might be in three-, six- or twelve-months' time. You then could decide to hedge based on the current pricing structure if you thought future prices would be lower. Just the reverse would be true if you expected prices to rise down the road.

Few consumers buy oil. They buy refined oil products—gasoline, diesel and home heating oil. While crude oil is the core cost component of the retail price, what it costs to transport and refine the oil into products, how much it costs to transport it to market, and finally, how much the refiner and distributor make, are all important components in setting the price for gasoline or diesel at the pump, or heating oil at the rack. We seldom think about all those other costs as we watch oil prices fluctuating. Up or down is either bad or good.

For the past three months, WTI futures have traded between \$54 and \$63 per barrel. The highs and lows have been influenced by the uncertainty surrounding all the questions above, as well as geopolitical events such as the Iranian attack on Saudi's oil facilities and the killing of the top Iranian terrorist general. In each of the latter cases, oil prices spiked since either 5 million barrels of supply was being removed from the market (shortage) for an undetermined time, or the Middle East was on the precipice of war. No shortage developed, nor did a war break out—at least not yet.

For the foreseeable future, oil prices will likely continue to trade in a range of \$55 to \$65 a barrel. The world has plenty of oil—not all of it readily accessible, but most is available with time. Barring an economic collapse sapping demand, there is little on the horizon to move oil prices dramatically beyond the extremes of our range. For the industry, and consumers, determining what oil will sell for five years from now may be more important, as that will provide insight as to how our economy and society may be shaped. Futures prices provide only a clue, but not a lot of wisdom. As you watch the news, and especially technology trends and geopolitics, keep the question of oil's price in 2025 in the back of your mind.

Natural Gas:

Natural gas prices have fallen below \$2 per thousand cubic feet—a low last seen in 2016. Did they call off winter? That's what gas traders and producers are wondering. Through the first 22 days of January, average temperatures in the United States are about 40 F warmer than the 10-year average and 30 F above last year's temperatures. Although gas production is below the pre-winter high due to well freeze-offs and LNG exports are climbing toward 9 billion cubic feet per day, the lack of traditional winter heating demand

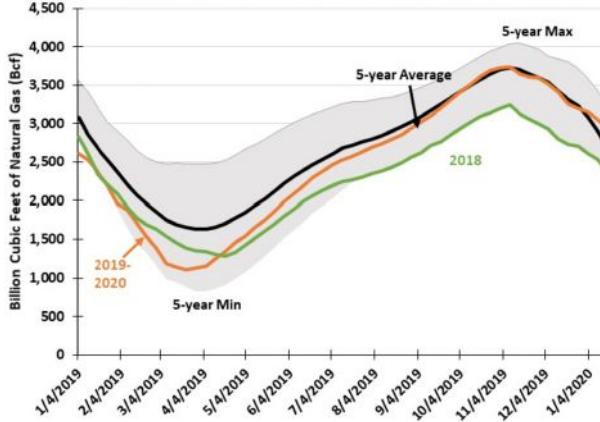
is boosting seasonal storage and pushing down gas prices.

Estimates are that gas production is 3-4 bcf/d below the pre-winter output of 96-97 bcf/d, which would normally be pushing gas prices up, or at least supporting them at levels above \$2/Mcf. Unless winter heating demand returns—and quickly—this winter will see the industry jamming lots of gas into storage or seeking other markets for sales.

As gas supply starts rebounding in the March timeframe, there is greater regulatory pressure on producers to stop flaring surplus gas. The lack of pipeline takeaway capacity from the Permian, our largest source of gas flaring, is being remedied, so as the gas gathering infrastructure increases, more gas supply will be seeking commercial markets. Expectations are that reduced oil well drilling in the Permian this year will slow the growth in associated natural gas output, but an often-overlooked consideration is that older fracked oil wells tend to become gassier in their output.

While gas prices are not likely to rebound materially this year, at least until we see if the summer will bring record hot temperatures, low gas prices will help U.S. LNG exporters compete for global markets. What we are learning is that the U.S. is well supplied with natural gas, something that will be good for consumer electricity and heating bills, petrochemical profit margins, and the health of our growing LNG industry. The risk we run is that we extrapolate our gas production growth and plan on new consuming facilities just as the capital discipline mantra impact producers and weak well economics cause a drilling slowdown. It wouldn't be the first time the gas industry found itself with "white elephant" projects.

Low Prices and High Output Rebuilt Gas Storage



2016 Was Last Time Gas Prices Below \$2/Mcf



Geopolitical Tensions and OPEC+ Production Cut Supporting





AMERICAS

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Cartagena de Indias, Colombia
» March 24-26
www.defenceiq.com/events-cabsec

Decommissioning & Abandonment Summit

Houston, TX » March 31 – April 1
www.decomworld.com/gom

MTS Buoy Workshop

Wilmington, NC » April 13-16
buoytech.mtsociety.org

IPF

Providence, RI » April 21-24
www.offshorewindus.org/2020ipf

Mari-Tech

Halifax, Nova Scotia » April 28-30
www.mari-techconference.ca

AUVSI XPOENTIAL

Boston, MA » May 4-7
www.xponential.org/xponential2020

OTC

Houston, TX » May 4-7
2020.otcnet.org

Int'l Conference on Ocean Energy

Washington D.C. » May 19-21
www.icoe-conference.com

H2O Conference

Halifax, Nova Scotia » June 15-17
www.h2oconference.ca

Int'l Conference on Ocean, Offshore, & Arctic Engineering (OMAE)

Ft. Lauderdale, FL » June 28 – July 3
event.asme.org/OMAE

EUROPE

Undersea Defense & Security

Southampton, UK » March 3-5
www.defenceleaders.com/home/events-page/underwater-defence-security

Seabed Mapping and Survey

Geilo, Norway » March 4-6
www.tekna.no/en/events/seabed-mapping-and-survey-38497/

Oceanology International

London, UK » March 17-19
www.oceanologyinternational.com

Eastern Mediterranean Offshore

Cyprus » April 7-9
www.emc-cyprus.com

Offshore Wind Decommissioning Summit

Rotterdam, The Netherlands
» April 21
energy.knect365.com/offshore-wind-decommissioning

MCE Deepwater Development

London, UK » April 21-23
www.mcedd.com

All-Energy

Glasgow, UK » May 13-14
www.all-energy.co.uk

Deep Sea Mining Summit

London, UK » May 13-14
www.deepsea-mining-summit.com

UDT

Rotterdam Ahoy, NL » May 26-28
www.udt-global.com

Seanergy

Nantes, Saint-Nazaire, France
» June 9-12
seanergy-forum.com/en/seanergyforum/Seanergy-2020

OTHER REGIONS

Asia Pacific Maritime

Singapore » March 18-20
www.apmaritime.com

OTC Asia

Kuala Lumpur, Malaysia
» March 24-27
www.2020.otcasia.org

OCEANS '20

Singapore » April 6-9
www.singapore20.oceansconference.org

Oceanology Int'l Middle East

Abu Dhabi » September 7-9
www.oceanologyinternationalmiddleeast.com

Telecoms World Middle East

Dubai » September 8-9
www.terrapinn.com/conference/telecoms-world-middle-east

Submarine Networks World

Singapore » September 23-24
www.terrapinn.com/conference/submarine-networks-world

Mediterranean Offshore Conference

Alexandria, Egypt » October 13-15
www.moc-egypt.com

MAST Asia

Tokyo, Japan » November 2-4
www.mastconfex.com/asia2020

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COVE SEEKS NEW CEO

The Centre for Ocean Ventures and Entrepreneurship (COVE) located on the shore of Halifax Harbour seeks a new Chief Executive Officer (CEO).

Located in what was once the Canadian Coast Guard facility on Halifax Harbour, COVE is home to local and global ocean technology businesses, post-secondary institutions, researchers, 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 has more than 60 tenants, has hosted many national and international delegations and thousands of visitors attracted to more than 100 events a year.

COVE's 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. COVE's new leader will welcome the challenge of helping our ocean economy achieve global prominence.

The new CEO will have a deep understanding of the ocean technology sector in Atlantic Canada and its position in the global context. He or she will most likely have a background in science, technology or engineering, will have had senior leadership experience and will think like an entrepreneur.

COVE's new leader will be comfortable dealing with multiple



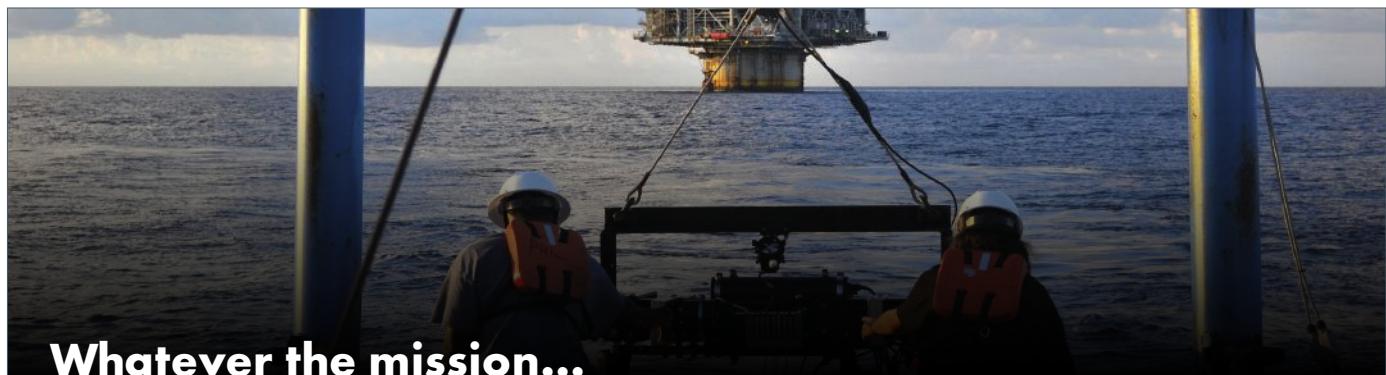
stakeholders from the public, private, and institutional sectors. He or she will be passionate about the ocean sector and its potential to create greater prosperity for Atlantic Canada.

COVE is governed by a private sector board of leaders. The COVE staff is small and nimble.

Interested persons are invited to submit their résumés to CEORecruitment@coveocean.com.

Recognizing that applicants for this role will likely be in senior positions with their current employers, we will treat all applications in strict confidence with only a small group of Board Members and the COVE Controller having access to the applications. We expect to complete the selection process before the end of March 2020.

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CSA NAMES JASON CLERMONT AS PROJECT SCIENTIST

CSA Ocean Sciences Inc. (CSA), a marine environmental consulting firm that specializes in multidisciplinary projects concerning potential impacts of activities in coastal and marine ecosystems, today announced that Mr. Jason Clermont has joined the Team at CSA's Northeast Regional Office, as a Project Scientist. Mr. Clermont will use his wide-ranging experience to support a variety of CSA's global scientific efforts.

"We are very happy to welcome Mr. Clermont to CSA, he brings valuable knowledge and experience to CSA as we continue to develop our initiatives in the Northeast," said Dr. Mark Fonseca, CSA's Vice President–Science.

Mr. Clermont is a fisheries biologist with an extensive background in marine conservation, marine technical operations, collaborative fisheries research, and offshore oceanographic and fisheries surveys. He has considerable experience with all aspects of research project management and execution, including research design and proposal drafting, permit acquisition, procurement and outfitting, equipment maintenance and troubleshooting, budget management, and dissemination of project results.

"I'm eager to apply my knowledge and skills to support CSA's environmental initiatives," stated Mr. Clermont. "The combination of sound science, cutting-edge technology, and rigorous data

analysis employed by CSA is particularly exciting and I'm very much looking forward to being a part of their Team."

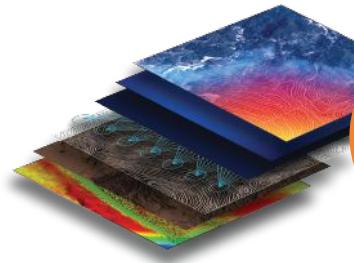
Prior to enrolling in the Biology Master of Science (MS) program at East Carolina University, Mr. Clermont was a Research Associate at Scripps Institution of Oceanography, where he worked in a research laboratory and participated in at-sea oceanographic research cruises. After receiving his MS from East Carolina University, Mr. Clermont helped to support sustainable fisheries initiatives at the New England Aquarium and served as the Technical Science Coordinator at the Sea Education Association. Before joining CSA, Mr. Clermont spent 3 years at the Coonamessett Farm Foundation, where he oversaw collaborative fisheries research projects with commercial fishers and served as the Principal Investigator and Chief Scientist for the Atlantic Sea Scallop Research Set-Aside Habitat Mapping Camera survey.

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Contact: Finn Otto Sanne at finn.otto.sanne@kongsberg.com



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Website: www.csaocean.com
Contact: Gordon Stevens



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Contact: Bruce O'Bannon



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A manufacturer of miniature data loggers with sensors as temperature, depth/pressure, salinity, tilt/acceleration, compass direction/magnetometer, light levels, acoustic receiving/transmitting. The loggers are used for various researches, including oceanography, fishing gear studies, equipment behavioral monitoring and fish tagging.

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SONAR SYSTEMS



ECHOLOGGER

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Echologger represents the best quality sonar products in the market. We are a leading developer/manufacturer of high-end ultracompact echosounders and high resolution scanning sonar that are equipped with state-of-the-art features and essential functionalities to match customers' needs in affordable price.

Founded in 2009 and a company located in South Korea, and with a brand name Echologger, EofE Ultrasonics Ltd. is a knowledge-based company that continuously designs, develops and manufactures high technology sonar devices and solutions to meet the changing needs of the customers. Having been in the industry for years, the company understands how the industry operates and what works best for the benefit of our valued customers.



EDGETECH

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EdgeTech designs, manufactures and sells industry-leading side scan sonars, sub-bottom profilers, bathymetry systems and combined sonar systems. Additionally, the company produces world class underwater actuated and transponding solutions including deep sea acoustic releases, shallow water and long life acoustic releases, transponders, reliable USBL acoustic tracking and positioning systems, and custom-engineered acoustic products.

KLEIN MARINE SYSTEMS, INC.

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Celebrating over 50 years in the marine technology industry, Klein Marine Systems continues to be a world leading sensor technology manufacturer of high-resolution side scan sonar equipment and radar-based security and surveillance systems. Klein Marine Systems has developed a worldwide reputation of excellence in the industry by providing quality products and excellent customer service. Klein sonar systems are deployed by government agencies, navies, port authorities, surveyors, oil companies and universities worldwide. Visit our web site at www.KleinMarineSystems.com and discover how Klein is Making the Oceans Transparent!

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Marine Sonic Technology builds high quality, high resolution side scan sonar systems. Located in Yorktown, Virginia, Marine Sonic has been in business for more than 25 years. Our towed systems are rugged, easy to deploy and simple to operate. We also offer highly efficient AUV/ROV embedded systems, which occupy minimal space and low power consumption.

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KONGSBERG

Kongsberg Maritime is a marine technology company providing innovative solutions for all marine industry sectors including merchant, offshore, subsea, naval and fisheries. The company delivers systems that cover diverse maritime applications. Within subsea, Kongsberg Maritime's sonars, Sub-bottom profilers, multibeam and single beam echo sounders, cameras, positioning and underwater communication & monitoring systems, instruments, software and Marine Robotics are used in survey and inspection operations worldwide. Working closely with customers to develop technology that pushes the limits in subsea applications, Kongsberg Maritime is also dedicated to developing innovative environmental monitoring solutions such as the K-Lander system in addition to cutting-edge Marine Robotic platforms such as the futuristic Elumelle vehicle.

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General Dynamics Mission Systems' Bluefin Robotics products provide undersea capabilities for defense, scientific and maritime customers worldwide. Bluefin Robotics products offer a range of systems and configurations that can operate in the open ocean and in constrained waterways. Our core autonomous product line includes Bluefin SandShark, Bluefin-9, Bluefin-12, and Bluefin-21, Hovering Autonomous Underwater Vehicle (HAUV), and Subsea Power technologies.

The Bluefin Robotics AUV family shares a free-flooded, modular, and open architecture backbone that has enabled the integration of 70+ sensors. We have developed and delivered AUVS worldwide to research institutes and industry and have provided AUVS to the United States' and International Navies.

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We design, research and manufacture SEAMOR ROVs and related accessories. The SEAMOR ROVs are at the forefront of the expansion of marine industries and research, providing safe and cost-effective eyes underwater to help guide industrial activity and monitor the health of underwater ecosystems. Our ROVs are very unique because of their modular design and their wide range of capabilities. Our engineers have developed system components (vehicle, controller, tether and power source) to be interchangeable across our product line; Mako, Chinook, and Steelhead. SEAMOR vehicles are quality machines and are built to last. Our vehicles can be easily upgraded and repaired.

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