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ON THE COVER:

Textron Systems completed an in-water demonstration of its Common Unmanned Surface Vehicle (CUSV®) as part of the U.S. Navy Fleet Forces Command's Trident Warrior 2012 Experiment. The company is developing the fourth-generation of its CUSV, which will be used as part of the U.S. Navy's Unmanned Influence Sweep System program.



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USVS HAVE EVOLVED AMID HEALTHY COMPETITION

BY: PHIL JOHNSTON,
HEAD OF BUSINESS DEVELOPMENT LEAD, AUTONAUT USV

Unmanned Surface Vessels are everywhere in 2019. Anyone wandering around the Ocean Business 2019 conference in Southampton, UK this April would have been overwhelmed by the sheer number of USVs on display, debuted and demonstrated. What's more, USVs now come in all shapes and sizes and they promise a wide range of capabilities.

The general discussion about USVs is dominated by ambitions for fully automated cargo vessels criss-crossing the world's oceans, but the vast majority of USVs are much simpler and, in all likelihood, already operating in a waterway near you. Many of these may still be in the early stages, but an increasing number are finding specific niches—and proving to be commercially viable.

It is no longer enough to simply build a boat that can be sent to sea on its own. USVs cannot now afford to be solutions in search of problems. A USV has to directly address a client's needs, both technically and commercially. More than that, any USV entering the marketplace has to achieve this over-and-above not just a conventional vessel but its USV rivals, not to mention competing alternative technologies that range from sub-sea gliders to moored buoys to satellites.

Of course, this opens up exciting opportunities for marrying complementary technologies, often with a USV as a key hub at sea—and versatility certainly remains important. However, it is increasingly clear that being able to carry a few sensors and do a few things "well enough" simply won't cut it in the longer term.

The most recent USVs to be unveiled have not been mere "robot-boats," they have been tools aimed at addressing a specific problem. That problem may be acquiring oceanographic data, conducting hydrographic surveys, or acting as a communications gateway, just to name a few. Whatever the application, a USV has to complete the mission to the existing expectations for quality of data, as well as standards of safety, and at a significantly reduced cost. If not, conventional methods will prevail. Alternative technologies will emerge or another USV will do it more efficiently.

This competition is healthy. It's a very positive sign that USVs are maturing and, while leading USV players have shared a genuine camaraderie in a "rising tide" market, business strategies are undoubtedly beginning to be tested. The boom is set to continue though and there are many applications and

markets yet to be eked out.

For the end-user, the question is: Which is the right USV for you? Which tool matches your mission? Shop around, because the market is robust and there are now some extremely good options available.



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UNMANNED SURFACE VEHICLES AND THE FUTURE OF THE U.S. NAVY

By Greg Leatherman, ON&T Editor

Due to high-profile engagements of aerial drones in global hotspots like Iraq, Syria, and Afghanistan, it may seem like the U.S. Department of Defense (DoD) is all in on the use of unmanned systems. It's true that the military role of unmanned aircraft systems has expanded in the 21st century. Initially used for intelligence, surveillance, and reconnaissance (ISR) missions, advances in technology have enabled increased capabilities for attack, suppression, network node or communications relay, search and rescue, and other applications.

When it comes to the U.S. Navy, however, not only have unmanned vehicles received less public attention, but the industry dialogue that remains critical in order to fully develop unmanned vehicles and their command and control systems is at a key juncture. As unmanned systems occupy a major part of U.S. Navy funding

requests, there has been an increased interest by companies looking to meet the requirements of the evolving fleet. Evidence of this can be found not only in the development of unmanned vehicles by companies like General Dynamics, Teledyne, Boeing, Kongsberg, and Lockheed Martin, but also in a series of strategic acquisitions and investments by these companies.

What follows is an overview of the Navy's status and plans regarding unmanned surface vehicles (USVs). We will cover unmanned undersea vehicles (UUVs) in a future issue, so renew your free subscription if you are interested in these topics.

HOW WE GOT HERE

While USVs have been an element of operating forces since WWII, only during the last two-decades have they occupied

the mainstream of operational assets. Recently, however, it has become apparent that they are trending toward ubiquity. So, how did this happen? With plenty of planning.

Since 2002, U.S. Navy's Office of Naval Research (ONR) has initiated several programs to help USVs perform naval missions, with a heavy emphasis on autonomous control system development. According to ONR, "The autonomous control system developed in the program has been installed on 14 different USV types, and has participated in numerous fleet experiments and demonstrations. One of these, the USV Swarm demonstration in August 2014, used five USVs under autonomous control to perform escort and surface attack missions. Attention is now turning to autonomous control of larger USVs that will have bigger payload

capacities, the ability to operate in higher sea states, and much longer ranges."

In 2016, a second demonstration allowed ONR to prove that boats converted to autonomous unmanned surface vehicles could not only perceive their surroundings and plan their routes accordingly, but could also work as a group to delegate tasks, select appropriate behaviors from a behavior library in response to events around them, and identify nearby vessels as friendly or unfriendly after matching what they see to a pre-programmed database of ships they could encounter.

In November 2013, the Navy sponsored a report from the RAND National Defense Research Institute that examined employment options for USVs.ⁱ That report looked at the USVs available in the market, along with their missions, capabilities,





» A common unmanned surface vehicle (CUSV) patrols for intruders during the Trident Warrior exercise in 2011. Photo credit: Seaman Scott Youngblood, U.S. Navy.

attributes, and the countries in which they are being developed. It also looked at ways the Navy could employ USVs and to what degree USVs are suitable for supporting Navy missions and functions.

The report concluded that USVs offered several strengths relative to other platforms. It touted the ability of USVs to operate sensors and communicate both above and below the waterline. USVs also feature potentially longer endurance, larger payloads, and higher power outputs than comparably sized unmanned air or undersea vehicles. Importantly, the report said, USVs also have a greater risk tolerance compared with manned systems.

The greater risk tolerance makes USVs desirable for overcoming adversaries' anti-access and area-denial measures. Their ability to interact both above and below

the waterline enables them to serve as critical nodes for cross-domain networks. USVs are also suited for missions such as characterizing the physical environment, observation and collection regarding adversaries, mine warfare, military deception/information operations/electronic warfare, defense against small boats, testing and training, search and rescue, and the support of other unmanned vehicles.

The RAND report noted that "Broadly speaking, missions in which payload weight, endurance, and multi-domain capabilities are important—and risk, cost, or other considerations make unmanned platforms preferable to manned ones—are likely to be more appropriate for USV employment. Likewise, missions in which speed is critical are likely to be more appropriate for UAVs, and missions in which stealth is paramount

will favor UUVs."

See **Table 1** for USV Attributes Compared with Other Similarly Sized Unmanned Vehicles, per the RAND Report.

Major recommendations of that RAND report were to advance the autonomy and communications of USVs, and use optional manning and payload modularity.

2019 AND BEYOND . . .

No fewer than 12 funded Navy programs supported autonomous maritime systems in the DoD's Fiscal Year 2019 Budget. Among these, the overriding theme is Research, Development, Test, and Evaluation (RDT&E). Systems in this phase include development across various platforms, with a prevalence of words like swarming, cooperative autonomy, situational awareness, and so

USV ATTRIBUTES COMPARED WITH OTHER SIMILARLY SIZED UNMANNED VEHICLES

● Clear advantage for USV ◐ Near parity ○ Clear disadvantage for USV

Attribute	USV Comparison with UAV		USV Comparison with UUV	
	Relative Advantage	Comment	Relative Advantage	Comment
Endurance	●	Advantage most pronounced when USVs can operate at low speed	●	Hydrocarbon fuels with unlimited oxidizers versus batteries and/or fuel cells
Power				
Propulsion	◐		●	UUVs are more volume-limited for propulsion systems; heat dissipation can be an issue
Mission packages	◐		◐	USVs have more power; UUV packages have lower power requirements
Speed	○		●	UUVs are speed-limited to a few knots
Range	○		●	
Payload capacity	●	UAV space, weight, and power for payloads are limited	●	Low energy density reduces UUV internal volume for payloads
Sensors				
Above the surface	○		●	
Subsurface	●		○	UUVs have more types of sensors and can position them better
Communications	◐	UAVs have better vantage points, but USVs have cross-domain capabilities	●	
Stealth	◐	Both USVs and UAVs have potential to be stealthy	○	
Autonomy requirements	○	UAVs have fewer traffic-avoidance problems and no seakeeping issues	◐	UUVs have limited seakeeping issues and fewer traffic-avoidance problems, although they need to avoid undersea hazards; USV autonomy demands are mitigated by better reachback capability

RAND RR384-5.1

» TABLE 1

forth. So far, ONR demonstrations have been where a lot of the autonomous action is, but real-world employment is about to catch up in a big way.

The Navy is moving forward this year with plans to equip littoral combat ships with quickly deployable fast-moving unmanned boats to clear large ocean areas of sea mines that could threaten aircraft carrier battle groups, commercial ship traffic, and other ocean assets.

One vessel suited for this type of operation is the Common Unmanned Surface Vehicle. Built by Textron Systems, this high-endurance vehicle is compliant with NATO Standards, joint architecture for unmanned systems protocol, and littoral combat ship communication architecture. It is also satellite communication capable and has tremendous payload flexibility. Now in its fourth generation, it's already been tested with packages including side-scan sonar, mine neutralization, ISR and non-lethal weapons.

For example, the CUSV is the primary, mine-hunting, unmanned patrol boat to be used in the new Unmanned Influence Sweep System (UISS), which has completed testing and being implemented in 2019. The CUSV will travel aboard the Littoral

Combat Ships and will deploy as necessary to detect, pinpoint, and trigger explosive sea mines. I highlight this application because it illustrates one of the interesting aspects of USVs for naval applications. They are particularly suited for riverine and littoral missions, where they play a significant protection and surveillance role.

Mine detection work in these areas has previously been performed by divers and small manned boats. Because USVs (and UUVs) save lives when it comes to this type of mission, future employments are likely to include "risk tolerant" swarms of USVs, where component parts can be lost without compromising the entire mission.

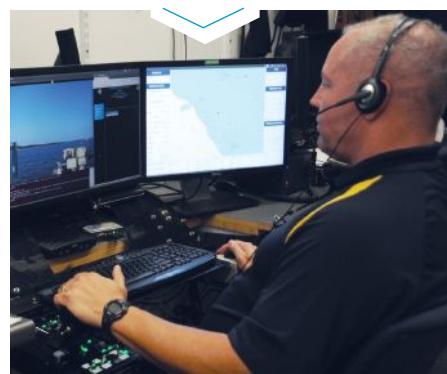
The FY 2019 budget also included a limitation that not more than 50 percent of the 2019 funds for the "ghost fleet overlord unmanned surface vehicle program" may be obligated or expended until the Navy certifies to Congress that the project accelerates development of the future USV program of the Navy; and is properly coordinated and not duplicative of the "unmanned surface vehicle Sea Hunter" program of the Navy.

In response, the Pentagon verified in December 2018 that the Strategic Capabilities Office's Ghost Fleet Overlord

program quickens the progress toward the Navy's USV program. This verification echoed a November 2018 letter from Under Secretary of Defense for Research and Engineering, Michael Griffin, and Navy Secretary, Richard Spencer, to the Senate Armed Services Committee, which said:

"The Navy is utilizing Sea Hunter to demonstrate a blue-water operations capability, as well as long-range and endurance autonomous operations under remote human supervisory control."

» A Navy USV operator at the 2016 USS Dahlgren demonstration. The USV was part of the Navy's evaluation of a strike group's gun weapon systems, combat systems, and unmanned vehicles integrated with surface and air assets. Photo credit: George Smith, U.S. Navy.





» The Sea Hunter Medium Displacement Unmanned Surface Vehicle (MDUSV). Photo credit: Defense Advanced Research Projects Agency.

In contrast, Ghost Fleet Overlord will develop optionally manned LUSVs (Large Unmanned Surface Vehicles) with both increased payload capability and capacity across multiple missions sets... Overlord will additionally mature integrated C3 systems and large-payload integration concepts, providing the Navy with Fleet-ready, multiple mission assets that will accelerate the development and procurement of future LUSVs within the program supporting the Navy's Future Surface Combatant Force architecture."

Securing this funding led to the Navy's Unmanned Maritime Systems Program Office issuing a sources sought/request for information (RFI) notice on 13 March 2019, in order to find sources to satisfy upcoming requirements for the LUSV program.

Even more recently, in his proposed FY 2020 Budget for the DoD, President Trump requests funding for 2 LUSVs at \$447 million,ⁱⁱ and the funding does not stop in 2020.

Across the Future Years Defense Program (FYDP), ship construction includes plans for 10 LUSVs.

According to the FY 2020 Defense Budget overview, "The USV investment . . . represents a paradigm shift towards a more balanced, distributed, lethal, survivable, and cost-imposing naval force that will better

exploit adversary weaknesses and project power into contested environments."

Some of the most promising testbeds for USV projects are being prototyped at the Defense Advanced Research Projects Agency (DARPA). For example, in January 2018, DARPA officially concluded about three years of collaborative development with the Navy by transitioning the Sea Hunter, a demonstration vessel that emerged from its Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV) program, to ONR. ONR is continuing development of the revolutionary prototype vehicle, the first of what ultimately could become an entirely new class of ocean-going vessel – the Medium Displacement Unmanned Surface Vehicle (MDUSV) – that traverses thousands of miles of open seas for months at a time, without a single human crewmember aboard.

When you add all of these funding and research activities together, it's clear that we are edging toward a future where manned and unmanned vessels complement each other in both tactical and strategic ways.

"ACTUV represents a new vision of naval surface warfare that trades small numbers of very capable, high-value assets for large numbers of commoditized, simpler platforms that are more capable in the aggregate," DARPA Tactical Technology

Office (TTO) Director Fred Kennedy said in an agency release. "The U.S. military has talked about the strategic importance of replacing 'king' and 'queen' pieces on the maritime chessboard with lots of 'pawns,' and ACTUV is a first step toward doing exactly that."ⁱⁱⁱ

LISTENING IN ON THE DIALOGUE

Increasingly, companies who will provide this technology to the defense sector are being given a clearer look at the expectations of program managers and acquisition personnel. Writing on the website of the Center for International Maritime Security (CIMSEC), U.S. Navy Captain Peter Small, Program Manager, Unmanned Maritime Systems, said that he expects the Navy's USV efforts to increase.^{iv}

"Unmanned systems are clearly a growing part of the future Navy," wrote Capt. Small. "We need to think now about the changes these systems will bring and ensure their introduction allows their capabilities to be exploited to the fullest."

Capt. Small explained that while the established families of USVs and UUVs are supported by "a number of Core Technology standardization efforts in the areas of battery technology, autonomy architecture, command and control, and machinery control... there are still a host of logistical and sustainability issues that the Navy must work through. Most of these unmanned platforms do not immediately align with long-established support frameworks for surface ships and submarines."

He solicited ideas and solutions to answer key questions about the long-term sustainment and support of both UUVs and USVs and responses to his request were published on the CIMSEC website during the week of May 6-10, 2019. The responses were not published in time to be references for this article, but they should be well worth reading for anyone interested in this topic. Visit www.cimsec.org to read them.

ⁱSavitz, Scott, et al. U.S. Navy Employment Options for Unmanned Surface Vehicles (USVs). Prepared for the United States Navy. RAND National Defense Research Institute.

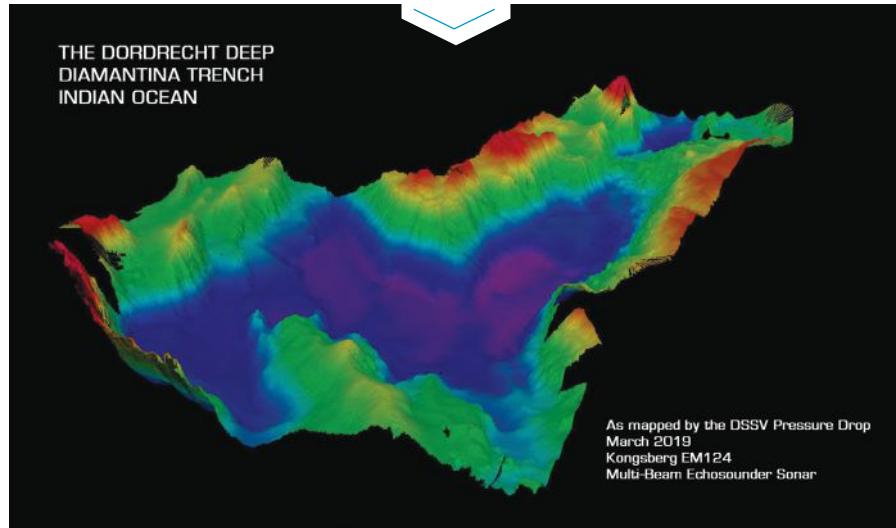
https://www.rand.org/content/dam/rand/pubs/research_reports/.../RAND_RR384.pdf. Retrieved 29 March 2019.

ⁱⁱ DoD Budget Request, Defense Budget Materials – FY2020. <https://comptroller.defense.gov/Budget-Materials/>. Retrieved 29 March 2019.

ⁱⁱⁱ Wilson, J.R., "Autonomous Technology Cometh" in DARPA: Defense Advanced Research Projects Agency 1958-2018. https://www.darpa.mil/attachments/DARAPA60_publication-no-ads.pdf. Retrieved 02 April 2019.

^{iv} Center for International Maritime Security website. <http://cimsec.org/40025-2>. Retrieved 29 March 2019.

DEEP SEA PIONEER IS FIRST TO THE DEEPEST POINT IN THE INDIAN OCEAN



» The expedition conducted the first detailed, sonar mapping and sample-collection mission at the Dordrecht Deep.

The Five Deeps Expedition has successfully completed a mission to reach one of the most isolated points on the planet: the deepest point of the Java Trench in the Indian Ocean. Now measured at 7,192 meters/23,596 feet deep, Victor Vescovo is the first human to dive to its depths in the DSV *Limiting Factor* (Triton 36000/2 model submersible) the world's deepest diving, currently operational submarine.

At the bottom of the trench, the team captured footage from the sub and from the landers of what are believed to be entirely new species, yet unseen by humans. From the sub, a new species of hadal snailfish was observed amongst many other bottom dwelling organisms, and the landers observed an extraordinary gelatinous animal – thought to be a stalked Ascidean, otherwise known as a Sea Squirt – which does not resemble anything seen before.

Dr. Jamieson said, "The stalked Ascidean was a really significant moment. It is not often we see something that is so extraordinary that it leaves us speechless. At this point we are not entirely sure what species it was, but we will find out in due course."

The Five Deeps Expedition is being filmed by

Atlantic Productions for a five-part Discovery Channel documentary series due to air in late 2019.

"Among other things, the Five Deeps Expedition has finally settled the debate about where the deepest point in the Indian Ocean is," said Vescovo. "Our Kongsberg EM124 multibeam sonar – the most advanced sonar currently mounted on a civilian vessel – provided detailed maps of the Diamantina Fracture Zone sea floor off the coast of Australia, as well as the deepest parts of the Java Trench. Together with physical visitation from unmanned landers and the DSV *Limiting Factor* submersible, we believe we have built the most precise maps possible of the deepest places in the Indian Ocean. The deepest point is in the central part of the Java Trench – not the east as was widely assumed – and that's exactly where we dove."

A second dive was piloted by Patrick Lahey, President of Triton Submarines and he was accompanied in the two-person submersible by Dr. Alan Jamieson, the Chief Scientist of the Five Deeps Expedition. With his dive to 7,180 meters it is believed that Dr. Jamieson, a Scot, has become the deepest-diving British citizen in history and the first to visit the hadal depths (greater than 6,000 meters).

In addition to Vescovo's solo dive, the Five Deeps Expedition has also accomplished:

- First descent to the bottom of the Indian Ocean
- The most solo dives (3) deeper than 7,000m made by a single individual (Vescovo)
- First manned descent below 2,000m in the Java Trench and the first descent to the absolute bottom of the trench (7,192m)
- Deepest dive by a British citizen (Jamieson, Scottish)
- First seabed lander operations including biological sampling and depth confirmation at the bottom of the Diamantina Fracture Zone in the Indian Ocean
- Discovered at least 4 new species of life, including one significantly-sized, stalked Ascidean, previously unseen by any member of the expedition science team

"Every time Victor successfully completes another objective on the Five Deeps

Expedition, we showcase the safety, reliability and importance of diving in a DNV-GL certified submersible," said Patrick Lahey of Triton Submarines.

Mapping of Diamantina Fracture Zone for GEBCO

In addition to the Java Trench dive, the Five Deeps Expedition conducted the first detailed, sonar mapping and sample-collection mission at the deepest part of the Diamantina Fracture Zone of the Indian Ocean – an area known as the Dordrecht Deep. Using advanced multi-beam sonar and an ultra-deep-sea lander, the team found it to be 7,019 meters deep, slightly shallower than previously thought when historically measured by other, less precise, methods.

This mission aimed to generate very strong evidence to conclude that this location is not the deepest place in the Indian Ocean as several geographic sources suggest, and provide the first biological samples from the deepest location in this area. The data will be an important contribution to the Nippon Foundation – GEBCO – Seabed 2030 Project to map the world's seafloor in detail by the end of the year 2030.

"Kongsberg is especially pleased to learn of this formal collaboration with GEBCO and to see the Five Deeps Expedition fully exploiting the EM 124's tremendous coverage and mapping productivity," said Chris Hancock, Vice President of Sales for Kongsberg Underwater Technology, Inc.

In addition to mapping the fracture zone, a scientific lander from Newcastle University was deployed to approximately 7,010 meters for six hours to measure water temperature and physically confirm the depths registered by the sonar. The lander also collected - for the

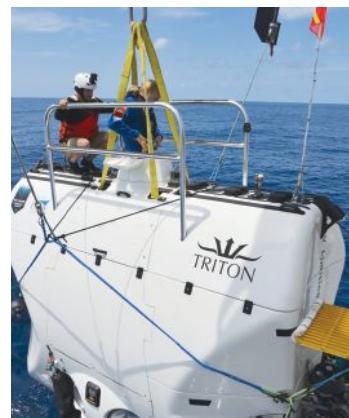
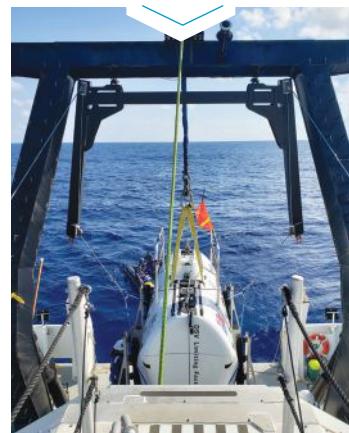
first time - biological samples of scavenging crustaceans known as amphipods. These samples will be brought back to Newcastle University and genetically analyzed to examine the role of ultra-deep fracture zones in evolution, the role of other faults and basins in the dispersal of hadal species, and the degree of genetic drift possible across deep ocean trenches.

The Next Dive: The Challenger Deep

The next stop on the Five Deeps Expedition is the Challenger Deep within the Mariana Trench, commonly known as the deepest ocean trench on earth. The bottom of the Mariana Trench has been reached by only two other manned submersibles: James Cameron's *Deepsea Challenger* in 2012, and Don Walsh and Jacques Piccard's bathyscaphe *Trieste* in 1960 -- both of which only reached the bottom once.

Thanks to the advanced design of the DSV *Limiting Factor*, it is believed that Vescovo will be able to reach the depths of the Challenger Deep multiple times within one week and remain at the bottom for longer than anyone has been there before. It will also be the first time any expedition has made a manned dive in the Challenger Deep using an advanced, multi-beam sonar and three independent landers to pinpoint the deepest area and precisely target the dive location. The Five Deeps Expedition will attempt to dive slightly deeper than even the USS *Trieste* did in 1960, if it is possible.

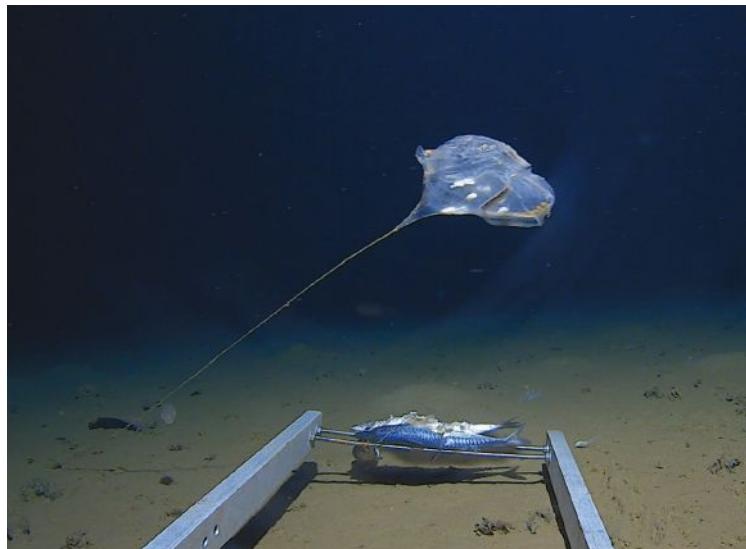
The other remaining major dives planned for the Five Deeps Expedition include Tonga Trench (Pacific Ocean, 10,882m) and Molloy Deep (Arctic Ocean, 5,573m). For updates, visit www.fivedeeps.com.



» The landers observed an extraordinary gelatinous animal, which could be a new species.



» The DSV Limiting Factor surfaces following record-breaking dive in the Indian Ocean.



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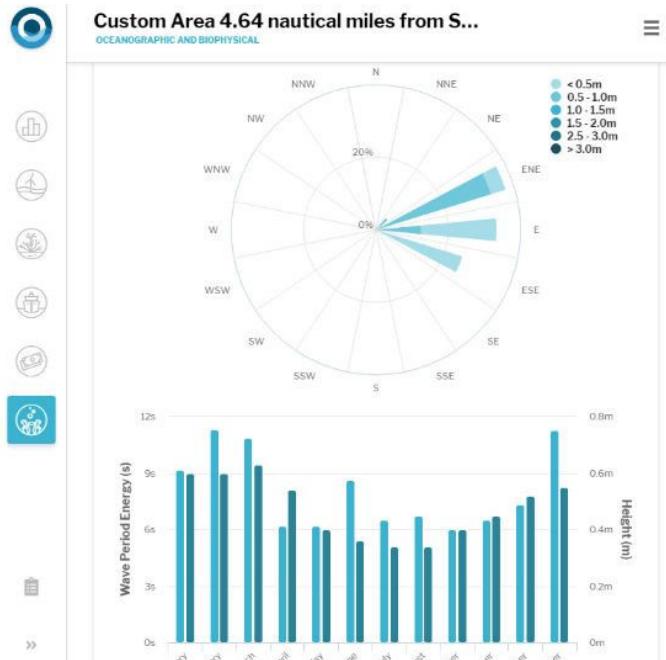
Provides analyses of "ocean neighborhoods" to support ocean commerce, energy development and conservation.

A new, web-based interactive tool for ocean mapping and planning created by the Department of the Interior's Bureau of Ocean Energy Management (BOEM) and the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) will give everyone from ocean industries to coastal managers, students, as well as the general public, the opportunity to be an ocean explorer right from their own computer.

The new OceanReports web tool, available at <https://marinecadastre.gov/oceanreports>, provides users specialized "ocean neighborhood analyses" including maps and graphics by analyzing more than 100 ocean datasets instantaneously.

U.S. ocean waters comprise nearly four million square miles and are one of the largest Exclusive Economic Zones (EEZ) in the world. Now, when you outline any area in the U.S. EEZ using the OceanReports app, you can get detailed information about habitats and species, industries at work, potential hazards such as undersea cables or shipwrecks, economic value of ocean commerce, and detailed oceanographic information.

"The world's largest collection of 'ocean intelligence' can now be accessed to help sustain and grow one of the world's largest blue economies," said Neil Jacobs, Ph.D., acting NOAA administrator. "Whether it's aquaculture siting, marine transportation, or offshore energy, OceanReports puts this data at our fingertips and gives us an edge as we continue to grow our national economy."



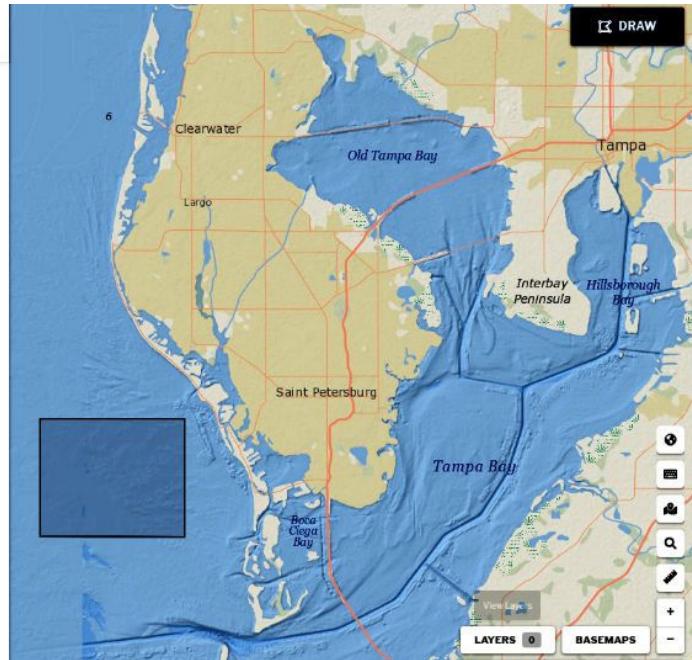
OceanReports builds on more than a decade of data collection to transform how seemingly disparate ocean information can be delivered to the nation's ocean and coastal industries, which add \$320 billion in gross domestic product to the nation's economy.

And while OceanReports provides a fountain of data for use by industry and science, it is still easy enough to use in the classroom to help students studying biology, chemistry, geography and even other disciplines like economics.

"With such a diverse range of ocean uses and stakeholders, the OceanReports tool greatly increases one's ability to understand and manage the resources in the complex ocean environment," said BOEM acting director Walter Cruickshank. "Our team worked diligently with NOAA to create this tool, which benefits the ocean community in addition to helping BOEM carry out its mission -- the responsible development of ocean energy and marine mineral resources for the nation."

"OceanReports is a monumental advancement for all ocean industries," said James Morris, NOAA marine ecologist and member of the OceanReports development team. "New industries such as aquaculture and existing industries such as energy and shipping will all benefit from having easy access to this unprecedented volume of ocean intelligence. Everyone will now be better informed and positioned to conserve marine resources and grow ocean commerce to new levels."

OceanReports is an example of strong federal interagency coordination and cooperation on ocean policy, as put forward by the President's Ocean Policy to Advance the Economic, Security and Environmental Interests of the United States (Executive Order 13840), signed 19 June 2018.

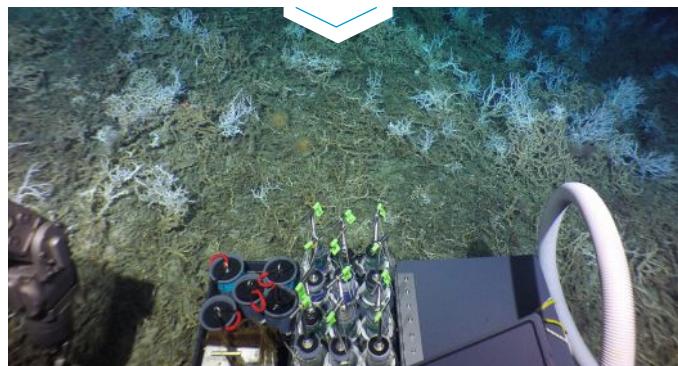


BOEM AND RESEARCH PARTNERS RESUME SOUTHEAST ATLANTIC EXPLORATION

The fourth ocean research mission off the U.S. southeast coast began on 9 April 2019 as scientists departed from Charleston, South Carolina for the next phase of the DEEP Sea Exploration to Advance Research on Coral/Canyon/Cold Seep Habitats (DEEP SEARCH) project sponsored by BOEM, USGS, and NOAA. Sailing aboard NOAA Ship Ronald H. Brown, the expedition will explore and characterize seeps, corals, canyons, and associated fauna along the Atlantic margin between Virginia and Georgia. New information from this study could be useful in protecting the sensitive habitats that are the focus of this study if offshore resource development is planned for the region.

The mission is deploying the remotely operated vehicle (ROV) Jason for surveys, and includes ship-based multibeam mapping, CTD casts, and multicore sediment sampling at several seep targets, and hard bottom features located between Virginia and Georgia.

BOEM scientists will join researchers from NOAA's Office of Ocean Exploration and Research, USGS, Temple University, and five other academic institutions all contracted by TDI Brooks International, who are collaborating on the study. Other organizations participating in the cruise include Florida State University, Harvey



» DEEP SEARCH 2018 discovered thriving Lophelia pertusa reefs further offshore and in deeper water than other known Lophelia reefs in the Atlantic. Photo: Dan Fornari, Woods Hole Oceanographic Institution.

Mudd College, the University of Georgia, the University of New Hampshire, and the Royal Netherlands Institute for Sea Research. In addition, Nova Southeastern University is collaborating. Now in its third year of field work, the research continues to increase our knowledge of continental margin geology, the types of communities found on the seafloor, and the distribution and ecology of deepwater habitats and related mid-water communities that interact with those seafloor communities.

Follow DEEP SEARCH on social media at #OceanDeepSearch and on the web at <https://oceanexplorer.noaa.gov/explorations/19deepsearch/welcome.html>

Total
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Robots



SUBSEA TECHNOLOGY

Image: Courtesy Bluefin General Dynamics

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| FEATURE |

THREE SURFACE VEHICLES FEATURED AT OCEAN BUSINESS 2019

Ocean Business 2019 (April 9-11 in Southampton, UK) featured over 180 hours of free training and demonstration sessions, as well as some amazing unmanned surface vehicles (USVs) on display at the exhibition stands. Here are three from that event that caught the eye of our team.

OceanAlpha's ME 120



OceanAlpha launched ME120 USV by deployment of Kongsberg M3 PHS system, successfully demonstrated as whole package survey solution in Southampton dockside during Ocean Business 2019. The ME120 USV utilizes a detachable catamaran design, making it easy for van transportation and for two people to assemble and disassemble. It's compatible with multibeam sonar, side scan and other survey instruments and is equipped with an automatic transducer lifter.

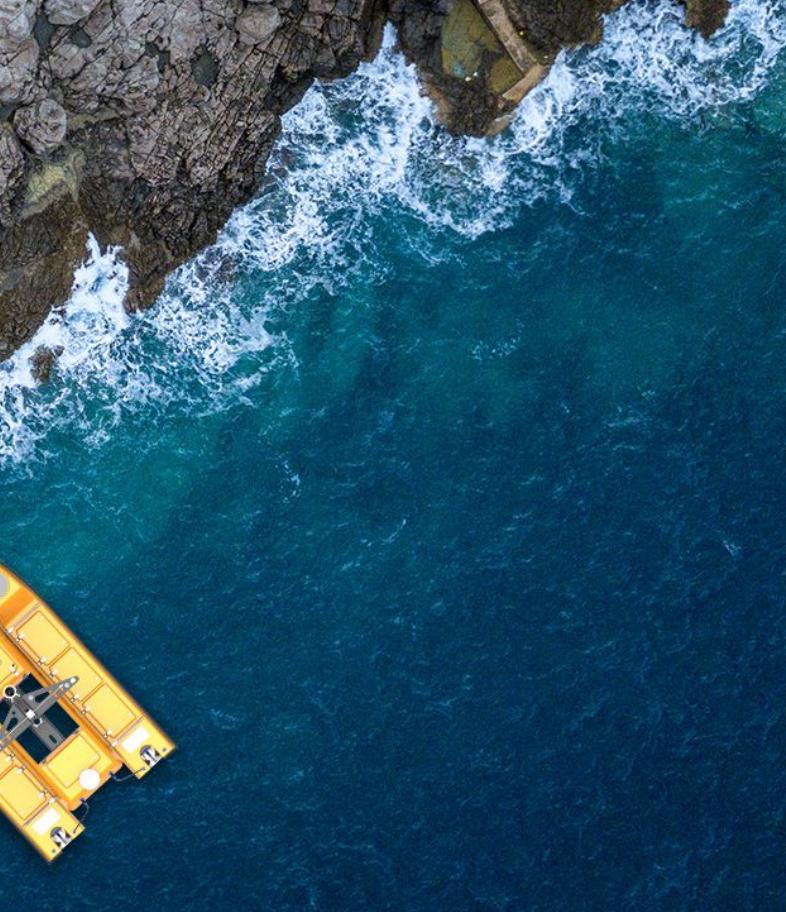
Both the USV and the survey instruments are controlled by the base station. The USV can complete autonomous surveying and send back data in real-time. An operator can also control

the USV manually through the remote controller. The USV is equipped with ultrasound sensors that can detect obstacles up to 40 meters ahead to avoid collision when in auto mode. Operators can observe water environments through a real-time video feed to better avoid obstacles when operating in manual mode.

The payload cabin of the ME120 USV is replaceable, so operators can change and install different instruments in the payload bay. With a standard instrument payload of 45Kg and maximum speed up to 5m/s, the ME120 USV shows great endurance with 8 hours continuous survey at 2m/s. Its lithium battery is easy to replace in the field to extend endurance when it is necessary.

SeaTrac Systems' SP-48

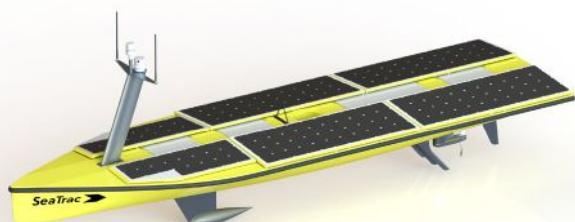
With its extremely durable design and construction, SeaTrac Systems' new autonomous SP-48 is meant for the open ocean. The sleek hull shape and simple, efficient, electrical power system provide speed through the water and power capacity for the payload. The boat gets energy from the sun, and stores it in large batteries, enabling it to operate through varying weather conditions. It runs programmed missions that can last from several hours up to several months. It normally makes decisions on its own, but it supports "person in-the-loop" and can be remotely controlled. Missions can be easily changed on the fly.



The waterproof handheld remote provides direct control of the SP-48 using a line-of-sight RF link for up to roughly .25 miles (with standard whip antenna), or up to 2 miles (with directional antenna). It is intended for launch and recovery operations or for any other time when local manual control is needed.

The software provides a live link to the boat and the payload to retrieve data and send commands. Customers can choose to control missions on their own or have SeaTrac Systems manage them.

The base package includes several wireless links for basic inshore and offshore operations. Additional options are available to satisfy a variety of control and data requirements. It can support a total payload of up to 70 kg, drawing up to roughly 500 W for day-long missions, or roughly 25 to 85 W for 24x7 operation (depending on desired cruise speed and available sun energy). This makes it adaptable to a wide range of payload sensors that can be integrated into the Sp-48 platform.



Maritime Robotics' Otter



The Otter is a turn-key and easily deployable system for seabed mapping and monitoring of sheltered waters. Its custom Vehicle Control Station (VCS) allows the surveyor to plan the missions in a maritime chart based Graphical User Interface and also monitor the mission and the data acquisition quality while the USV is underway. Sensor and payload data can be monitored in the Vehicle Control Station. Multibeam data, swath width, coverage area, and quality parameters can be displayed in real-time on an intuitive user interface.

The Otter is equipped with electric thrusters that are powered by up to 4 powerful and easily interchangeable battery packs. The Otter can carry a variety of customer defined sensors for seabed and environmental mapping. Quality control and monitoring of the sensor performance and coverage area are performed via the Vehicle Control Station (VCS). Sensors such as ADCP, CTD, fluorometers, hyperspectral imager and other environmental sensors are easily and cost-efficient integrated.

Repetitive tasks like bathymetry are an ideal task for an automated robotic system. The Otter performs these tasks without the expense or extensive resources involved in traditional surveys. Ultra-compact singlebeam and multibeam sonar systems are available for integration for the Otter. This makes the Otter a turnkey bathymetric survey system for sheltered waters.

With a footprint of only 200 x 105 x 85cm and a weight of 95 kg, the Otter is an easily deployable asset that can be transported in a van or even within normal airliners to the survey site. Electric propulsion and a tightly integrated bathymetric survey system makes this system a cost-efficient turn-key solution for bathymetric surveys in sheltered waters such as smaller lakes, canals, rivers, ponds and harbor areas.



SEAROBOTICS ADDS TO THEIR ASV PORTFOLIO WITH THE LAUNCH OF THE SR-SURVEYOR M1.8

SeaRobotics Corporation (SeaRobotics) unveiled its newest entry into the ASV market by introducing the SR-Surveyor M1.8 at the 2019 Ocean Business conference in Southampton, UK. The ASV leverages SeaRobotics' extensive expertise for high-precision bathymetric and hydrographic surveys.

The SR-Surveyor M1.8 is a man-portable ASV with a small profile and shallow draft designed to streamline survey logistics and easily navigate shallow and hard to access remote locations. The SR-Surveyor M1.8 can be deployed in the most challenging environments with minimal support. Intelligent, fully integrated, and capable of rapid deployment, the SR-Surveyor M1.8 is the ideal solution for professional surveyors requiring high quality, bathymetry, and LiDAR data.

"SeaRobotics is thrilled to introduce the SR-Surveyor M1.8 with its broad range of sensors, which makes this compact and agile ASV the most fully-integrated ASV on the market," stated Don Darling, president of SeaRobotics Corporation.

The SR-Surveyor M1.8 employs tightly integrated, industry-leading technology to provide best-in-class capability, performance and, data quality. The SonTek M9 Acoustic Doppler Current Profiler provides water column velocity data and acoustic bottom tracking. This bottom tracking functionality is utilized to enable precise navigation in GPS denied areas, allowing accurate hydrographic surveys in the most demanding environments. The EdgeTech 2205 MBES sonar system and an integrated forward-looking camera complete the SR-Surveyor M1.8's surveying capabilities.

Sensors have plug-and-play capabilities, allowing the SR-Surveyor M1.8 to be easily customized to site-specific needs. Optional sensors include Velodyne Puck LiDAR for terrestrial mapping and the SonTek M9 ADCP for current profiling and bottom tracking.

"We are very excited to offer the SR-Surveyor M1.8. By partnering with Edgetech we were able to drastically reduce the power consumption and hydrodynamic drag of their industry-leading technology. The

result is an ASV that outperforms all others in its class by simultaneously collecting high resolution sidescan, bathymetry, backscatter, LiDAR, and current profiling data," according to Geoff Douglass, ASV development manager at SeaRobotics.

SeaRobotics Corporation is headquartered in Stuart, Florida and specializes in smart survey vehicles that are manned/unmanned and autonomously operated. SeaRobotics clients include major military and commercial organizations, both U.S. and foreign. SeaRobotics' seasoned marine survey software interfaces with most data acquisition hardware, software and sensing systems to produce multi-spectral, georeferenced data for survey, research or surveillance efforts. Applications for SeaRobotics vehicles range from bathymetric and hydrographic surveys to coastal, harbor, and riverine surveillance. Many SeaRobotics vessels are small, modular and man-portable, allowing rapid deployment in remote areas or deployment by larger vessels; their command and control systems are user-friendly and compact allowing for safe and efficient surveying.



» SonTek M9 ADCP for current profiling and bottom tracking



» Velodyne Puck LiDAR for terrestrial mapping and GNSS receiver for SBG Ekinox INS



» The launch of the SR-Surveyor M1.8 at Ocean Business 2019

To learn more, visit
WWW.SEAROBOTICS.COM



SR-ENDURANCE 7.0

Workboat ASV with extensive payload deck and optional manned operation

The SR-Endurance 7.0 provides a large aft flexible payload deck to accommodate a broad range of payloads. As currently configured, the system utilizes an electromechanical winch and instrumented A-frame for launch and recovery of towed sonars, dipping sonars, or ROVs. The direct-diesel electric propulsion provides an exceptionally quiet platform for sonar research when operated on battery power. The SR-Endurance 7.0 is a workhorse ASV with unlimited potential.

- Optional manned operation
- Direct diesel drive propulsion option
- Flange mount for hull mounted instruments
- Multi-day endurance at survey speed



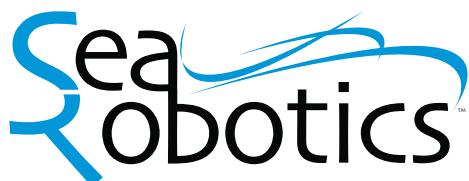
Tow Body Launch and Recovery



Automated Winch



Under-hull Flange for Sonar Mount



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» *Reach System* - A new generation of subsea robotics.
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» *Field Proven* - Integrated on Teledyne Seabotix, VideoRay, SRS, BlueRobotics and more. Photo credit: BlueprintLab



» Advanced control solutions. Photo credit: BlueprintLab

Blueprint Lab is an Australian company specializing in the development of robotics for the subsea industry. Our Reach System robotic manipulators are a capability multiplier for inspection class subsea vehicles and enable operations in complex and confined spaces. This includes the articulation of probes to monitor the corrosion of maritime infrastructure, and UIED intervention for the military.

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To learn more, visit

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SOLUTION TO RIDDLE OF OCEAN CARBON STORAGE

A team of oceanographers has proposed a new explanation for how the ocean absorbs and stores carbon, solving a riddle that has long puzzled scientists. It's well established that carbon in the atmosphere is absorbed by phytoplankton and transported to the ocean floor as the microscopic organisms die and sink by gravity through the water. However, researchers say that this process -- the biological gravitational pump (BGP) -- cannot account for all of the carbon reaching the deep ocean.

Led by Professor Philip Boyd of the University of Tasmania and including scientists from France and the U.S., the article in the journal Nature proposes that additional pathways known as particle injection pumps (PIPs) move just as much carbon as the BGP. The research was based on a review of previous studies and new modelling.

"The ocean stores huge amounts of carbon indirectly absorbed from the atmosphere," Professor Boyd said. "We can measure the sinking flux of carbon-rich particles and compare it with the gradient of dissolved inorganic carbon from low levels near the surface to high levels in the deep ocean. But until now we haven't been able to 'balance the books' in explaining the mechanisms that transport and store carbon, as the BGP only explains around half of the carbon that is present . . . By combining the effects of the biological gravitational pump with PIPs we can, for the first time, balance the books and fully account for ocean carbon storage."



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OCCIDENTAL AND CHEVRON: COMPETING OFFERS FOR ANADARKO



In mid-April 2019, Chevron Corporation (NYSE: CVX) announced a definitive agreement with Anadarko Petroleum Corporation (NYSE: APC) to acquire all of the outstanding shares of Anadarko in a stock and cash transaction valued at \$33 billion, or \$65 per share.

Chevron's own press release claimed the move would provide \$2 billion in anticipated annual operating cost and capital synergies. Based on Chevron's closing price on 11 April 2019 and under the terms of the agreement, Anadarko shareholders would receive 0.3869 shares of Chevron and \$16.25 in cash for each Anadarko share. The total enterprise value of the transaction is \$50 billion.

However, Chevron's offer was followed on 24 April by reports that Occidental Petroleum Corporation (NYSE: OXY) had offered \$38 billion for Anadarko, topping Chevron. After accounting for debt, that offer was valued at \$57 billion. Occidental's bid followed two earlier proposals.

According to their own press release, Occidental Petroleum Corporation delivered a letter to the Board of Directors of Anadarko Petroleum Corporation setting forth the terms of a proposal to acquire Anadarko for \$76.00 per share, in which Anadarko shareholders would receive \$38.00 in cash and 0.6094 shares of Occidental common stock for each share of Anadarko common stock. A deal would add nearly a quarter million acres to Occidental's holdings in the Permian shale basin, and double its production to 1.4 million barrels of oil and gas per day.

Because each acquisition includes shares of the company making the offers, Anadarko shareholders are sure to consider which company has the strongest long-term position. Such a bidding war is rare in the modern exploration and production industry.

As of year-end 2018, Anadarko had 1.47 billion barrels-equivalent of proved reserves, making it one of the world's largest independent exploration and production companies.

Chevron's Chairman and CEO Michael Wirth said, "The combination of Anadarko's premier, high-quality assets with our advantaged portfolio strengthens our leading position in the Permian, builds on our deepwater Gulf of Mexico capabilities and will grow our LNG business. It creates attractive growth opportunities in areas that play to Chevron's operational strengths and underscores our commitment to short-cycle, higher-return investments."

"Occidental and Anadarko have a highly complementary asset portfolio, providing us with a unique opportunity to realize significant operating, cost, and capital allocation synergies and achieve near-term cash flow accretion," said Vicki Hollub, President and Chief Executive Officer of Occidental.

To learn more, visit
WWW.ANADARKO.COM

FEDERAL JUDGE DISMISSES TAYLOR ENERGY'S SUIT TO RECOVER \$432 MILLION IN DECOMMISSIONING FUND



A judge from the U.S. Court of Federal Claims has thrown-out a lawsuit filed against the government by New Orleans-based Taylor Energy Co.

The company, which has been unable to end the longest running oil spill in U.S. history, sought to recover \$432 million remaining in a trust established to pay for plugging leaking oil wells in the Gulf of Mexico. Senior Judge Nancy Firestone of the U.S. Court of Federal Claims dismissed Taylor Energy's demand that the U.S. Interior Department return the money, which is the amount still left in a \$666 million trust established in 2008 for decommissioning Taylor's oil platform and damaged oil wells 12 miles off the mouth of the Mississippi River.

Judge Firestone concluded that the government can use the money to determine if more can be done, or even to change its assessment of the risk. Oil has been leaking from the site 450 feet below the surface since a platform that Taylor Energy owned fell in an underwater mud-slide during Hurricane Ivan in 2004. The platform had been connected to 26 oil and gas wells when it toppled.

"Taylor Energy is disappointed with the court's ruling. However, by no means is this question resolved. We are reviewing the ruling and will consider all options going forward," the company said in a statement Wednesday. "Taylor Energy remains committed to its role as the current responsible party and continues to advocate for a response that is grounded in science and prioritizes the well-being of the environment."

Judge Firestone ruled that, "the government cannot be held liable for breaching its duty of good faith and fair dealing ... until 50 years expire."

Last fall, the Coast Guard seized partial control of spill-response operations and now has contractors on the scene, trying a new method to cap the leak, against Taylor's objections. The company argues in separate court cases that the Coast Guard and its contractor are hurting containment efforts.

IEA RELEASES STATEMENT ON GLOBAL OIL MARKETS

The International Energy Agency (IEA) says that, "Further tightening of sanctions on Iran will have an impact on its export capacity. Iranian shipments of crude and condensates are running around 1.1 million barrels a day (mb/d) in April, 300 000 barrels a day lower than March, and 1.7 mb/d lower than May 2018."

In a statement released 23 April 2019 IEA added that Saudi Arabia had cut far more than required under the OPEC+ supply cuts. Meanwhile, "Total oil supplies from the United States are expected to grow by 1.6 mb/d this year. Furthermore, as infrastructure bottlenecks in the United States are easing, oil exports are now more able to keep pace with production trends."

WWW.IEA.ORG

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ØRSTED US OFFSHORE WIND AND EVERSOURCE INVEST \$4.5 MILLION TO GROW RHODE ISLAND'S OFFSHORE WIND EDUCATION AND SUPPLY CHAIN

Governor Gina M. Raimondo has announced that Ørsted US Offshore Wind and Eversource have pledged \$4.5 million to support offshore wind education and supply chain development for the growing offshore wind industry in Rhode Island.

"Ørsted and Eversource's commitments, as part of their Revolution Wind offshore wind farm, will expand our efforts already underway to build our talent pool and provide opportunities for college students in Rhode Island to study for a career in offshore wind," said Governor Raimondo. "When they are ready to work, we will have plenty of jobs for them in our growing offshore wind supply chain, right here in Rhode Island."

Ørsted and Eversource have committed to invest \$4.5 million locally, with a \$3 million investment in higher education around offshore wind programs led by the University of Rhode Island, a national leader in ocean engineering, environmental science and other marine-related fields. URI will be working in partnership with other institutions of higher learning in the state.

Ørsted and Eversource will invest an additional \$1.5 million, designated to the Rhode Island Commerce Corporation and the Rhode Island Department of Labor and Training, to support the development of Rhode Island's offshore wind supply chain and workforce. These investments will position Rhode Island to remain a leader in the growing American offshore wind industry.



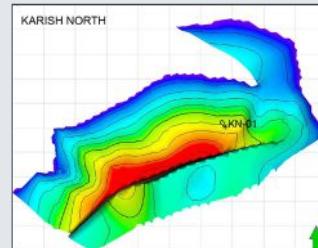
In February, National Grid filed its proposed power-purchase contract with Ørsted and Eversource for the 400-megawatt (MW) Revolution Wind offshore wind farm with the Rhode Island Public Utilities Commission for review. Ørsted and Eversource's investments are subject to the PUC's decision on the project, which is expected by June 1, and final permitting of the project by state and federal agencies.

If approved, Revolution Wind will generate approximately one-quarter of all the electricity used by Rhode Islanders annually and will help increase the state's clean energy portfolio ten-fold by the end of 2020. Once permits are in-hand, local construction work on Revolution Wind could begin as early as next year, with the project potentially in operation by 2023. The Revolution Wind project will be located in federal waters approximately 15 miles southeast of the New England coast.

The project – originally developed by Providence-based Deepwater Wind, which has since been acquired by global offshore wind leader Ørsted – is expected to create more than 800 direct construction jobs and 50 permanent jobs for Rhode Islanders at every skill level. Hundreds more jobs will be supported indirectly as the region's burgeoning offshore wind industry takes off.

In March 2017, Governor Raimondo set a goal to accelerate Rhode Island's adoption of green energy and make the state's energy system ten-times cleaner by 2020. Revolution Wind was selected through an open and competitive market procurement that attracted both domestic and international project developers. If approved by the PUC, this offshore wind project will more than double Rhode Island's existing clean energy portfolio. The state's clean energy progress is updated quarterly and may be viewed at <http://www.energy.ri.gov/renewable-energy/governor-clean-energy-goal.php>.

ENERGEAN MAKES SIGNIFICANT GAS DISCOVERY OFFSHORE ISRAEL



Energean Oil and Gas plc, an oil and gas producer focused on the Mediterranean has announced that the Karish North exploration well has made a significant gas discovery.

The well reached an intermediate TD of 4,880 meters approximately 7 days ahead of schedule. A gross hydrocarbon column of up to 249 meters was encountered and a 27-meter core was recovered to surface. Further evaluation will now be undertaken to further refine resource potential and determine the liquids content of the discovery. Preliminary analysis indicates initial gas in place estimates of between 1 Tcf (28 Bcm) and 1.5 Tcf (42 Bcm) and a high quality reservoir in the B and C sands.

Drilling of the initial phase of the Karish North well is complete. Energean will now deepen the well to evaluate hydrocarbon potential at the D4 horizon. Once operations are completed on Karish North, the Stena DrillMAX will return to drilling the three Karish Main development wells. Following this four-well program, Energean has six drilling options remaining on its contract with Stena Drilling.

The Karish North discovery will be commercialized via a tie-back to the Energean Power FPSO, which is located 5.4km from the Karish North well. The FPSO is being built with total processing and export capacity of 8 Bcm/yr (775 mmcf/d), which will enable Karish North, and future discoveries, to be monetized.

In December 2018, Energean signed a contract with I.P.M Beer Tuvia ('I.P.M.') to supply an estimated 5.5 Bcm (0.2 Tcf) of gas over the life of the contract. The contract is contingent, inter alia, on the results of Energean's 2019 drilling program and today's announcement significantly increases the likelihood of its conversion into a firm contract.



CARBON TRUST'S REVEALS WINNERS OF DYNAMIC EXPORT CABLE COMPETITION

The Carbon Trust has announced the five winners of its dynamic export cable competition as a part of the Floating Wind Joint Industry Project (Floating Wind JIP), which aims to accelerate and support the development of commercial-scale floating wind farms. The Floating Wind JIP is a collaboration between industry partners EnBW, ENGIE, Eolfin, E.ON, Equinor, innogy, Kyuden Mirai Energy, Ørsted, ScottishPower Renewables, Shell, Vattenfall, Wpd, with support from the Scottish Government.

address the lack of availability of high voltage dynamic export cables for the transmission of power from wind farms to shore, which has been identified by industry as a potential bottleneck for the commercial deployment of floating wind technology. The objective of the competition is to ensure that this necessary technology is a viable option for developers for commercial floating wind projects within the next 5-10 years.

The competition winners are:

- ➊ Aker Solutions (Norway)
- ➋ Furukawa Electric Co. (Japan)
- ➌ Hellenic Cables S.A. (Greece)
- ➍ JDR Cable Systems (UK)
- ➎ Zhongtian Technology Submarine Cable Co., Ltd [ZTT] (China)

Drawing on the expertise of existing offshore wind cable suppliers, as well as tapping into the oil and gas supply chain, the competition funding will support the design, initial testing and development of dynamic cables ranging from 130kV to 250kV to enable the efficient transmission of power from floating wind turbines to shore.

The Carbon Trust and the twelve Floating Wind JIP developers will be supporting and collaborating with these cable suppliers to support the development of their cables. This first phase of the project will conclude in March 2020. Results may then help to inform subsequent project phases to support the deployment of dynamic export cables across the industry.

For more information, please visit www.carbontrust.com/offshorewind



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BSEE FINALIZES NEW BLOWOUT PREVENTER AND WELL CONTROL REGULATIONS



On 2 May 2019, the U.S. Department of the Interior's (DOI) Bureau of Safety and Environmental Enforcement (BSEE) released its final new Blowout Preventer Systems and Well Control regulations. BSEE's final Well Control Rule – as the regulation is commonly known – updates regulations on offshore development that were put into place in 2010 after the Deepwater Horizon oil spill. The revised rule reflects the Trump Administration's view that such regulations are burdensome on the American offshore oil industry.

"Today's final rule puts safety first, both public and environmental safety, in a common sense way," said U.S. Secretary of the Interior David Bernhardt. "Incorporating the best available science, best practices and technological innovations of the past decade, the rule eliminates unnecessary regulatory burdens while maintaining safety and environmental protection offshore. Under President Trump's leadership, America is a leader on energy resulting in greater security and economic prosperity."

Jill McLeod, a partner at the international law firm Dorsey & Whitney who specializes in the oil and gas industry told ON&T that the changes should be well received by the oil and gas industry, but are unlikely to escape litigation from environmental groups.

"This will be another case to watch as environmental groups step up their efforts to push for environmental regulation while by contrast the Trump administration continues with

its deregulatory focus to advance energy security," McLeod said.

According to DOI, the final revised rule leaves 274 out of 342 original Well Control Rule provisions – approximately 80 percent – unchanged. Sixty-eight provisions were identified as appropriate for revision, and 33 provisions were added to improve operations on the OCS. Following the direction of both Executive Order 13795 and Secretary's Order 3350, the final rule addresses offshore oil and gas drilling, completions, workovers, and decommissioning activities.

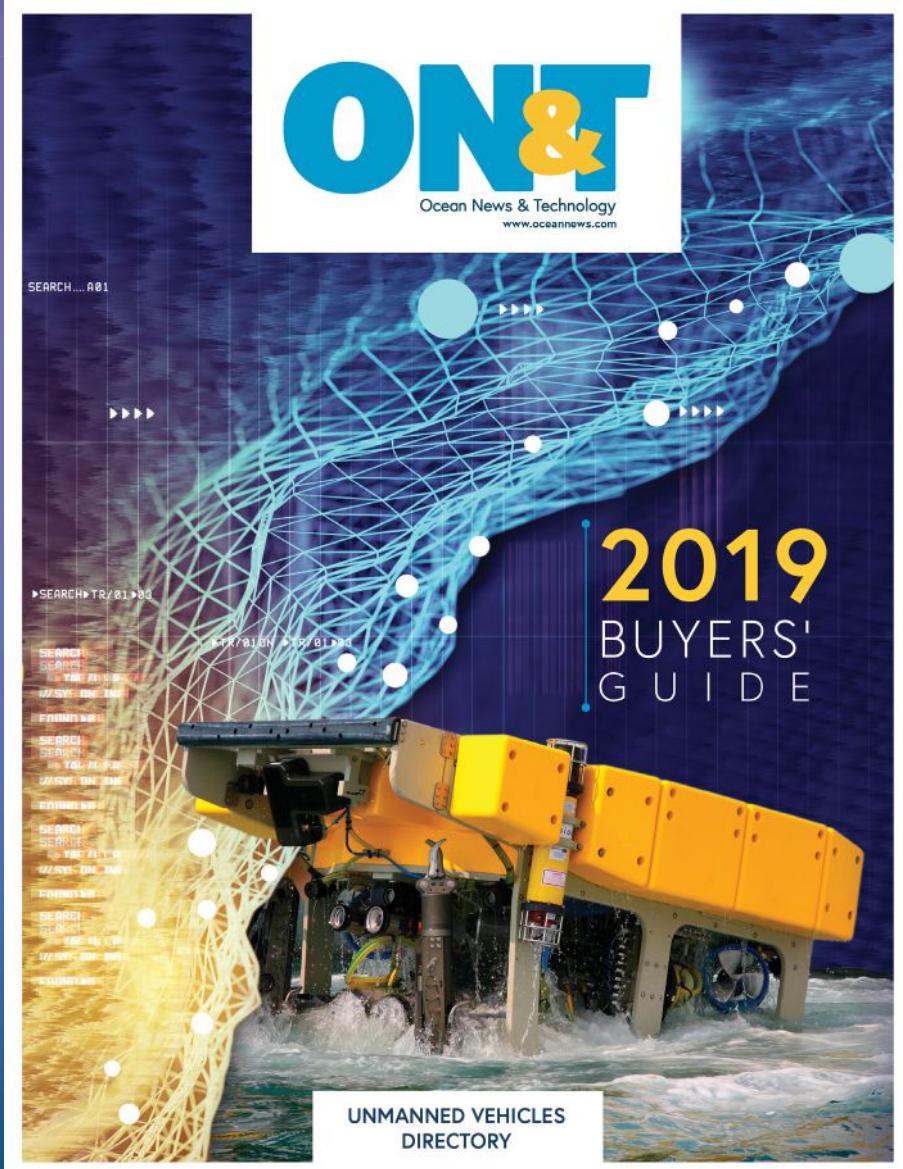
Furthermore, BSEE reports that they considered all 424 recommendations arising from 26 separate reports from 14 different organizations developed in the wake of and in response to the Deepwater Horizon and found that none of the revisions contravened any of these recommendations.

The changes to requirements for Blowout Preventer (BOP) design and testing include:

- Limiting the number of connection points to the BOP, reducing the number of potential failure points;
- Equipping each BOP with a high-flow receptacle to ensure faster delivery of fluid to perform the function from a Remotely Operated Vehicle (ROV);
- Requiring an array of rams, which are steel covers designed to close rapidly around and over a drill pipe to stop the flow of hydrocarbons, with specific capabilities, allowing the most effective use of each ram type and maximizing functionality; and
- Improving the expected lifespan of a critical BOP component by specifying a testing methodology that provides a readiness check without putting unnecessary wear and tear on the component.

BSEE published proposed revisions to the Well Control Rule on May 11, 2018, opening a 60-day public comment period that was later extended to 87 days. Publication in the Federal Register is forthcoming. A pre-publication version and additional information can be found at www.bsee.gov/guidance-and-regulations/regulations/regulatory-reform/bsee-well-control-rule-2019.

NEW 2019 UV Buyers' Guide / Coming this summer!



The UV Buyers' Guide was our **MOST POPULAR** publication last year, and for good reason.

- It is essential. Whether you are listing a vehicle, or looking for one, this comprehensive catalog is a must-read for operators in the subsea industry.
- It is up-to-date. The information it includes comes straight from the providers and is backed by our four decades of experience building this type of publication.
- The Guide is sectioned into eight classifications based on the ROV Committee of the Marine Technology Society (MTS).
- For each vehicle, we've indicated the industry segment the vehicle fits within.
- The Guide is a living document. Not only does ON&T update it every year, but we include links to more detailed specifications.

Visit www.oceannews.com for more updates.

OCEANEERING'S NEW MULTI-SERVICE VESSEL OCEAN EVOLUTION



Oceaneering International, Inc has taken delivery of the advanced subsea construction support vessel, Ocean Evolution.

The vessel has completed sea trials and received all necessary ABS and U.S. Coast Guard certifications and is currently in Port Fourchon, Louisiana, completing final outfitting and preparing for project work scheduled to begin in June 2019.

The *Ocean Evolution* is the most advanced, U.S.-flagged, Jones Act-compliant, multi-service vessel (MSV) in the market. Its capabilities are headlined by its 250 mT active heave compensated (AHC) crane, two work-class remotely operated vehicles (ROVs) with AHC launch systems, survey systems and subsea tooling all built for

work in up to 4,000 m water depths. The vessel serves the deepwater stimulation and intervention needs of our customers with its well stimulation and well intervention design, ABS Well Stimulation and Well Intervention (WS/WI) ready notation and under deck capacity to store special products.

Mike Ellis, Vice President, Subsea Projects, said, "The *Ocean Evolution* is a world class vessel ready to service the construction and intervention needs of our customers in deepwater. We are excited about the upcoming integrated services that will be provided with this vessel when combined with Oceaneering's portfolio of subsea products and services. This combination will provide unmatched productivity, safety, and value for many years to come."

Measuring 353 ft long, 72 ft wide and Light Ship weight 6,900 T, *Ocean Evolution* is an ABS class DP2 subsea multi-service vessel built in the US under Jones Act requirements for coast-wise trade of personnel and equipment. The vessel has accommodations for 110 persons, helideck and a working moonpool measuring 23 ft x 23 ft.

The vessel's 12,595 ft² (1170 m²) steel-constructed deck is designed to carry heavy loads and equipment, which accommodates a wide variety of missions. The deck is rated to support 10 mT/m² with a total cargo carrying capacity of 1,900 mT. The steel deck and on deck utilities including water, power, fuel and communications enables easier and faster loading, welding tie down and hook up of specialized deck equipment during project mobilizations and demobilizations.

The vessel is equipped with a 250 mT AHC main crane with a 13,000 ft working depth capacity. This crane has a special lifting mode that allows heavy lifts with alternate reeving of the boom eliminating the jib that provides increased hook heights of 118 ft (36 m) above the main deck. This provides the ability for crews to lift tall wellheads, large pin piles, and other oversized equipment off the deck utilizing the maximum lifting capacity of the crane. A second auxiliary crane on deck adjacent to the working moonpool is capable of 40 mT for lifting and handling of equipment on deck and to water depths of 600 ft.

Ocean Evolution features a unique layout bridge, configured with port and starboard redundant control stations. These control station locations provide bridge officers and DPOs a better view of crane operations, ROV deployment and simultaneous operations (SIMOPS) with other vessels and platforms on each side of the vessel. As a result, offshore operations are safer and more productive.

Ocean Evolution is built for reliability with five low-emission EPA Tier 4 diesel engines with a combined generating capacity of 16 MW on a three-bus system. The Tier 4 rating is the EPA's strictest emission

requirements for non-road diesel engines and the combination of five engines and third bus provides enough excess capacity to allow full capability and redundancy of the vessel if one engine is down for maintenance.

Ocean Evolution features enhanced station keeping capabilities, which allows it to maintain position even during extreme weather conditions. The vessel's position is held using two tunnel thrusters and a drop-down thruster in the bow along with two Azipull thrusters in the stern. Props on the propulsion systems can be turned 360° and were designed to optimize dynamic positioning of the vessel. The vessel achieved an ERN station keeping reliability rating of 99.99.99.99 which is the highest rating possible further proving the ability of the vessel to keep station in difficult conditions.

The vessel's design and construction was done with well stimulation and light well intervention in mind as a key capability. The underdeck storage capacity of up to 109,000 gal of special products maximizes use of the critical deck space for pumping and intervention equipment. The vessel layout and safety systems meet ABS class requirements for a special well stimulation and well intervention notation.

CGG COMPLETES 2D SURVEY OFFSHORE GABON

Acquisition of CGG's 9,800 km long-offset broadband 2D multi-client seismic survey in the highly prospective Gabon South Basin has been completed. Fast-track data sets will be delivered in batches from the end of April, giving interested oil companies sufficient time to understand offshore petroleum systems and appraise blocks offered in Gabon's 12th offshore licensing round planned for September 2019.

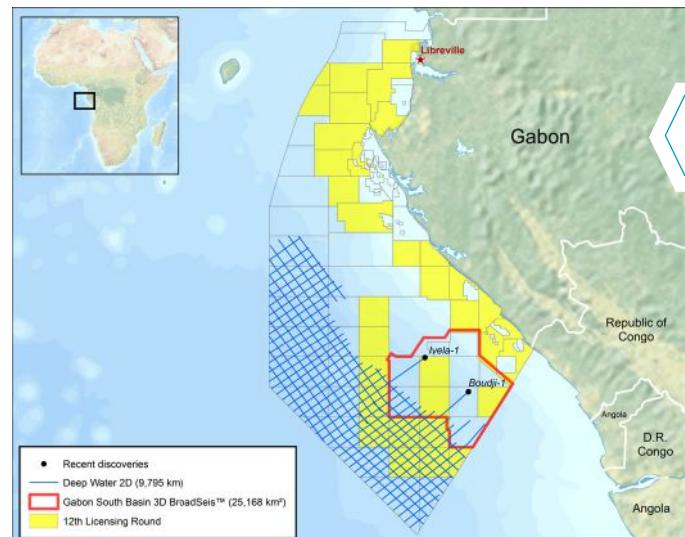
This modern data set will help define the full extent of existing and new plays in the region. It will also aid in understanding the thickness variations in the sediment overburden for source rock and maturity analysis. Broad bandwidth data will not only increase resolution and improve characterization of the turbidite systems that represent potential exploration targets, it also provides deep imaging penetration with low frequencies to help describe the nature of the crust. New insights from this data will expand and update CGG's Gabon South Basin JumpStart integrated geoscience package.

Sophie Zurquiyah, CEO, CGG, said: "The vast offshore acreage of Gabon includes unexplored areas with good potential for a hydrocarbon system. However, there is often not enough high-quality geological and geophysical data to effectively reduce the exploration risks. This new 2D survey, which received significant industry pre-funding, puts the right data in the hands of our clients at the right time, enabling them to de-risk opportunities and select

The vessel is equipped with two Oceaneering work class ROV systems. One 220 hp Millennium® Plus and one 250 hp NEXXUS systems are onboard each with active heave compensated launch and recovery systems installed in a custom indoor hanger for port and starboard launch. Integrated survey and communication systems round out permanently installed equipment that provide positioning and data services for all operations.

The features and capabilities for the vessel when integrated Oceaneering's related products and services will provide customers with world class installation services for subsea tiebacks, solutions for subsea maintenance, repair and decommissioning and well stimulation and light well intervention services.

For more information, visit www.oceaneering.com/subsea-projects/vessel-fleet/ocean-evolution/.



» Map showing location of the current 2D and recent 3D surveys with blocks available in the 12th round.

the appropriate blocks during the current licensing round. It also extends CGG's data coverage from our recent 3D survey further inshore, which led to two successful discovery wells."

ASHTead TECHNOLOGY ACQUIRES AQUA-TECH SOLUTIONS

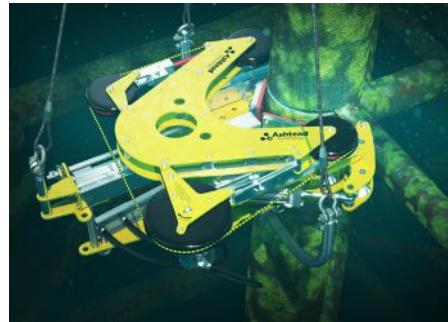
Ashtead Technology has announced it has acquired Louisiana-based subsea equipment rental and cutting services specialist, Aqua-Tech Solutions, as part of the company's international growth plans in the USA.

The combined business will see clients in the Gulf of Mexico region benefit from a robust and enhanced offering, allowing more timely and cost-effective access to the group's full range of equipment and services from locations in Broussard and Houma, Louisiana.

The acquisition significantly strengthens Ashtead Technology's ROV and mechanical tooling offering, broadening its already

well-established survey sensor rental fleet. It also sees the firm's specialist subsea services capability extended with the introduction of subsea cutting equipment.

This latest transaction is the fourth deal completed by Ashtead Technology since the business was acquired by Buckthorn Partners and APICORP in April 2016. The agreement firmly establishes the company's position as a global leader in the provision of subsea equipment rental and project services. It has facilities in the UK, UAE, Canada, Singapore and USA and the acquisition takes the total number of personnel up to 160 across its operations.



» A diamond wire saw, one of the new assets in Ashtead Technology's fleet following its acquisition of Aqua-Tech Solutions.

WWW.ASHTEAD-TECHNOLOGY.COM

FUGRO'S ADVANCED ROV SYSTEM FOR KOREAN NAVY'S SUBMARINE RESCUE VESSEL

Fugro has been awarded a multimillion-dollar contract to supply an advanced Remotely Operated Vehicle (ROV) system as part of a new submarine rescue vessel for the Republic of Korea Navy. The system will enhance the operational capabilities of the auxiliary submarine rescue vessel - ASR-II - which is being provided by South Korean shipbuilder, Daewoo Shipbuilding and Marine Engineering (DSME).

Designed and built by Fugro at its ROV production facility in Singapore, and with a water depth operating capability of 1000-meters, the ROV system will be installed as part of the rescue vessel's onboard submarine recovery systems. Offshore trials will take place prior to the vessel entering operational service in 2022.

The ASR-II is the latest generation auxiliary submarine rescue vessel and will be equipped with a state-of-the-art saturation diving system (with a 300-metre depth capability) and a new deep-sea rescue vehicle (DSRV) for submarine crew rescues to depths of 500 meters.

WWW.FUGRO.COM

ACTEON TO ACQUIRE GEOPHYSICAL SURVEY COMPANY BENTHIC

Subsea services group Acteon has agreed to acquire offshore marine geotechnical and geo-physical survey company Benthic.

Headquartered in Houston, Texas, Benthic adds leading deepwater and ultra-deepwater surveying capabilities to Acteon through its proprietary portable remotely operated drill (PROD) technology. Benthic's latest generation PROD system can conduct insitu penetration testing and collect samples and cores in extremely challenging conditions, including seabed slopes greater than 20° and water depths exceeding 3000 m.

Benthic has a long and extensive record of innovation. Its subsea drilling technology offers an unrivalled solution compared with traditional geotechnical surveying techniques. The company has undertaken comprehensive geotechnical site investigations and geophysical surveys in all the world's deepwater basins for leading oil and gas clients. Work has recently been executed in South America in water depths exceeding 2100 m, and the latest equipment upgrades enable operations in depths up to 4000 m, and there are plans to expand services to include offshore wind and scientific research.

The transaction is expected to complete in May 2019. Pywell will continue to lead the Benthic team and will help Acteon to provide its clients with an increasingly comprehensive geosciences service to meet their requirements around the world. Acteon's principal advisors for the transaction were Evercore, Clifford Chance and KPMG.

WWW.ACTEON.COM



Canada's Catalyst In Creating Revolutionary Ocean Tech Advances

In October 2018, the Centre for Ocean Ventures and Entrepreneurship (COVE) officially opened its doors as the only facility of its kind where start-ups, small and medium sized enterprises, large companies and others are housed together to develop revolutionary advances in ocean technology. As of April 2019, COVE has 50 tenants including: 13 start-up companies, a full-service machine shop, and private sector ship operators.

COVE is an ocean tech business park that encourages collaboration across sectors to connect local and international companies in the ocean industry. Its focus is to bring together people, ideas, companies and research to forge new opportunities for the industry. COVE is a hub for all ocean tech stakeholders.

The tenant mix at COVE consists of organizations such as IBM, Lockheed Martin, and Lloyd's Register, with innovative companies, Sensor Technology, MacArtney Canada, and Turbulent Research, among others. Dalhousie University, one of Canada's prominent ocean research universities, and the Nova Scotia Community College (NSCC), provide applied ocean focused training for students, are also on site. The day-to-day interaction among these diverse tenants is the true magic of COVE.

COVE occupies a former Canadian Coast Guard base in Halifax, Nova Scotia. The renovated facility spans an 8-acre urban waterfront property with 53,000 square feet of building space and excellent marine access with 3,000 linear feet of deep-water wharfs. COVE provides test and deployment facilities, with a 13-acre water lot, and workshop space for product development.

A contribution of almost 6 million CAD from Irving Shipbuilding Inc. supports COVE in its mandate to grow the Canadian ocean

economy by supporting the adoption of innovative ocean technology. This is different from the more general role taken by ocean industry trade associations and marketing support organizations. COVE believes that the largest, most sustainable opportunity for growth comes from the use of ocean technology to gain international competitive advantage and the development of a competitive workforce. Its focus on technology is the key growth lever.

In addition to Canada's 30 billion-dollar National Shipbuilding Strategy, the region is the host to more than \$500 million in strategic investments focused on the ocean. These include Canada's Ocean SuperCluster,

the Ocean Frontier Institute, DeepSense, and others. COVE is partnering with these organizations to bring its valuable network of tenants and partners to these programs.

On June 6th & 7th, the Ocean Technology Council of Nova Scotia (OTCNS), an industry association representing the ocean technology and industry sector in Nova Scotia, is hosting the H2O Conference. The conference engages the ocean technology industry in Atlantic Canada with national and international organizations, and will include; an ocean industry showcase, international delegates, research, development and commercialization presentations, networking events and the Oceans Gala Dinner. This year's conference will also include an On-Water Demo Day on June 5th, at COVE. Find more information about the H2O conference at www.h2oconference.ca/.

Overall, COVE is a place where new ideas are developed and brought to market, and where companies are inspired, encouraged, and provided the opportunity to connect with leaders in the ocean industry. We invite you to come see for yourself in June. Find more information about COVE at www.coveocean.com.



» The Kraken Robotics KATFISH™ aboard the LeeWay Odyssey.



» COVE has direct access to the ocean so businesses can get their product to market faster.



» MacArtney Canada Ltd. assemble a Multiplexer, which provides a fibre optic link between surface and seabed.

VALEPORT LAUNCHES NEW ENVIRONMENTAL RANGE



A leading designer and manufacturer of hydrographic and oceanographic instruments, Valeport, who celebrates 50 years serving the subsea sector in 2019, has launched a new Environmental range of optical sensors.

Hyperion Turbidity is the industry's first standalone turbidity sensor with such a small footprint to combine Nephelometer and OBS readings in the same instrument. Created for inshore, coastal and oceanographic monitoring, this new sensor delivers a minimum detection level of just 0.03 NTU (nephelometer) and can measure turbidity up to 6,000 NTU (OBS). The titanium housing, data output up to 16Hz and low power requirements ensures this sensor can be placed in situ for extended periods with easy access to highly accurate data.

SWiFTplus Fluorometer designed by Valeport's in-house specialists, this unique new range of probes combine the power of the SWiFTplus technology and a fluorometer for the high performance measurement of Chlorophyll a, Fluorescein, Rhodamine or Phycocyanin. Compact and robust, the suite of instruments are ideal for shallow water bathymetric and environmental survey, where observations can be monitored and recorded for surveys for up to 3 days continuous operation. These savvy sensors combine all you need to carry out survey grade Sound Velocity, Salinity, Density, CTD and optical profiles up to 200 metres, in a single instrument.

For more information visit:
WWW.VALEPORT.CO.UK

FORUM LAUNCHES NEW SIMULATOR TRAINING FOR NEXT GENERATION eROV

Forum Subsea Technologies has launched the latest version of its VMAX simulator to integrate with its next generation of electric remotely operated vehicles (eROV).

The XLe Spirit was the first vehicle to be launched from the new range last year and Forum has now added the eROV to its choice of vehicles within the simulator. The new light-weight and ergonomically designed eROV Hand Controller console can also be interfaced to VMAX to allow pilots to be trained in the use of the new console.

The VMAX software is a 3D ROV simulation system which is predominantly used for the training and evaluation of ROV pilots. It can also be utilized by subsea engineering teams for modelling and verification of procedures involving intervention tasks for subsea equipment.

The system provides a variety of ROV scenarios designed to test pilots' skills such as tether management, manipulator control and tooling operation within realistic operational conditions,

The XLe Spirit is the smallest in the new range but is powerful enough to perform subsea maintenance and repair work with the use of its optional electric or hydraulic five function manipulator arm.

It uses the same advanced Forum Integrated Control Engine (ICE++) found in larger work-class and trencher vehicles in the Forum product range. This provides a wide range of auto-pilot and pilot assist modes when appropriate sensors are fitted.

WWW.F-E-T.COM



SANDPOINT HYDROGRAPHIC SIGNS LONG-TERM LEASING CONTRACT FOR WAM-V 16 ASV

Sandpoint Hydrographic has entered into a long-term lease agreement with Marine Advanced Robotics, Inc. for a WAM-V 16 ASV.

Marine Advanced Robotics, Inc. is the designer and sole manufacturer of the WAM-V vessel class of agile ocean robots for maritime professionals. The WAM-V 16 is the middle-tier offering, designed for offshore and inshore applications. The modular system can be shipped air freight to a worksite anywhere in the world, then be deployed from a beach, a boat launch, or a workboat with minimal crew. Its payload capacity and all-day endurance make it well suited to survey operations. The versatile platform, now operating in 10 countries worldwide, has proven itself in real-world conditions with sonar systems from R2Sonic, Norbit, TeledyneReson, Kongsberg, and others.

Sandpoint Hydrographic delivers quality hydrographic survey services by combining the latest technologies with proven operational processes. Founder and President James Coleman said "The stability and seakeeping of the unmanned WAM-V platform allows us to collect superior data across a wide range of conditions, and the lease allows us to minimize capital expenditure and keep tight controls on operating expenses."

The leasing contract is a part of the new RaaS (Robotics as a Service) offerings from Marine Advanced Robotics, designed to minimize barriers to entry and allow more industries to take advantage of the capabilities and efficiencies of unmanned robots in the marine sector. This WAM-V will be outfit by Sandpoint Hydrographic with a number of sensors to perform marine survey for bathymetry, dredging operations, oil exploration, and related activities.

WWW.WAM-V.COM



» WAM-V 16 outfit for Survey Ops. Photo courtesy of Marine Advanced Robotics Inc.



Model: MCM-015
MHU USV Winch



The next generation of cost effective autonomous handling systems from Okeanus

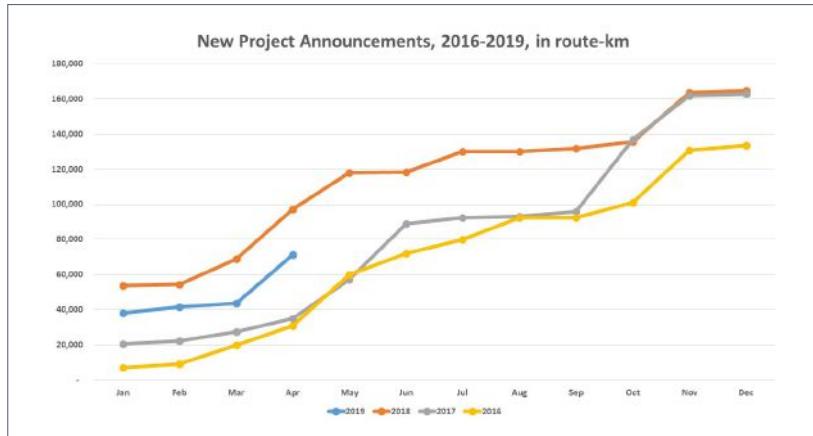
- Design and production capability for customized Winches and Launch and Recovery Systems (LARS).
- USV specific designs and customized autonomous solutions for military or commercial applications.
- Custom designed handling systems for towed or autonomous vehicles deployed from a USV.



WWW.OKEANUS.COM

SUBMARINE FIBER OPTIC CABLE ANNOUNCEMENTS

JAN-APR 2019



This listing of submarine fiber optic cable announcements for 2019 is provided by our partners at SubCableWorld.

Tracking announcements of new systems gives some insight into the level of optimism in the industry for the need for new cables and the ability to raise money to build them, even if these cables do not ultimately get built.

In some cases, projects are not formally announced until the supply contract has been awarded. When this happens, they appear in both this listing and the submarine cable contract awards listing for the same month. This seems to happen frequently with projects involving over-the-top media services.

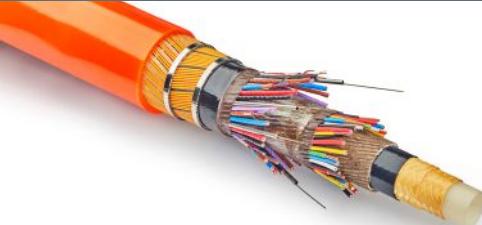
April saw four large-scale cable projects announced, bringing the total for the first four months of 2019 to 16 systems totaling just over 70,000 kilometers of cable. As seen in the chart below, 2019 is following the trend seen in 2018, which was a record breaker, but at about a 30% lower pace. 2019 is, however, running at about twice the pace compared to 2016 and 2017. The most important takeaway from new project announcements, however, is that the pipeline continues to be replenished in spite of the large number of systems coming into service.

The project announcements for 2019 are listed in the following table.

Project	Route-km	Developer(s)	Month
Antigua Cable	150	Antigua Public Utilities Authority (APUA)	January
Asia Direct Cable (ADC) adjustment	5,500	CAT, China Telecom, PPTel and others to be announced	January
SEA-ME-WE 6	20,000	To be announced	January
SxS	10,500	RTI-C	January
IRIS	2,000	Farice	January
England Cable	700	NO-UK.com	February
UAE-Pakistan Cable	2,000	EITC (du)	February
QCTC Okinawa Cable	760	Okinawa Cellular	February
TASIM Azerbaijan-Kazakhstan	250	To be determined	March
TASIM Azerbaijan-Turkmenistan	250	To be determined	March
Google Cuba Cable	150	Google, ETECSA	March
Gondwana-2/PICOT-2	1,500	OPT-NC	March
H2 Cable System	10,000	H2 Cable	April
H2 Cable extensions	15,000	H2 Cable	April
BlueMed	1,000	Tl Sparkle	April
BlueMed extensions	1,500	Tl Sparkle	April
Total	71,260		

For more information visit:
WWW.SUBCABLEWORLD.COM





FIRST TERRESTRIAL FIBER BETWEEN ALASKA AND CONTIGUOUS US PLANNED

MTA Fiber Holdings, LLC, a wholly-owned subsidiary of MTA, plans to build AlCan ONE (Alaska Canada Overland Network), the first and only all-terrestrial fiber network connecting Alaska to the contiguous United States and beyond.

The new all-terrestrial network will initially have capacity of over 100 terabits per second, which can be expanded and increased in the future as demand grows. The network will establish a secure and reliable fiber connection to any point in the contiguous United States, providing MTA's members, as well as Alaska, with a robust internet transport connection for decades to come.

"This is a major step for Alaska that will ensure future capacity requirements for MTA members and can support the continuing growth of broadband across the state of Alaska," said Michael Burke, CEO of MTA.

Currently, MTA pays significant broadband transport fees to other carriers to facilitate high-speed access for its membership. The new all-terrestrial line will lower transport expenses, provide a secure and reliable route to the contiguous U.S. and provide Alaska with a stable internet transport connection. It is a long-term solution to give MTA and its members access to internet capacity while giving the option to reinvest funds in other parts of the company to better improve technology access.

"This new terrestrial network will ensure the future viability and growth of the internet in Alaska," said Burke. "Alaska's leaders have talked about a terrestrial fiber optic path out of the state for more than 20 years. We are pleased to be the ones to be able to make this a reality. This will be a major win for the people who live, play and work in Alaska, supporting business, job growth, and ultimately, the state's economy."

MTA Fiber Holdings has secured partnerships with Canadian carriers in order to extend MTA's existing network from North Pole, Alaska, through Canada and on to any major hub in the United States. Only traffic that both originates and terminates in the United States will be carried over MTA Fiber Holdings' all-fiber network.

Construction of the new terrestrial fiber line has commenced and will continue throughout 2019, with a goal of being completed by the middle of 2020.

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SCIENTISTS PROPOSE A ROUTING SCHEME TO MAKE AUV NETWORKS MORE RELIABLE

Passive sensors can collect all sorts of data in the ocean depths, but transmitting that data—even to a nearby Autonomous Underwater Vehicle (AUV)—is a tremendous challenge. Guangjie Han at Hohai University and his colleagues have proposed a new approach for how autonomous underwater vehicles (AUVs) patrolling the ocean's depths can better collect data from passive sensors. Their design was published in IEEE Transactions on Mobile Computing.

Each sensor, referred to as a node, sits stationary while it collects data. Meanwhile, a fleet of AUVs is dispatched across the network on a predetermined trajectory to collect data from each node. Radio waves are absorbed by water, so underwater sensors and vehicles typically transmit and receive information by using acoustic signals. But sound waves cannot travel as fast or as far in water as radio waves can in the air. And with more AUVs comes more challenges.

"Particularly, it is difficult to communicate directly and synchronize the information among AUVs, due to the poor quality of underwater acoustic communication and short communication range," Han says.

What's more, nodes that are not close to the projected path of an AUV must relay their data to other nodes that will be close enough to an AUV to transmit it. This creates "hot regions" in the network, where some nodes are overburdened and may run out of energy and die. As Han says, "After some nodes in a hot region die, a node near the hot region may not be able to find a neighbor node to communicate [with], resulting in the data loss."

In the new proposed approach, called HAMA (High-Availability data collection scheme based on Multi-AUVs), AUVs are able to adjust their trajectories to alleviate the hot region problem. As well, HAMA has a malfunction discovery and repair mechanism, to avoid data loss when some AUVs malfunction. If a node trying to send its data to an AUV discovers that the AUV has failed, it uses a multi-hop communication approach to inform the other nodes. Functioning AUVs then take the place of the broken-down AUV in collecting data.

Han says that simulation results show that, "compared with the other algorithms or schemes, by adopting HAMA, the network lifetime is prolonged, the energy consumption of the nodes is reduced and balanced, and the packet delivery ratio is increased."

However, this approach also results in a greater delay time for information to be received, compared to the other approaches in this study. This could be problematic when it's important to have updated information—say, if an underwater volcano is erupting. Han and his team plan to address this issue in future work.

"We think that the network delay is mainly caused by the data transmission time, the data processing time, and the movement of AUVs. So, in the future, we will reduce the network delay from these aspects," he says.

Source: <https://spectrum.ieee.org>

GP NETWORK OFFERS ENHANCED MARITIME COMMUNICATION

Grameenphone (GP) has completed the enhancement of its deep-sea network capacity in the Bay of Bengal. As a result of the wider mobile network range, fishermen and commuters on the deep sea will now be able to communicate through GP with the Bangladesh mainland.

Grameenphone is providing this deep-sea network coverage from the point of Cox's Bazar, Kuakata, Char Kukrimukri in Bhola, and Char Montaz in Patuakhali, up to 38 km from the Bangladesh coastline, according to a press release.

From the currently available data, more than 500 vessel units use Grameenphone's services to connect with the mainland from more than 20 km out in the deep sea.

Deputy CEO and CMO Yasir Azman stated, "The coastal region and the Bay of Bengal is an essential contributor to the national exchequer. People who depend on the sea for their livelihood also plays a significant role in providing foods for our homes. Their safeguarding is of paramount importance and we believe that this network development will be able to play a huge role in this."

Every year the coastal area faces a lot of natural disasters such as cyclones, tornadoes and tidal waves which results in loss of lives as well as damage in the economy. The average loss per year can accumulate up to BDT 45 billion due to these natural disasters. Apart from natural disasters, pirate activities also hamper the livelihoods of fishermen and commuters.

This network development is poised to aid these bread earners and commuters at sea and keep them safe with prompt communication with relevant authorities and with their families. Currently, mariners use high frequency radios to communicate with each other and the mainland.





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» GNSS-powered AIS global ship tracking, reduce pollution, and promote monitoring of dangerous cargo.
Image courtesy of the European Space Agency (ESA).

GNSS ATTACKS EMERGE AS VIABLE THREAT

THE FOLLOWING IS A SUMMARY OF A REPORT BY C4AD ENTITLE *ABOVE US ONLY STARS: EXPOSING GPS SPOOFING IN RUSSIA AND SYRIA*, AS COMPILED BY GREG LEATHERMAN, ON&T EDITOR

What if a vessel containing \$100 million of crude oil was diverted into hostile or territorial water, but the tracking and positioning systems indicated that it was still on course?

"In the summer of 2013, a research team from The University of Texas at Austin (UT) successfully hijacked the GPS navigation systems onboard an \$80 million superyacht using a \$2,000 device the size of a small briefcase," says a new report from C4AD. "The experimental attack forced the ship's navigation systems to relay false positioning information to the vessel's captain, who subsequently made slight course corrections to keep the ship seemingly on track. In reality, the falsified signals generated by UT Austin's device had successfully set the vessel off course by several degrees, all without tripping a single alarm on the ship's navigational alert systems. While this was a controlled experiment, a malicious actor could use the same techniques to direct a vessel to stray into hostile waters.

"The 2013 experiment demonstrated the use of one of the world's first openly acknowledged GNSS spoofing devices. At its core, GNSS spoofing is the deliberate transmission of signals designed to emulate the authentic satellite systems that underpin much of the world's critical infrastructure. GNSS spoofing is distinct from other forms of navigation interference such as GNSS jamming, which simply drowns

out satellite signals to prevent receivers from using them. Instead, spoofed signals are able to force vulnerable GNSS receivers, like those installed on the superyacht, to lose their lock on authentic satellite signals and instead lock on to the signals generated by the spoofing device. Once a receiver locks on to the spoofed signals, the spoofing transmitter can relay false position or timing information to the victim receiver, thereby taking control. UT Austin's successful experiment served to expose just one of the many systems vulnerable to GNSS spoofing attacks."

Ships and ports have come to rely on GNSS for a huge array of applications relating to position, velocity, and precise universal and local time, but the exposed vulnerability stretches far beyond the world of shipping. In every issue of ON&T, we report on a cutting-edge product that is satellite-enabled. From self-locating buoys to drill rig positioning, a tremendous amount of what happens offshore depends on accurate data from global navigation satellite systems (GNSS). Other applications are survey and mapping, dynamic positioning, the automatic identification system (AIS) for vessels, and much more. GPS and other GNSS are used in everything from cellular communication networks, to basic consumer goods, high-end military systems, and stock trading inputs.

What's more, this technology is becoming more important every year,

with the global GNSS downstream market forecast to grow by 6.4% annually between through 2020.

According to C4ADS' report, "by attacking positioning, navigational, and timing (PNT) data through electronic warfare (EW) capabilities, state and non-state actors can cause significant damage to modern militaries, major economies, and everyday consumers alike. With recent technological advances, the tools and methodologies for conducting this interference are now at a high risk for proliferation. An emerging subset of EW activity: the ability to mimic, or "spoof," legitimate GNSS signals in order to manipulate PNT data is on the rise. C4ADS' study shows that there were 9,883 suspected incidents of GNSS hacking across 10 locations, including 1,311 civilian maritime vessel navigation systems between February 2016 and November 2018. All these instances point to Russian interference – willfully creating a threat to navigation systems across the world. The agency relied on publicly available information such as GNSS positioning data, official records, news and social media reporting and satellite imagery to zero in on the cause and effect of these hacking incidents."

These systems are high-tech, but as UT Texas has demonstrated, they are not fool proof or inherently secure. Real-world incidents offer even more startling evidence. In 2017, the U.S. Maritime Administration (MARAD) reported that

the master of a ship positioned off the Russian Black Sea port of Novorossiysk, noticed that his global positioning system placed his ship over 32km inland, at Gelendzhik Airport. The AIS used to track vessels also placed at least another 20 ships at the same airport in this incident.

In fact, MARAD reported that, "During the week of June 19, 2017, multiple vessels operating in the Black Sea reported GPS interference, which included intermittent signals, no signals, or an incorrect signal."

According to the C4ADS report, "Activity was reported on a larger scale during military exercises, including Russia's Zapad 2017 and NATO's Trident Juncture 2018, when Norway and Finland reported severe GPS outages affecting commercial airliners and cell phone networks for several days."

As a result, the proven effectiveness of GNSS spoofing attacks on critical systems like maritime navigation equipment is increasingly recognized by US and other governments. A 2012 National Risk Estimate conducted by the US Department of Homeland Security found that US critical infrastructure sectors are increasingly at risk and concluded that GNSS spoofing attack scenarios in particular presented the highest consequences to critical national infrastructure due to the potential lapse of time between when the interference begins and when it is detected.

A similar report commissioned by the United Kingdom Space Agency in 2017 asserted that "all critical national

infrastructure" in the UK relies on GNSS to some extent, and that the fallout from GNSS failure in the maritime sector over a five day-period could cost GBP£1.1 billion in lost gross value added (GVA) in the United Kingdom alone (or about 1.4 billion USD).

Despite these vulnerabilities, says C4ADS, leaders in the public and private sectors have paid little attention to the threat of GNSS spoofing. The report adds:

"Until recently, this was for good reason. Signal generators capable of conducting a spoofing attack cost of tens of thousands of dollars and required expert knowledge to operate. But this all began to change over the past decade with the advent of cheap, commercially available, and portable "software defined radios" (SDR) and open-source code capable of transmitting spoofed GPS signals. SDRs are used for a variety of innocuous applications including amateur radio broadcast, aircraft tracking, and ship tracking. Today, these devices are capable of mimicking authentic, multimillion-dollar GPS satellite signals and can be produced for under \$300—less than the price of a new television. Inexpensive systems have already been used to hijack vehicle navigation systems . . .

The Russian Federation is a pioneer in the use of these techniques to further its strategic interests at home and abroad. In response to NATO's advantage in C4ISR capabilities, Russia has prioritized the development of a comprehensive suite of asymmetrical EW systems designed to deceive, degrade, and deny military and civilian GNSS receivers. In effect, Russian forces now have the capability to create large GNSS denial-of-service spoofing environments, all without directly targeting a single GNSS satellite. These systems are widely believed to be in use across Russia's Western and Southern Military Districts at the border with NATO and reportedly have been forward deployed in conflict zones such as Ukraine and Syria."

"To date, methods for detecting GNSS spoofing and other interference have been reserved for organizations with the ability to leverage advanced means for signals collection. As a result, the full scope of this activity has rarely been discussed in the public domain. With the democratization of technological capabilities and access to data, these advanced means are now available to a wider audience."

Other assets vulnerable to this type of attack could include unmanned surface vehicles (USVs). So far, because aerial drones are more common, most of the discussion has focused on them, but the comparison is an obvious one.

According to C4ADS, the head of US SOCOM Gen. Tony Thomas has referred to Syria as, "the most aggressive electronic warfare environment in the world" and the report calls that region a testbed for Russian electronic warfare equipment where "deployment of EW capabilities has successfully targeted smaller US military drones."

C4ADS says, "The tools used to conduct this activity may be openly available, but so too are the technologies and methodologies for detecting, tracking, and geolocating these activities."

For example, during their study, C4ADS and the University of Texas Austin used a GPS receiver onboard the International Space Station (ISS) to record, characterize, and ultimately geolocate a denial-of-service GPS spoofing transmitter to the Khmeimim Airbase in Syria. As a result, they found clear evidence of GPS spoofing in the recorded signal data. The researchers successfully geolocated the source of the signals in all three samples to Khmeimim Airbase, the nerve center of the Russian military campaign in Syria. They noted that "Because denial-of-service spoofing would prevent receivers from calculating any navigation information, this activity may appear to be jamming . . ."





» Stranded sailors in a life raft use an Emergency Position Indicating Radio Beacon (EPIRB) to signal for help. A built-in GNSS receiver enables rescuers to accurately locate the beacons, which are installed on marine vessels and registered through search and rescue organizations. Photo courtesy of the European Global Navigation Satellite Systems Agency (GSA).

The report concludes that "Significant opportunities exist for both public and private sector organizations to get ahead of the curve and address these challenges head-on. Increased public awareness of GNSS interference threats can lead to not only a more measured and proportional response by private sector organizations, but also a more open discussion on how these threats can be successfully mitigated. Public efforts to protect, toughen, and augment existing PNT systems, such as those promoted by the Resilient Navigation and Timing (RNT) Foundation, combined with evidence-based reporting on these issues, can serve to enhance this dialogue."

The report from C4ADS serves as one of the first systems-level demonstrations of how publicly available data can be used to identify, detect, and expose the deployment of denial-of-service GNSS spoofing capabilities. In doing so, it demonstrates how the use of GNSS spoofing in the Russian Federation, its occupied territories, and its overseas military facilities is far more pervasive and advanced than previously thought. To read the full report, visit <https://c4ads.org/reports>.

ABOUT C4ADS

C4ADS (www.c4ads.org) is a 501(c)(3) nonprofit organization dedicated to data-driven analysis and evidence-based reporting of conflict and security issues worldwide. They seek to alleviate the analytical burden carried by public sector institutions by applying manpower, depth, and rigor to questions of conflict and security. Their approach leverages nontraditional investigative techniques and emerging analytical technologies. They recognize the value of working on the ground in the field, capturing local knowledge, and collecting original data to inform our analysis. At the same time, they employ cutting edge technology to manage and analyze that data. The result is an innovative analytical approach to conflict prevention and mitigation.

ⁱGNSS Downstream Market. European Global Navigation Satellite Systems Agency. <https://www.gsa.europa.eu/market/gnss-market>. Retrieved 18 April 2019.

U.S. SENDS TWO CARRIER STRIKE GROUPS TO THE MEDITERRANEAN



» The Nimitz-class aircraft carrier USS Abraham Lincoln (CVN 72) transits the Strait of Gibraltar, entering the Mediterranean Sea as it continues operations in the U.S. 6th Fleet area of responsibility. Abraham Lincoln is underway as part of the Abraham Lincoln Carrier Strike Group (ABECSG) deployment in support of maritime security cooperation efforts in the U.S. 5th, 6th and 7th Fleet areas of responsibility. Photo credit: Mass Communication Specialist 2nd Class Clint Davis, U.S. Navy.

The John C. Stennis Carrier Strike Group (CSG) joined the Abraham Lincoln CSG in the Mediterranean, providing a unique opportunity for two strike groups to work together alongside key allies and partners in the U.S. 6th Fleet area of operations. Multiple media reports interpreted the action as a clear message to Russia, which has expanded its military presence in the region since joining forces in Damascus with Syria in 2015.

This is the first time that two carriers have operated in the Mediterranean at the same time since the summer of 2016, when the Dwight D. Eisenhower and Harry S. Truman CSGs were deployed to the region simultaneously.

"It's a rare opportunity to train with two

carrier strike groups together," Vice Adm. Lisa M. Franchetti, commander of U.S. 6th Fleet, said. "Dual carrier operations here in the Mediterranean showcase the inherent flexibility and scalability maritime forces provide to the joint force, while demonstrating our ironclad commitment to the stability and security of the region."

During their deployments, the CSGs will work with a number of our regional allies and partners at sea, creating opportunities for high-end maritime integration in a challenging environment while improving collective proficiency and interoperability.

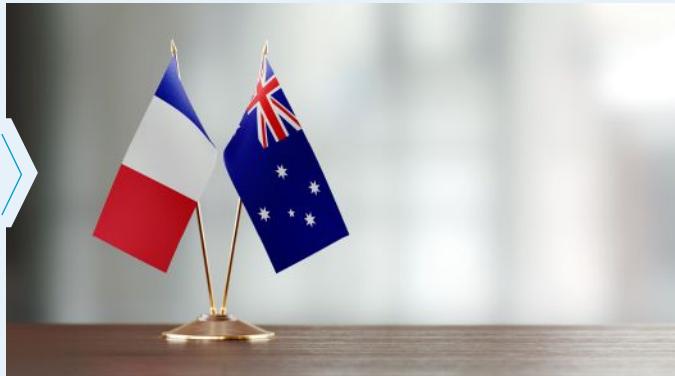
"These combined operations will enhance combat readiness and interoperability with key allies and

partners, and ensure our forces are better prepared to carry out a full range of missions, anytime, anywhere, around the world," Franchetti said.

USS John C. Stennis (CVN 74) deployed from Naval Base Kitsap-Bremerton, Oct. 15, 2018, while USS Abraham Lincoln (CVN 72) deployed from Naval Station Norfolk, April 1, 2019. The carriers are in the midst of a homeport shift, with Stennis eventually heading to Norfolk and Lincoln heading to San Diego.

U.S. 6th Fleet, headquartered in Naples, Italy, conducts the full spectrum of joint and naval operations, often in concert with allied and interagency partners, in order to advance U.S. national interests and security and stability in Europe and Asia.

AMOG & ECA GROUP FORM FRENCH-AUSTRALIAN JOINT VENTURE



Minister Pakula witnesses Australia-France joint venture signing

Australian marine technology firm AMOG Ventures Pty Limited (AMOG) and French naval technology specialist ECA GROUP have formed a Melbourne-based Joint Venture company to pursue a Royal Australian Navy contract worth up to \$100 million.

The birth of the new 50:50 joint venture company, Advanced Magnetic Ranges Australia Pty Limited (AMRA), was witnessed by Victorian Minister for Jobs, Innovation and Trade, The Hon Martin Pakula MP, and the French government's Direction Générale de l'Armement (DGA) representative here in Australia for the RAN's submarine project, SEA1000, General Yannick Cailliez. The two companies, along with Victoria-based THYCON Industrial Pty Limited (THYCON), had previously signed a preliminary Memorandum of Understanding (MoU) at the Euronaval 2018 show in Paris.

AMRA will bid for the RAN's forthcoming Project SEA 1350, to develop a new Magnetic Treatment facility for the Navy. This will see Australia's existing and new submarines and surface ships undergo a vital pre-deployment process called deperming, which reduces or eliminates the magnetism of a steel hull and so aids its stealth, preventing it triggering magnetic mines or attracting certain types of torpedo. All warships and submarines must undergo this process periodically.

The traditional deperming process sees the entire body of a ship or submarine wrapped in a massive wire coil. Electricity is then passed through the coil to reduce the magnetic 'signature' of the vessel - a painstaking process that can take several days. The innovative AMRA approach uses wire coils laid down on the sea bed through which a specific current form is passed as the vessel moves over the coils. This 'over-run' process takes less than one day and therefore provides a significant operational advantage when compared to the traditional wrapping, which can take up to 10 days.

Project SEA 1350 is worth between \$50 and \$100 million dollars and will replace an existing deperming facility used by the RAN; if successful, AMRA would install the new deperming system at Fleet Base West. A key sub-contractor and Australia's leading manufacturer of power quality and conversion solutions, THYCON, also based in Melbourne, will perform the electrical design and manufacturing. Wherever possible, Australian companies will be used in the design, construction and maintenance of the range.

AMOG, which has extensive experience in the offshore oil and gas industry, will carry out the underwater system design; ECA GROUP provides the design expertise and Intellectual Property, and AADI Defence will assist in customer relations.

WWW.AMOGCONSULTING.COM

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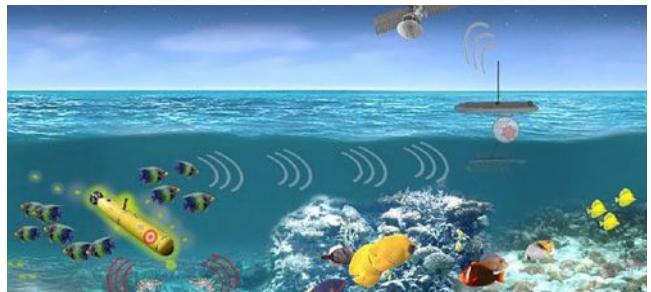
NORTHRUP GRUMMAN SENSING CAPABILITIES FOR DARPA'S PALS PROGRAM

The Defense Advanced Research Projects Agency (DARPA) Biological Technology Office has selected Northrop Grumman Corporation (NYSE: NOC) to prototype sensing capabilities using undersea organisms to assist in passively detecting and tracking undersea threats.

As part of the PALS program, Northrop Grumman will develop biological sensing hardware that has increased sensitivity for certain sensor modalities, achieving greater range. Artificial intelligence will be applied to observe patterns in the marine environment to help classify targets. Northrop Grumman is partnered with Coda Octopus (Nasdaq: CODA), Duke University, University of Maryland, Baltimore County and the University of Memphis.

"The detection, classification and tracking of undersea objects is a critical military capability and we are excited to work with DARPA to develop this next generation approach," said Mike Meaney, vice president, advanced missions, Northrop Grumman.

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MARINE JET POWER AWARDED TAIWAN COAST GUARD CONTRACT



Marine Jet Power (MJP) has been awarded a multi-unit, multi-year contract with CSBC Shipyard to provide propulsion for 15, 100-ton class vessels for the Taiwan Coast Guard (TCG).

The 34-meter vessels will be built at CSBC's facility in Keelung, Taiwan. Featuring dual MJP stainless steel 750 DRB waterjets, the vessels are predicted to exceed 30 knots and will be powered by MTU inboard diesel engines.

"MJP has a long history with the Taiwan Coast Guard and to date we have been involved in TCG previous builds already operational; 50-ton, 100-ton and 500-ton class projects. We are excited to build TCG's next generation of 100-ton class vessels and the start of our relationship with CSBC," said Nils Morén, Sales Manager for MJP.

MJP's DRB line of waterjets are constructed from duplex stainless-steel and feature all inboard hydraulics. The mixed flow pump design offers high performance and increased operational efficiencies resulting in lower

maintenance cost and minimal service intervals.

Michael Kuan from UDC Marine, MJP's Taiwanese Representative, commented on the contract win: "MJP's all stainless-steel construction was a huge consideration for the shipyard and the end user when selecting a propulsion package. CSBC ultimately selected MJP for durability and ease of maintenance in addition to the other long-term benefits waterjets provide to the operator over the life span of the vessels."

Marine Jet Power will begin to deliver waterjets to the shipyard later this year and the 15 vessels will be constructed over the next four years.

WWW.MARINEJETPOWER.COM

PAP-6000 DAVITS FOR THE ROYAL NORWEGIAN NAVY'S LARGEST SHIP

Royal Norwegian Navy's biggest ship to date, KNM Maud, lands in Norway fully equipped with innovative MOB boat launch and recovery system courtesy of Vestdavit.

A high-profile example of the continuing preference of navies and coastguards for Vestdavit boat launching and recovery systems arrived in Bergen's Haakonsvern naval base during March, in the shape of the davits on board KNM Maud.

The multirole Navy Logistics vessel, whose primary task will be to operate as a supply ship is nonetheless the largest ship ever to join the Norwegian Navy fleet. Originally ordered in 2013, the ship was accepted from South Korea's Daewoo Shipbuilding and Marine Engineering yard at the end of 2018 following exhaustive inspections by our home navy, leaving the Okpo yard on 3 February for arrival in Norway by late March.

KNM Maud features two PAP-6000 marine davits capable of lifting MOB boats weighing up to 6 tons in conditions up to sea state 6. The davits are fully equipped with the innovative Vestdavit combination of hydraulic shock absorber, self-tensioning system, hydraulic end stop, wire puller and docking head. These davits can also be operated by Remote Control, so that the operator can get the best view of operations for optimized control.



NAVY CHRISTENS GUIDED MISSILE DESTROYER AND HIGH-SPEED TRANSPORT VESSEL



» The Military Sealift Command high-speed transport USNS Guam (HST 1). Photo credit: Bill Mesta, U.S. Navy.

The U.S. Navy christened its newest Zumwalt-class guided missile destroyer, the USS Lyndon B. Johnson (DDG 1002), during a 10 a.m. EST ceremony Saturday, April 27, at General Dynamics-Bath Iron Works shipyard in Bath, Maine.

The third ship in the Zumwalt-class, DDG 1002 is named in honor of late President Lyndon B. Johnson, who served in office from 1963-1969, and is the first ship to bear his name. The multi-mission Zumwalt-class destroyers will be capable of performing a range of deterrence, power projection, sea control, and command and control missions while allowing the Navy to evolve with new systems and missions. Zumwalt ships are 610 feet long, have a beam of 80.7 feet, displace almost 16,000 tons, and are capable of making 30 knots speed.

That same day, the Navy will also christen its newest high-speed transport vessel, the USNS Guam (T-HST 1), during a 10 a.m. Japan Standard Time ceremony Saturday, April 27, in Okinawa, Japan.

USNS Guam is named to honor the long-standing historical and military relationship between Guam and the United States. She is the fourth ship to bear the name Guam. USNS Guam is an aluminum catamaran designed to be fast, flexible and maneuverable, even in austere port conditions, making the vessel ideal for transporting troops and equipment quickly. USNS Guam's 25,000-square-foot mission-bay areas can be quickly reconfigured for any cargo requirement, from supporting disaster relief to transporting troops and equipment.



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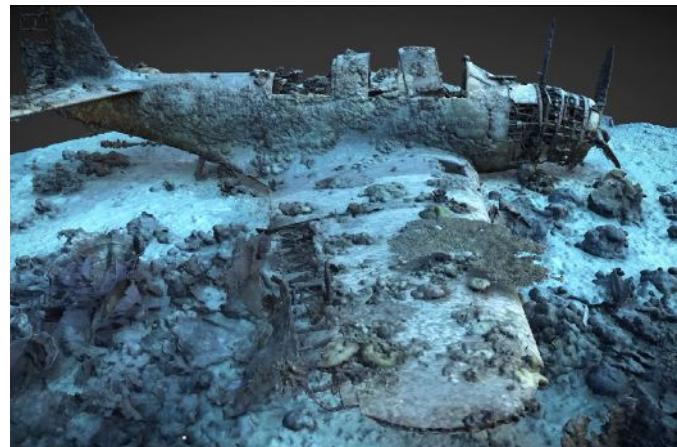
3D AT DEPTH CONDUCTS SUBSEA LASER LiDAR TAKES UNDERWATER SURVEY OF DOUGLAS TBD-1 DEVASTATOR EXPEDITION

3D at Depth Inc. has developed an innovative underwater survey technique that integrates photogrammetry with Subsea laser LiDAR (SL) technology to create accurate, precise, reverse engineered 3D models.

The technique was developed during an October 2018 expedition with the Air/Sea Heritage Foundation to document the wreck of U.S. Navy Douglas TBD-1 Devastator aircraft resting at the bottom of Jaluit Lagoon in the Republic of the Marshall Islands (RMI). Of the 129 Devastators built, all were either lost in battle, destroyed in operational accidents, or scrapped before the end of World War II. Part of the ongoing "Devastator Project," this expedition aimed to capture precise, repeatable, millimetric data to build an accurate 3D model as a site map for this significant cultural asset; and to serve as a "pre-disturbance survey" for the proposed recovery, conservation and public exhibition of the plane at the National Museum of the United States Navy in Washington, DC.

This particular Devastator, formerly assigned to Torpedo Squadron Five aboard the aircraft carrier USS Yorktown, is located in a sensitive marine habitat. In order to conduct a safe, touchless, accurate survey, that would render a world-class 3D model, the expedition brought together a group of leading experts and volunteers utilizing the most advanced technology available.

Although the Devastator appeared largely intact from previous research expeditions, the sensitive nature of the wreck and often low water clarity conditions around the site provided

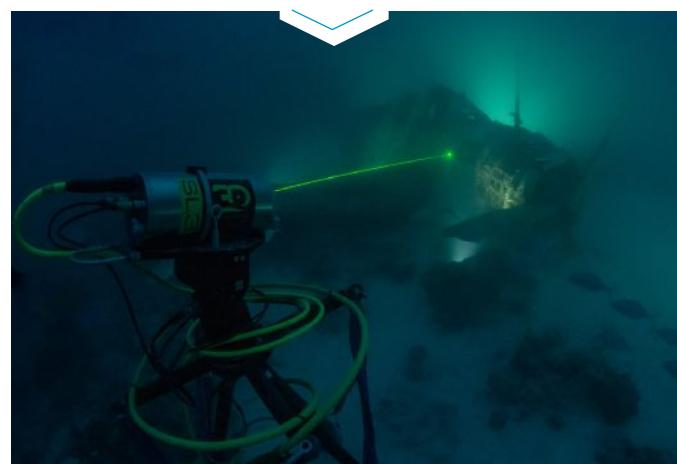


» Image courtesy of 3D at Depth.

limitations for most of the standard data collection processes and other optical imagery collection methods. In addition, as a pre-disturbance survey, it was important to capture not only the repeatable, accurate, millimetric details of the aircraft but also the substance and structures of the marine biomass on and around the aircraft. These challenges created a unique opportunity for 3D at Depth's SL3 subsea laser LiDAR with its powerful real-time 3D data processing unit. In addition, the team used still photography, 4K video, 3D photogrammetry, and 360° VR.

Over six days on site, dozens of dives were conducted to the wreck located under 130 ft of water. Four registration markers were set in pre-approved areas to check accuracy for both laser scans and photogrammetry technology. 3D at Depth's SL3 laser was deployed at varying ranges from the wreck site while maintaining a safe distance, so as not to disturb the surrounding area. The steerable beam allowed for flexibility and accuracy while working alongside other technology applications. The SL3 pulsed at 40,000 measurements/sec for each scan position acquiring very high-density sector scans. 3D at Depth's patented index of refraction correction algorithm was able to deliver repeatable data sets in low clarity water quality where other optical solutions would struggle to operate.

In total, the SL3 LiDAR laser delivered a total of 92 million points and the photogrammetric data after processing produced 5.7 million vertices. Each dense point cloud was then surface modeled and moved into a 3D design computer. Optical imagery from photogrammetry, 360 VR and stills were integrated into the designs to render an exact 3D model of the Devastator. Along with the laser LiDAR data, the team captured 1,398 still images with photogrammetry.



» Photo credit: Brett Seymour, Air/Sea Heritage Foundation.

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SPRINGTIME IN THE OIL PATCH

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

CRUDE OIL MARKET

Last month, we wrote how Springtime would present the first true test of the health of the global oil market, as June will mark the end of the six-month OPEC+ production cut agreement that has propped up oil prices. We suggested that OPEC, led by Saudi Arabia, would work overtime to convince Russia to agree to an output cut extension as insurance against another buildup in oil inventories, should global economic activity slow, sending oil prices into the tank. Recent business news highlights conflicting economic outlooks around the globe. Germany's economic growth is barely positive, while fears about slowing U.S. growth are being dispelled by strong monthly retail and new home sales. Elsewhere, China is pumping up its economy, while Japan's slows, and in the European Union, 2019's projected growth rate has been cut by half a percentage point to 1.5 percent. Weaker economies are not good for oil demand.

On the oil supply side, the crumbling infrastructure of Venezuela and continuing leadership battle has translated into a steady fall in output. The civil turmoil in Libya has escalated, prompting fears over its future output. But, the most important event was the Trump administration's decision to allow waivers for the purchase of Iranian crude oil to expire. Beginning in May, eight countries – India, China, Turkey, Greece, Italy, Japan, South Korea and Taiwan – with waivers must seek new sources of crude oil, or risk continuing to trade with Iran, even surreptitiously, in defiance of U.S. sanctions. To offset concern about a potential supply shortfall and sharply higher oil prices, the United States announced that Saudi Arabia and the United Arab Emirates, long-standing supporters of U.S. Iranian policies, would increase their exports. The market expects this additional supply, coupled with continued U.S. oil production growth, will be sufficient to meet global oil needs.

The U.S. sanctions announcement sent global oil prices soaring, extending the market's up-trend that began in February. Domestic oil prices have climbed above \$66 per barrel, while Brent exceeded \$74. Oil producers are enjoying the increased revenue from higher commodity prices, but this extra income has not created an activity frenzy – at least not yet. The recent second quarter earnings reports of leading oilfield service companies – Schlumberger and Halliburton – carried the message that the worst of the service pricing drop due to the 2018 oil market collapse is behind them. The key messages from the managements is that customers remain cautious about spending (forecasts call for modest declines this year), but they are looking increasingly for opportunities offshore and internationally. Both venues are more attractive now due to operational efficiencies and overall cost-cutting that have reduced breakeven prices.

In North America, higher oil prices have yet to boost drilling and production. The Grand Dame of the oil patch – the Permian Basin – remains hampered by the lack of pipeline capacity to move

increased output to market. This constraint will ease as we enter the second half of 2019 when new pipelines begin operating. Then the test of managements' financial discipline will begin. Producers will have more money for drilling, debt reduction, and to return to shareholders. Will stepped up activity be greeted with cheers or jeers? Whichever reaction emerges, it will influence future supply growth, and in turn future oil prices. More supply will cap the oil price advance. On the other hand, soaring oil prices will prompt a consumer reaction, sending demand down and causing another oil patch slump. The future of oil prices in the second half of 2019 and in 2020 will become clearer as we move through the ensuing weeks. Will the green shoots of higher oil prices thrive, or will they be suffocated by too much drilling and production?

NATURAL GAS MARKET

What once was merely a boring market may become a terrifying one. For months, gas producers have wondered why prices have not responded to the extremely low natural gas storage reports. Traditionally, when gas storage volumes are at or near record lows, prices rise to induce producers to bring on more supply. That additional supply was crucial if the industry was to satisfy current gas demand and rebuild storage for the following winter's needs. Last year, and to date this year, gas prices have failed to respond to the sharply lower storage volumes.

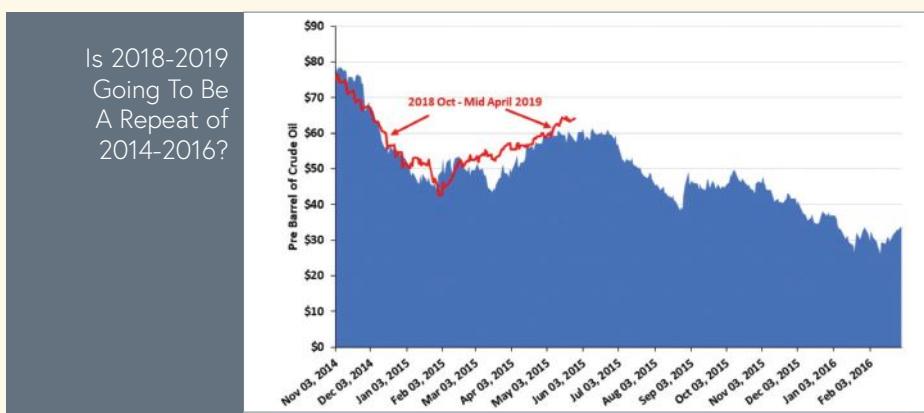
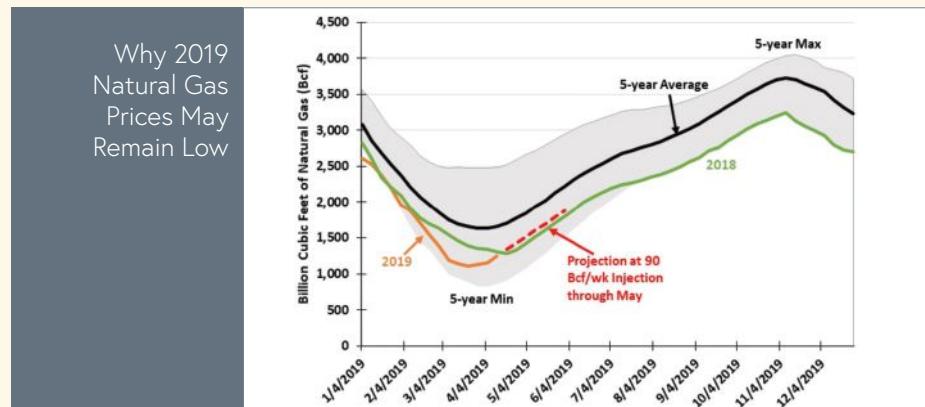
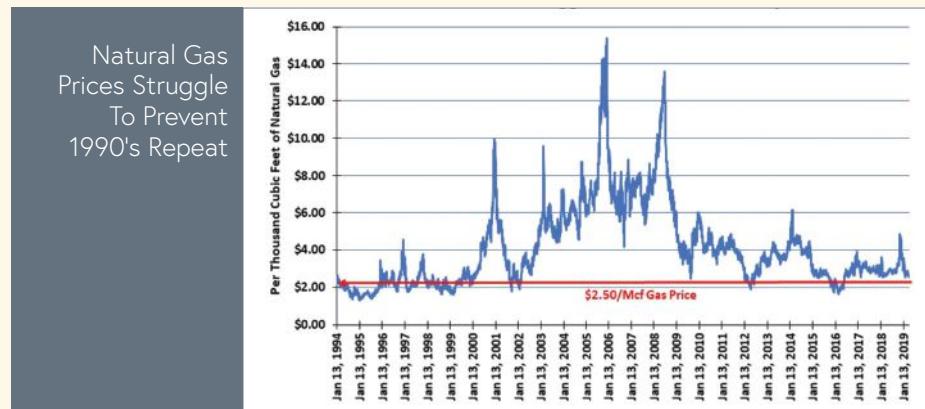
This lack of concern over possible supply shortfalls was reinforced by the EIA gas storage report for the week ending April 12. It showed the industry not only meeting all current gas demands – home heating, electricity generation, LNG exports, and pipeline shipments to Canada and Mexico – but also injecting 92 billion cubic feet of gas into storage. That was more than four times the average for the comparable week during 2014-2018. All of this was accomplished as producers in the Permian flared record volumes of natural gas extracted in association with the crude oil.

With the nation finally moving out of winter's cold and into more moderate weather, the absence of heating demand and electricity for air conditioning will foster several weeks of large gas storage injections. That expectation is reinforced by continuing gas production growth, even in basins where it is impossible to get the output to market, forcing it to be flared. There is so much gas being produced in the Permian that the price fell below zero, meaning producers were paying pipelines to haul the gas away rather than being paid for the commodity.

If gas injections remain at the April 12 level for the balance of April and May, gas storage will climb above last year's level. More importantly, from the end of May through the end of the injection season in October, the industry needs to only average 60 Bcf/week of injections to reach last winter's starting gas inventory. If weekly injections average one-third larger, storage would return to the 5-year maximum.

The EIA has predicted that average gas production during this year's spring/summer injection season will increase by 8.3 Bcf/week over 2018's volume. That additional supply will handle current gas needs plus meet an additional 2.7 Bcf/week of LNG and pipeline export demand. That signals there is plenty of gas supply – in fact, maybe a glut! That supply cushion begins to erode in 2020, however, gas prices have yet to recognize that trend.

In anticipation of the April 12 storage report, gas futures prices dropped precipitously. Gas prices currently are below \$2.50 per thousand cubic feet. As the accompanying chart shows, since the 1990s, prices have only been below \$2.50/Mcf, and even below \$2/Mcf, four times, but none for any meaningful duration. That may not be the case this year. Could we be headed for \$1+ natural gas prices? The next few weeks will prove crucial for the gas market.

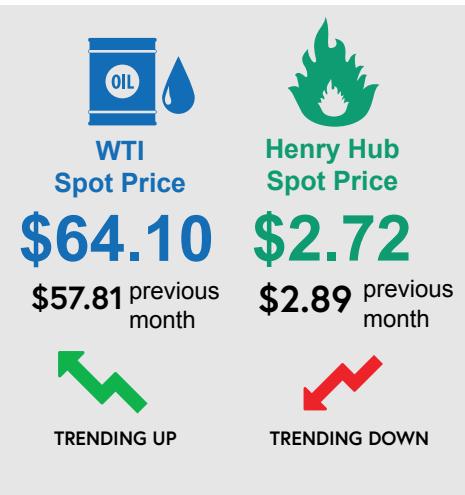


CRUDE & NATURAL GAS Spot Prices

PRICES IN US DOLLARS AS OF APRIL 12, 2019

Oil prices continued their steady climb through 2019 and reached a six-month high in mid-April. The WTI Spot Price crossed the \$60 per barrel mark in April and continued climbing over concerns that new U.S. sanctions on Iran could tighten supply, according to CNBC.

Natural gas prices, however, are falling. Prices have been below \$3.00 per million BTU for most of 2019, with just a couple of spikes during



KEY EQUITY Indexes

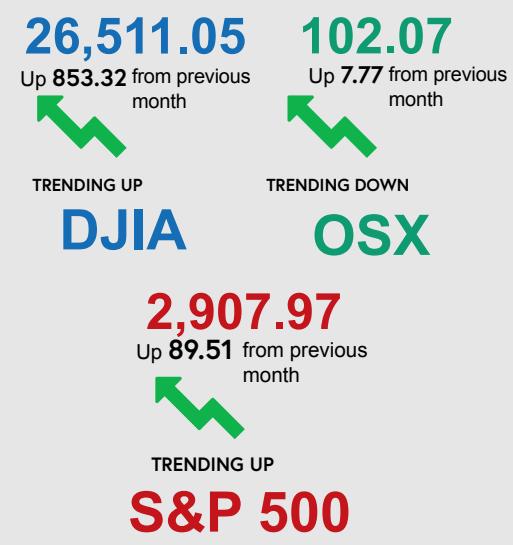
PRICES IN US DOLLARS AS OF APRIL 22, 2019

THE DOW JONES INDUSTRIAL AVERAGE AND S&P 500 have fallen significantly in the past month

The Dow Jones and S&P 500 indexes have gained consistently, if slowly, in 2019, but in the past month the gains were more dramatic. Driven largely by solid financial reports, both indexes are nearing record levels. The Dow gained nearly 1,000 points in the past month, surpassing the 26,500-point mark. The only other time the Dow has reached that territory was last fall, when the index exceeded 27,000 points briefly before dropping back. The S&P 500 gained nearly 100 points in the last month to pass the 2,900-point mark. Again, this puts the index into territory that it only reached a couple of times before – in the late summer and fall of 2018.

The Philadelphia Oil Service Sector Index (OSX) has had a good 2109 as well. The OSX has risen consistently through the first four months of 2019 and surpassed the 100-point level in mid-April, reaching 102 points on April 22. While this is still well below the 155 points where the OSX stood a year ago, it represents a steady improvement from the low of 77 points it recorded in late December.

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www.h2oconference.ca

US Offshore Wind

Boston, MA » June 10-11
events.newenergyupdate.com/offshore-wind

Brazil Offshore

Rio do Janeiro, Brazil » June 25-28
www.brasiloffshore.com

ESRI User Conference

San Diego, CA » July 8-12
www.esri.com/en-us/about/events/uc/overview

PORTS'19

Pittsburgh, PA » September 15-18
www.portsconference.org

OilComm

Houston, TX » October 2-3
www.2019.oilcomm.com

Teledyne Marine Tech Workshop

San Diego, CA » October 6-9
www.teledynemarine.com/events/TMTW2019

LAGCOE

New Orleans, LA » October 9-11
www.lagcoe.com/home-expo

AWEA Offshore WINDPOWER

Boston, MA » October 22-23
engage.awea.org/Events

OCEANS'19

Seattle, WA » October 28-31
www.seattle19.oceansconference.org

OTC Brazil

Rio de Janeiro, Brazil » October 29-31
www.otcbrasil.org

EUROPE

Seanergy

Dunkerque, France » June 5-7
www.seanergy2019.com

OMAE

Glasgow, UK » June 9-14
www.event.asme.org/OMAE

OCEANS '19 Europe

Marseille, FR » June 17-20
www.oceans19mtsieemarseille.org

European Wave and Tidal Energy Conference

Napoli, Italy » September 1-6
www.ewtec.org/conferences/ewtec-2019

SPE Offshore Europe

Aberdeen, UK » September 3-6
www.offshore-europe.co.uk

Maritime Transport

Rome, Italy » September 10-12
www.wessex.ac.uk/conferences/2019/maritime-transport-2019

DSEI

London, UK » September 10-13
www.dsei.co.uk

Ocean Energy Europe

Dublin, Ireland » Sept. 30 - Oct. 1
www.oceanenergy-europe.eu/annual-event/oee2019

Offshore Energy

Amsterdam, The Netherlands
» October 8-9
www.offshore-energy.biz

WindEurope Offshore

Copenhagen, Denmark
» November 26-28
www.windeurope.org/offshore2019

AUSTRALASIA

MAST

Tokyo, Japan » June 17-19
www.mastconfex.com/asia2019

Philmarine

Manila, Philippines » June 18-20
www.philmarine.com

Marine & Offshore Expo

Batam, Indonesia » August 20-22
www.batam-marine.com

Submarine Networks World

Singapore » September 17-19
www.terrapinn.com/conference/submarine-networks-world/index.stm

Bahrain Int'l Defense Conference

Manama, Bahrain » October 28-30
www.bahraindefence.com

ADIPEC

Abu Dhabi » November 11-14
www.adipec.com

Oceanology International China

Shanghai » November 13-15
www.oichina.com.cn/en/home

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FEBRUARY		
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MARCH		
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APRIL		
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MAY		
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JUNE		
» Offshore Energy Exploration » Ocean Sound	Sonar Systems and Vessels; Imaging & GIS; Magnetometers	TBD
JULY		
» Unmanned Vehicles Buyers' Guide	ROV, AUV, USV, Glider, Towed Vehicles	TBD
AUGUST		
» Submersibles (AUV, ROV, UUV)	Cranes, Winches, LARS & Control Systems; Sensor, Profilers, Measurement; Thrusters; Umbilical, Tether, Cables, and Connectors	SPE Offshore Europe » September 3-6 Teledyne Marine Tech » October 6-9
SEPTEMBER		
» Renewables » Offshore Energy Installation & Maintenance	Energy Storage Devices; Inspection Drones; Current Meters	Ocean Energy Europe » Sept. 30-Oct. 1 Offshore Energy » October 8-9
OCTOBER		
» Ocean Science & Technology	Acoustic Modems; Acoustic Releases, Transponders, Command & Control Systems; Technical Schools, Training Programs	OCEANS'19 » October 28-31
NOVEMBER		
» Oil Spill Prevention & Response » Ocean Archaeology & Salvage » Executive Profile	Buoyancy Materials; Pressure/Watertight Housing; Well Control Equipment	TBD
DECEMBER		
» Upper Deck Equipment Guide	LARS, Winches, Cranes, A-Frames, and Buoys	TBD



JAN DE NUL DELIVERING MONOPILES TO TAIWAN OFFSHORE WIND PROJECT

Jan De Nul Group reached an important milestone on the Formosa 1 Phase 2 Offshore Wind Farm (OWF) project when all 20 foundation monopiles left the EEW SPC yard in Germany onboard of two heavy load transport vessels. This transport was an important step in the procurement phase of this project, because their arrival in Taiwan means that installation operations can begin.



Apart from the overseas procurement and services, Jan De Nul Group has finalized various service and subcontract agreements with local entities in Taiwan. After having appointed Taichung Port as marshalling harbor for the project, Jan De Nul set up its local supply chain, which includes quarry rock production for the foundation scour design, rock load-out operations, storage and transport of the foundation structures, installation of transition joint bays and land cables installation.

Philippe Hutse, Offshore Director at Jan De Nul Group, said, "These engagements fit perfectly in our philosophy of involving the local supply chain as much as possible."

The Formosa 1 offshore wind farm is located 3 km off the coast of Miaoli. Formosa 1 Phase 1 OWF contains two Siemens 4MW demonstration turbines, the very first offshore turbines installed off Taiwan. Phase 2, the contract awarded to Jan De

Nul Group, concerns the extension of the Phase 1 OWF adding twenty 6MW turbines with a total output of 120MW.

Jan De Nul's scope entails the procurement and installation of the WTG foundations, including scour protection and cables. Construction will be completed in 2019.

The Formosa 1 Phase 2 Offshore Wind Farm is owned by Formosa 1 Wind Power Co. Ltd., a partnership of Ørsted A/S (35%), JERA (25%), Macquarie Capital (25%), and Swancor Renewable Energy Co. Ltd (15%).

<https://www.jandenul.com/en/pressroom/press-releases/jan-de-nul-reaches-important-milestone-in-formosa-1-phase-2-owf-project>.

JUDGE RULES AGAINST RE-OPENING ARCTIC OCEAN FOR OIL DRILLING

Feds to appeal decision that could set lasting legal precedent.

By Greg Leatherman, ON&T Editor

On 29 March 2019, a federal judge for the District of Alaska ruled that a key section of President Donald J. Trump's executive order titled 'Implementing an America-First Offshore Energy Strategy' is 'unlawful and invalid.'

That section would have opened up federally protected areas that cover large swathes of the Arctic Ocean for oil and gas exploration and production. The ruling also blocks offshore drilling around coral canyons that stretch from Maine to southern Virginia. However, the potential reach of this ruling does not end with these offshore lands. Because the ruling required the Court to interpret a federal statute, it could have broad implications for this and future presidential administrations.

In the lawsuit brought by the League of Conservation Voters, et al., plaintiffs argued that the President does not have the authority to revoke previous executive actions withdrawing lands from oil and gas leasing. Counter arguments from the federal government, the State of Alaska, and the American Petroleum Institute (API), were made on behalf of the President's order being valid.

Arguments on both sides centered on

language in the Outer Continental Shelf Lands Act (OCSLA) of 1953, which provides for the jurisdiction of the United States over OCS lands and authorizes the Secretary of the Interior to lease such lands for certain purposes, such as natural resource extraction.

The case specifically focused on a section of the OCSLA that says, ""The President of the United States may, from time to time, withdraw from disposition any of the unleased lands of the outer Continental Shelf."

As summarized in official court documents, in 2015 and 2016, President Obama issued three memoranda and one executive order withdrawing certain areas of the Outer Continental Shelf from easing. On April 28, 2017, President Trump issued Executive Order 13795, which purported to revoke the 2015 and 2016 withdrawals. Both the decision to withdraw lands, as well as the reversal, were unprecedented.

Plaintiffs maintained that this text only authorizes a President to withdraw lands from disposition; it does not authorize a President to revoke a prior withdrawal. Plaintiffs also assert that under the Property Clause of the U.S. Constitution,



the authority to revoke a prior withdrawal was not delegated by this statute to the President and thus remains vested solely with Congress.

The federal government argued that such authority to revoke prior land withdrawals (offshore, in this case) could be implemented at the President's discretion.

In her ruling, U.S. District Judge, Sharon Gleason vacated the section of Executive Order 13795 revoking those withdrawals and denied motions from the federal government, the American Petroleum Institute (API), and the State of Alaska. The federal government is expected to appeal the decision to the Court of Appeals for the Ninth Circuit and the case could eventually go to the U.S. Supreme Court, due to its unique questions of presidential authority.

BOB BRYCE JOINS REVER OFFSHORE EXECUTIVE TEAM

Rever Offshore, subsea services provider to the oil and gas industry, has announced the appointment of Bob Bryce to the newly-created role of Operations Director.

Mr. Bryce's 40-year career in the oil and gas industry has seen him hold senior leadership positions on a global basis with key subsea-surf contractors, including McDermott, Subsea7 and Technip. He joins Rever's executive team with a remit to oversee the operations, assets & services and QHSE functions. He does so as the company announces a board restructure and will sit alongside fellow executive team members, Barry Macleod (CEO), Nicky Etherson (Commercial Director) and Neale Stewart (Chief Financial Officer).

The reorganization reflects the commitment to strengthen operational execution, together with a real focus upon growth opportunities. An increase in flexibility and responsive decision making will allow Rever to reinforce client relationships and exceed expectations.

Commenting on Mr. Bryce's appointment, Barry Macleod said, "His strong track record in day-to-day project operations and EPIC contract execution will add valuable strength to the company. He brings a huge amount of experience in asset development from the design and build of vessels and heavy



» (Left to Right) Barry Macleod and Bob Bryce

installation equipment, to global CAPEX portfolio management and we are confident that his skills and experience will ensure we continue to create sustainable competitive advantages."



www.reveroffshore.com

SENSOR TECHNOLOGY SHIPS FIRST HYDROPHONES FROM ITS NEW NOVA SCOTIA FACILITY

Sensor Technology Ltd. made its first shipment of custom hydrophones during the week of 3 May 2019 from its new facility at Nova Scotia's Centre for Ocean Ventures and Entrepreneurship (COVE). Sensor Technology's President and CEO, Niru Somayajula was on hand for the occasion and excited about the expanded manufacturing capacity the new facility offers.



» The NS Sensor Technology team, from right to left: Sheila Mason, Geof MacIntyre, Alice Qi, Derek MacKenzie, Niru Somayajula, and Gennavieve Ruckdeschel.

"Due to strong growth in the past few years, our production facilities in Collingwood were bursting at the seams and under increased pressure. The COVE facility opened at a perfect time for us, proving both much needed space, as well as a key connection to the heart of the Canadian Ocean Tech community."

The first shipment of custom hydrophones is going to Switzerland as part of a long-standing contract with a key customer.

About Sensor Technology Ltd.

Sensor Technology Ltd. provides piezoelectric solutions to companies around the globe. The company has been designing and manufacturing piezoelectric ceramic materials, custom acoustic transducers, and custom hydrophones in Canada, since 1983. For more information, visit <https://sensortechcanada.com/>

FIRST UK OFFSHORE WIND FARM DECOMMISSIONED



The two-turbine 4MW Blyth project, the first offshore wind farm (OWF) built in UK waters has been decommissioned by E.ON. The Blyth OWF features two 2MW turbines commissioned in December 2000, which were at that time the most powerful units.

According to E.ON, wind farms usually have a lifespan of 20-25 years and Blyth has reached the end of its time. One turbine is expected to be recycled and reused for spare parts within E.ON's onshore wind project, with the other to be used by the Port of Blyth for training purposes.

E.ON UK Renewables developed Blyth in a consortium with Shell Renewables, Nuon UK and AMEC Wind.

MARINE TECHNOLOGY SOCIETY AWARD NOMINATIONS NOW OPEN FOR 2019

The Marine Technology Society (MTS) has opened a public call to members for nominations for the MTS awards presented during the OCEANS North America Conference, October 27-31, 2019, in Seattle, Washington.

As part of this event, ON&T will present the Young Professional Award to an individual 35 years of age or younger who is an MTS member in good standing, who has shown leadership in MTS, and who works in a professional capacity in management, engineering, or research and development in a marine technology field.

Overall, there are a total of ten awards ranging from Designation as a Marine Technology Fellow to awards for the sections, committees, and individuals of the Society. A new award added in 2019 is the John P. Craven Mentor Award for outstanding and sustained service to the field of marine technology through mentoring.

Recipients receive an award and published recognition in brochures, the OCEANS program, the bi-monthly newsletter, Currents, as well as industry magazines. Recipients of these awards represent the respected recognition of accomplishments, dedication, and contribution to the marine industries by their peers.

How to Nominate: Please submit complete nomination packages to the MTS staff point of contact, Monica Ostrander, via email: Mostrander@mtsociety.org. Nominations are due by 11:59 p.m. EST on May 31, 2019. Late nominations will not be accepted. Applications are available on the MTS website: <https://www.mtsociety.org/About/awards.aspx>



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www.H2Oconference.ca



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

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 Contact: Shawn Amirehsani



For over 50 years, Falmat Cable has been a key supplier and a solution provider to many global OEMs and end users supporting a wide range of marine applications. We design and manufacture high performance cables for use in harsh and demanding environments. Our rugged Xtreme cables are known and preferred worldwide for superior reliability and durability in commercial and military projects. We offer XtremeMarine cables with precision coaxial components for use with SD/HD video requirements, wet rated submersible pump cables, miniature fiber optic cables, a comprehensive range of highly engineered ROV Tethers plus our well recognized Xtreme Ethernet cables. Falmat is a Certified ISO9001/AS9100 organization. Visit our web site: www.falmat.com.

SOUTH BAY CABLE CORP
 54125 Maranatha Drive
 P.O. Box 67
 Idyllwild, CA 92549
 Phone: (951) 659-2183
 Fax: (951) 659-3958
 E-mail: bill@southbaycable.com
 Website: www.southbaycable.com
 Contact: Bill Tell, Sales Manager



Since 1957, South Bay Cable Corp has designed and manufactured specialized electrical, electro-mechanical and electro-optical-mechanical cables for use in demanding marine environments. Cables are designed to meet customer requirements and include tether and umbilical cables for ROVs, tow cables, video inspection, faired cables and a host of other customer specific applications.

CONNECTORS

BIRNS, INC.
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 Oxnard CA 93033-1863 USA
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 Fax: +1 805 487 0427
 USA: +1 888 BIRNS 88 (+1 888 247 6788)
 E-mail: service@birns.com
 Website: www.birns.com
 Contact: Eric Birns



BIRNS has served the subsea industry since 1954, and is an ISO 9001:2015 certified global leader in the design and manufacturing of high performance connectors, cable assemblies and lighting systems. With a NAVSEA PRO-020 certified molding facility, it offers sophisticated connector lines, including 6km-rated electrical, electromechanical, coaxial, electro-coax, optical, electro-optical and electro-opto-mechanical hybrids. BIRNS provides the industry's highest volume of cost-effective hydrostatic and helium pressure testing, and has a wide range of ABS Product Design Assessment (PDA) certified fiber optic and electrical penetrators. BIRNS' LED and tungsten-halogen marine, chamber, security and commercial diving lights are trusted in the world's most extreme environments.

BIRNS AQUAMATE LLC
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 Pawtucket, RI 02860 USA
 Tel: +1 (401) 723 4242
 Fax: +1 (401) 753 6342
 E-mail: sales@birnsaquamate.com
 Website: www.birnsaquamate.com
 Contact: Eli Bar-Hai



Birns Aquamate design and manufacture underwater electrical connectors, cable assemblies, and cable terminations. The company produces a wide range of standard industry products such as the 5500 Series, SC, MC, LP, FAWL/FAWM, NANO, TC, Rubber Molded, etc. Birns Aquamate is the only manufacturer to guarantee compatibility with other uw connectors. Birns Aquamate also specializes in fast turn-around for custom design of special connector solutions. All connectors are manufactured under DNV ISO 9001:2000 certification. Dealers in Canada, Brazil, UK, Belgium, Holland, Norway, Germany, South Africa, Holland, Italy, and China.

SEACON
 1700 Gillespie Way
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 Tel: +1 619 562 7071
 Fax: +1 619 562 9706
 E-mail: elcajonsales@te.com
 Website: www.seaconworldwide.com



For the widest range of connectivity and sensor solutions designed for subsea applications, TE Connectivity (TE)'s portfolio includes over 2,500 underwater electrical and fiber optic connectors, and complete connectivity systems to give you a wide range of advanced connectivity options. The portfolio includes not only SEACON products, but DEUTSCH connectors, Rochester engineered cables, and TE sensors – giving you one-stop access to rugged, reliable solutions.

TELEDYNE MARINE
 1026 N. Williamson Blvd.
 Daytona Beach, FL 32114
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 E-mail: TeledyneMIS@teledyne.com
 Website: www.teledynemarine.com



Teledyne Marine Interconnect Solutions integrates the resources of ODI, DGO, Impulse, and Cable Solutions into a single organization that supplies innovative, high-performance solutions for harsh environment interconnect. Solutions for these harsh environments include wet-mate, splash-mate and dry-mate connectors, pressure boundary penetrators, cable assemblies, cable terminations, and custom-engineered encapsulation and molding. TMIS contains a broad portfolio of field-proven, time-tested electrical, optical, and hybrid interconnect capabilities optimized for applications where performance and reliability are imperative. Products are available as stand-alone items, or as complex solutions that integrate technologies into advanced, value-added systems.

DESIGN & ENGINEERING

HYDRO LEDUC NA, INC.
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 Houston, TX 77084
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 E-mail: bogden@hydroleduc.com
 Website: www.hydroleduc.com



Hydro Leduc is a specialist in the design and manufacture of hydraulic piston pumps, hydraulic motors, hydro pneumatic accumulators, and customized hydraulic components satisfying customer needs with reliable products from a reliable source. As the leader in micro hydraulics, it is feasible to obtain several tons of force from a minimal power source within a restricted space envelope. The techniques of micro hydraulics allow simple solutions to problems that are often beyond the limits of traditional mechanical options. Hydro Leduc's expertise is at your service in varied applications such as oil service tools, oceanographic instrumentation, aeronautics, and any extreme working condition of temperature, pressure, medium, and environment.

DIGITAL VIDEO RECORDING SYSTEMS

DIGITAL EDGE SUBSEA, LTD
 Doubletree Court, Cavendish St.
 Ulverston, Cumbria
 LA127AD
 E-mail: john@digitaledgesubsea.com
 Website: www.digitaledgesubsea.com
 Contact: John Benson



The EdgeDVR is currently used worldwide by most of the major ROV and Diving contractors. With our present Version 4 software, we have 6 models. The EdgeDVR has become an essential part of any ROV and Diving system offshore, easy to use and reliable. The system is capable of recording simultaneous High Definition and Standard Definition video, together with auto creation of Dive, Video, Photo and Anomaly logs. Multi channel digital overlay is also available for all recorded channels, logos and real-time survey data can be displayed. With around 500 systems now offshore, we have a proven record of reliability.

Our version 5 software is currently in development and full details will be released soon....

EQUIPMENT RENTAL

OKEANUS SCIENCE & TECHNOLOGY, LLC

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Fax: 985-346-8444
E-mail: Bleblanc@okeanus.com
Website: www.okeanus.com
Contact: Benton LeBlanc



Okeanus is the premier rental provider for oceanographic and marine scientific research equipment utilized in nearshore and offshore projects around the world. Focused on providing industry-leading customer service, Okeanus offers advanced, high-quality technology coupled with knowledgeable and experienced staff that can deliver dedicated support regardless of a project's location.



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Website: www.oceanspecialists.com



Ocean Specialists, Inc. (OSI) is a system development and advisory firm for undersea cable projects and technology with global capabilities. OSI works with clients during all project phases of subsea network development, from planning and design to procurement and implementation. Our customers, primarily representing Oil and Gas, Telecommunications and Ocean Observing, recognize the value of fiber optic networks to their field and services solutions, and look to OSI to deliver the skills and experience that developing these networks require.

GYRO COMPASSES

KONGSBERG SEATEX AS

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Fax: +47 73 51 50 20
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Website: www.km.kongsberg.com/seatex
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KONGSBERG

Kongsberg Seatex is a leading international marine electronics manufacturer specializing in the development and production of precision positioning and motion sensing systems. Our commitment is to provide quality products and solutions for safe navigation and operations at sea in the commercial offshore, maritime, hydrographics and defence industries.

LIQUID STORAGE

AERO TEC LABORATORIES, INC. (ATL)

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Fax: +1 201 825 1962
E-mail: atl@atlinc.com
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Contact: David Dack



ATL specializes in the design/manufacture of custom bladder-type fluid containment systems, including tanks, inflatables, pillows and bellows for surface and subsea. ATL's flexible fluid containers boast unparalleled chemical tolerance, abrasion resistance, and remarkable durability - used with methanol, diesel fuel, gases, ethylene glycol, hydraulic fluids and chemical cleaning cocktails. Expedited deliveries are also available.

MARINE ENVIRONMENTAL CONSULTING SERVICES

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Website: www.csaocean.com
Contact: Gordon Stevens



CSA Ocean Sciences Inc. (CSA) is a marine environmental consulting firm specializing in multidisciplinary projects concerning potential environmental impacts of activities throughout the world. With extensive experience in environmental sciences and technical field operations, CSA is staffed and equipped to offer a complete range of services for projects in offshore, nearshore, estuarine, wetland, and freshwater environments.

MARINE VENTURES INTERNATIONAL, INC. (MVI)

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Website: www.marineventures.com
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Marine Ventures International, Inc. (MVI) provides high quality, marine environmental and technical experts to conduct coastal and offshore field operations worldwide. We leverage our wealth of talent and resources to bring you a customized team of independent contractors, subject matter experts and specialized equipment to get the job done. Our professionals work in a variety of sectors from submarine cable projects and engineering services to protected species observation and environmental consulting.

MOTION SENSING EQUIPMENT

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NAVIGATION & POSITIONING SYSTEMS

ADVANCED NAVIGATION

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E-mail: sales@advancednavigation.com.au
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Advanced Navigation is a privately owned Australian company that specialises in the development and manufacturing of navigation technologies and robotics. The company has a focus on generating products of the highest quality standard, both in terms of hardware and software. Advanced Navigation has specialised expertise across a broad range of fields including sensors, GNSS, inertial navigation, RF technologies, acoustics, robotics, AI and algorithms. Advanced Navigation is an ISO 9001 certified company and maintains a strict quality control system across the two research facilities and three manufacturing facilities that they operate in Australia. Advanced Navigation is a carbon neutral company, offsetting all emissions due to energy use through the planting of trees.

EVOLOGICS GMBH

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Website: www.evologics.de



EvoLogics provides the world's most advanced spread-spectrum underwater communication systems (S2C) with multi-channel data management, networking capability, built-in tracking and positioning functions with USBL Data loggers, acoustic wake-up module and releasers optionally included. Deployments in offshore platforms (FPSO, ABS), environmental monitoring, defense systems, ROV and AUV operations and more. Applications include simple positioning and sensor information to transmission of underwater photos.

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RJE International offers product design, development, evaluation and marketing for military divers, offshore and marine scientific communities, search and rescue teams, and more. RJE has become the industry leader in diver navigation and acoustic relocation. Our team has an extensive background in developing, manufacturing, and supplying underwater acoustic marking and relocation systems, diver navigation platforms, and other subsea equipment.

ROMOR OCEAN SOLUTIONS

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 Contact: Darrin Verge, President & CEO



ROMOR Ocean Solutions provides instrumentation solutions for the geophysical, oceanographic, defense, security, oil & gas, and renewable energy industries. By partnering with world renowned manufacturers, ROMOR is able to offer technical knowledge, value added services, logistics expertise, and the most reliable instrumentation on the market.

NETWORK & DATA COMS

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SEA-BIRD SCIENTIFIC

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Sea-Bird Scientific provides best-of-class sensors and systems for oceanographic research and environmental water quality monitoring of physical and biogeochemical properties. Sea-Bird Scientific is the leader in accurate, stable ocean instruments for measuring conductivity (salinity), temperature, pressure, oxygen, pH, chlorophyll, CDOM, turbidity, beam attenuation, irradiance, radiance, PAR, nitrate, and phosphate. Our CTD profilers, water samplers, moored CT recorders, wave/tide recorders, DO sensors, and optical sensors are used by research institutes, ocean observing programs, government agencies, and navies globally.

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Victoria, BC, Canada
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- **Metcean Equipment Leasing:** Acoustic Doppler Current Profiler ADCPs (including StreamPro & RiverRay), Ice Profilers, AZFP, acoustic releases, wave/tide gauges, pingers, satellite beacons, CTD+DO+Tu profilers, DO & turbidity loggers, weather station, cages, flotation, bottom frames.
- **Oceanographic Products:** Acoustic Zooplankton Fish Profiler (AZFP), Ice Profiling Sonar (IPS5) & shallow water Ice Profiler (SWIP), Imagenex scanning sonar logger (IRIS), instrument cages, bottom frames. Custom acoustic products and system integration.
- **Consulting:** Field work, data collection, analyses, numerical modelling, acoustics, remote sensing, oceanographic mooring design and system integration.
- **Manufacturer's Representative:** Teledyne RD Instruments, Deep Water Buoyancy, WERA Northern Radar.

STAR-ODDI

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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.

RBR

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RBR creates instruments to measure the blue planet. From the ocean abyss to the polar ice caps, our sensors track water parameters – temperature, depth, salinity, dissolved gases, pH, and many others. With design and manufacturing centrally located in Ottawa, Canada, our team works in a fast-paced, dynamic atmosphere to serve customers all over the globe.

SONAR SYSTEMS

ECHOLOGGER

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Tel: +82-2-3158-3178
Email: info@echologger.com
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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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Website: www.kleinmarinesystems.com



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!

MARINE SONIC TECHNOLOGY

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E-mail: Regan.Lipinski@na-atlas.com
Website: www.marinesonic.com



MARINE SONIC TECHNOLOGY
A brand of ATLAS NORTH AMERICA

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.

SOUND VELOCITY PROBES/CTDS

SAIV A/S

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E-mail: info@saivas.com
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Environmental Sensors & Systems

- STD/CTD, Sound Velocity probes/recorder with optional multi-parameter facilities; Turbidity, Fluorescence, Oxygen etc. The new CTD/STD model SD208 with wireless communication and high accuracy: 0.002 mS/cm, 0.002 °C.
- Precision pressure / depth (0.01% accuracy) and temperature sensors/recorders. Applications: hydrographic profilings, installation on ROVs and towed systems, etc. Robust and compact designs are combined with accuracy and "plug and play" compatibility. Output format for sonar equipment, e.g. EM1002, EM3000, SSP, HiPAP and Reson 8125.

SUBSEA FABRICATION

NEW INDUSTRIES

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Website: www.newindustries.com
Contact: Bill New



New Industries provides quality fabrication services to the offshore oil & gas and marine industries focusing on large diameter pressure vessels, suction piles, DNV buildings and deepwater subsea production equipment such as jumpers, PLETs, PLEMs and manifolds.

SUBSEA TECHNOLOGY

**KONGSBERG MARITIME AS – SUBSEA DIVISION
(DIVISION OF KONGSBERG GROUP)**

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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 Eelume vehicle.

UNMANNED MARITIME VEHICLES

**GENERAL DYNAMICS MISSION SYSTEMS'
BLUEFIN ROBOTICS PRODUCTS**

553 South Street
Quincy, MA 02169
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E-mail: adam.mara@gd-ms.com
Website: gdmissionsystems.com/
underwater-vehicles/bluefin-robotics
Contact: Adam Mara



Mission Systems

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.

**INTERNATIONAL SUBMARINE
ENGINEERING LTD. (ISE)**

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Port Coquitlam, BC, V3C 2M8
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E-mail: info@ise.bc.ca
Website: <https://ise.bc.ca/>

International Submarine Engineering Ltd. (ISE) is a world leader in the design and integration of autonomous and remotely operated robotic vehicles and terrestrial robotics. Over our 40+ years in business, we have accumulated a great deal of expertise in the design, manufacture, and maintenance of:

- Autonomous Underwater Vehicles (AUVs)
- Remotely Operated Vehicles (ROVs) for subsea operation
- Human Occupied (HO) submersibles
- Customized systems for the offshore oil industry
- Customized systems for the Military-Naval sector
- Hydraulic, pneumatic, and electric robotic manipulators
- Teleoperated and autonomous robotic systems
- Robotic systems for nuclear Industry applications
- Communications and real-time control system

**L3 OCEANSERVER, INC.**

275 Martine Street
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E-mail: sales@ocean-server.com
Website: www.iver-auv.com
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L3 OceanServer, Inc. is one of the leading manufacturers of unmanned underwater vehicles (UUVs) with over 300 units delivered to customers around the world.

The Iver UUV is an affordable, simple to operate commercial system for military, survey, water quality, and research applications.

**OUTLAND TECHNOLOGY**

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Website: www.outlandtech.com
Contact: Jeff Mayfield

Offering the most rugged equipment and unsurpassed customer service, Outland Technology has been the world's leading manufacturer of underwater video, lighting and ROV equipment for over 30 years. We recognize that no two jobs are the same and specialize in products that are customizable for your specific applications.

**TELEDYNE OCEANSCIENCE**

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Website: www.teledynemarine.com/oceanscience
Contact: Jamie Carrig



Teledyne Oceanscience manufactures unmanned deployment platforms for echosounders and environmental monitoring instrumentation. Our major products are remotely-controlled Q-Boats and tethered instrumentation deployment Riverboats for echosounders and ADCPs, remotely-controlled Z-Boats for hydrographic surveys in shallow or hard to access areas, the Underway CTD that provide affordable and compact profiling from a moving vessel, and the popular Sea Spider and Barnacle seafloor platforms.

TELEDYNE SEABOTIX

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Fax: +1 619 450 4001
E-mail: inquiries@teledyne.com
Website: www.teledynemarine.com
Contact: Jamie Carrig



Teledyne SeaBotix is a world leading manufacturer of capable underwater MiniROVs that perform a multitude of tasks including maritime security, search and recovery, hull and pipeline inspection, hazardous environment intervention, aquaculture, sensor deployment and oceanographic research. The Little Benthic Vehicle systems have become the benchmark in compact ROVs around the world and ROV equipment for over 30 years. We recognize that no two jobs are the same and specialize in products that are customizable for your specific applications.

VIDEORAY

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Fax: +1 610 458 3010
E-mail: sales@videoray.com
Website: www.videoray.com
Contact: Chris Gibson



With more than 3,700 ROVs in service around the world, VideoRay is the global leader in Observation ROV technology. VideoRay's underwater robot systems are extremely versatile, portable, affordable, and reliable solution for underwater operations including surveys, offshore inspections, search & recovery, homeland & port security, science & research, aquaculture, and many other underwater applications. The latest Mission Specialist systems provide solutions for particularly difficult underwater challenges. VideoRay is available on the General Services Administration (GSA) Schedule.

WINCHES, HANDLING, & CONTROL SYSTEMS**MARKEY MACHINERY COMPANY**

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Preferred by the U.S. fleet, Markey's advanced oceanographic winch systems provide ultimate dependability, reliability and precise performance when and where you want it. Operating within critical windows of opportunity you can count on our custom winches, capstans, windlasses and auxiliary machinery for the successful execution and completion of your research.

OKEANUS SCIENCE & TECHNOLOGY LLC

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Fax: +1 (425) 869-5554
E-mail: info@oceanus.com
Website: www.oceanus.com
Contact: Ted Brockett



SOSI and DT model winches, handling systems, and engineered solutions are available exclusively from Okeanus Science & Technology. Proven, reliable, and cost-effective standard and custom designed winches range from small all-electric instrumentation winches to high horsepower all-electric or hydraulic umbilical and multi-purpose oceanographic systems. Our winches can be packaged or supplied with skids, A-Frames, over-boarding sheaves, docking assemblies, HPU's, and other auxiliary equipment. Okeanus has offices in Houston, TX, Redmond, WA, and Houma, LA.

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SMART SUBSEA SOLUTIONS

S2C TECHNOLOGY: COMMUNICATION AND TRACKING COMBINED

- time, space and cost-saving solutions
- low power consumption for autonomous operations
- advanced data delivery algorithms, addressing and networking, remotely configurable settings
- extendable platform with multiple configuration options: power-saving Wake Up module, acoustic releaser, additional sensors, custom solutions, OEM versions available

USBL POSITIONING SYSTEMS

simultaneous positioning and communication - no need to switch between positioning mode and modem mode

- flexible SiNAPS positioning software
- reliable data transmissions
- range: up to 8000 m
- accuracy: up to 0.04 degrees

UNDERWATER ACOUSTIC MODEMS

reliable data transmissions even in adverse conditions, customizable R-series modems, light and compact M-series "mini" modems, the S2CM-HS high-speed modem, special editions for developers, S2C communication and positioning emulator - remote access or standalone device

- range: up to 8000 m
- depth: up to 6000 m
- data rate: up to 62.5 kbps

LBL POSITIONING SYSTEMS

highly accurate, precise and stable performance, simultaneous positioning and data transmissions

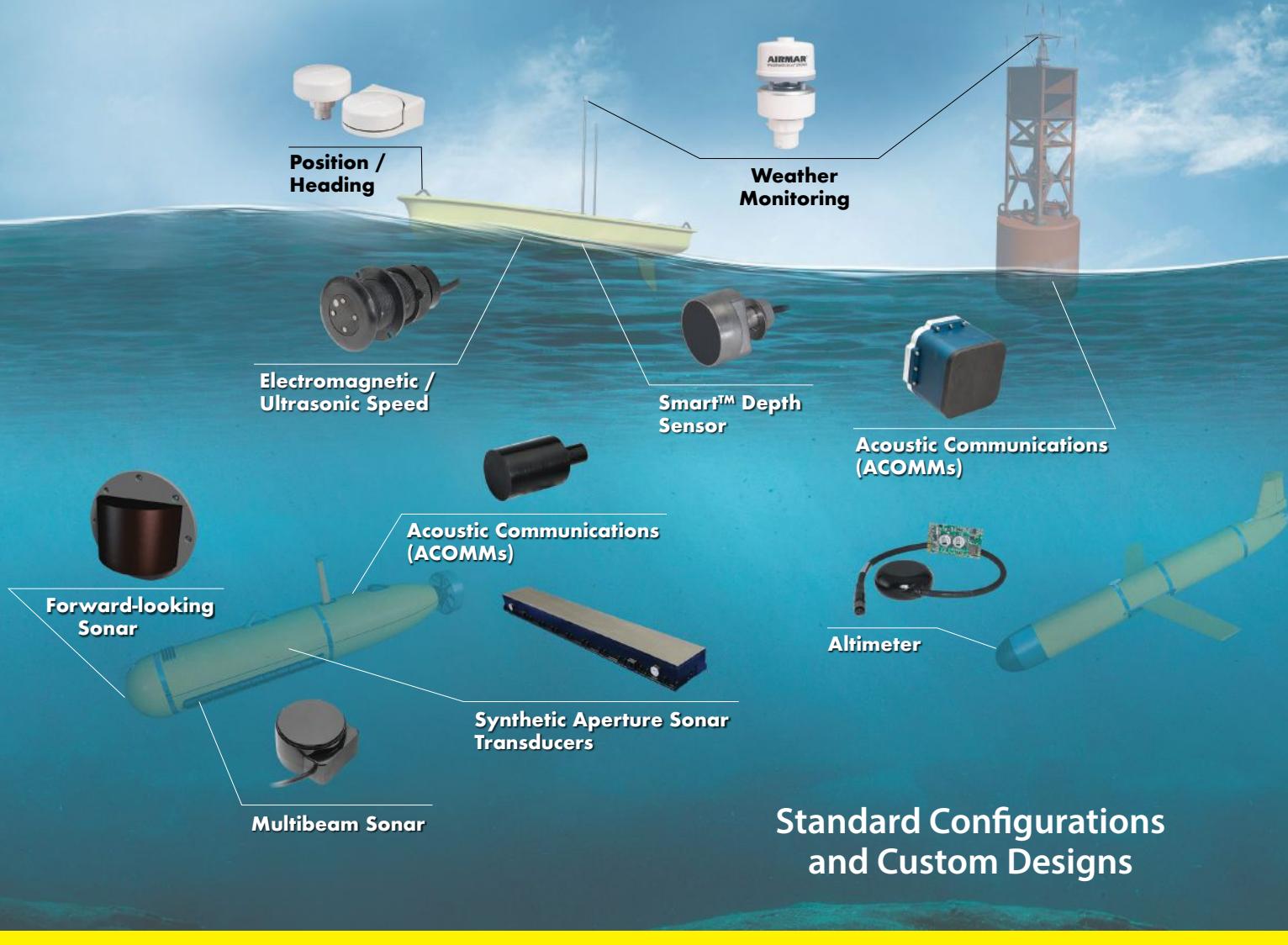
- flexible SiNAPS positioning software
- reliable data transmissions
- range: up to 8000 m
- accuracy: better than 0.01 m

NEW!
ULTRA-COMPACT
"TINY" MODEMS



S2C M (left) and the new S2C T "tiny" modem - 20% smaller and lighter

Acoustic Transducers and Arrays



From prototype to production AIRMAR and MSI push the boundaries of sonar technology. Whether you need a simple single element sensor or a large multi-element array, we have the solution. We specialize in partnerships providing strong engineering support, innovative technology, advanced manufacturing capabilities and exceptional customer service.



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