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A large submarine is shown moving through the ocean, creating a massive wake. The submarine's hull is dark grey, and its wake is white and turbulent. The water in the background is a deep blue.

BLACKFISH:
Three Decades in the Making
Redefining Low-cost Autonomous
Underwater Vehicles

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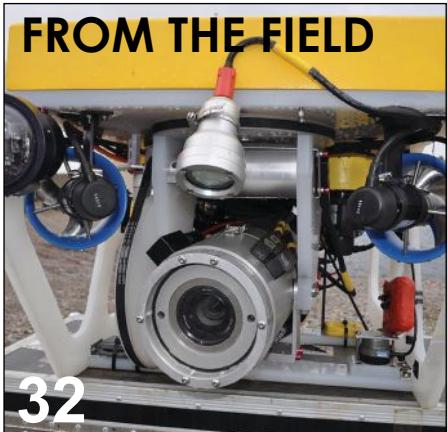
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The Virginia-class submarine USS North Dakota (SSN-784) at sea.

Photo Credit: General Dynamics Electric Boat

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Editor

Rhonda Moniz

News Editor

John Manock

UK Correspondent

Kira Coley

Art Director/Production Coordinator

Suzanne Short

Copy Editor

Robyn Bryant

Newsletter Editor

Inger Peterson

Web News Coordinator

Whitney Schwerin

Circulation

Jessica Lewis

Jlewis@tscpublishing.com

ADVERTISING SALES**North American Ad Sales:**

Lisa Chilik

Tel: 574-261-4215

Lchilik@tscpublishing.com

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International Ad Sales:

Mimi Shipman

Mob: +44 (0) 777 6017 564

mshipman@tscpublishing.com

ADVISORY BOARDPhilippe Pierre Cousteau
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Justin E. Manley
Founder, Just Innovation Inc.

Everything is Going Unmanned...

That phrase was used more than once at Ocean Business, the global oceantech gathering in early April in Southampton, UK. In that case, it meant that the tradeshow floor was well populated with unmanned technologies. On display was a proliferation of unmanned surface vessels (USVs) and new generations of unmanned undersea vehicles (UUVs) as well as increased autonomy in ROVs and even instruments. Companies specializing in sensors and software to enable this growing field were also prominent. Beyond the obvious expansion of products and technologies, there are other trends to note.

The business dynamics are evolving rapidly. The offshore oil sector is still challenged, but the sentiment appears to be that the bottom has passed and some optimism exists. Applications such as seafloor resident vehicles and new tools for inspection repair and maintenance (IRM) are appearing. Kongsberg's Eelume offering is one example. Ocean Infinity's fleet approach to survey using unmanned maritime vehicles (UMVs) and UUVs is another example of progress in the commercial sector.

In defense of the UMV industry, there is positive growth in this field. The acquisition of OceanServer Technology by L-3, similar to last December's acquisition of Liquid Robotics by Boeing, indicates that unmanned systems for naval applications growing. This strength enables new ideas, such as the "Digital Ocean" concept Liquid Robotics promoted in Southampton. As a system of machines drawing on technologies from diverse vendors, this concept can only succeed by building upon a collaborative, confident industry. Major acquisitions are one sign of such strength in the sector.

New products of note launched in early 2017 include compact affordable AUVs, like the micro-UUV family from Riptide, a revival of coastal gliders from Exocetus, and the third generation of Slocum gliders from Teledyne Marine. While these represent evolution of known technologies, disruptive new concepts are appearing as well. A dedicated swarm approach to UUV operations from Hydromea brings a new outlook on not just UUV operations but also component design. New service offerings such as satellite-derived bathymetry on demand from TCarta Marine will provide valuable support to unmanned system operations.

The developments at Ocean Business are complemented by other global examples. A March announcement from Rolls Royce that they will invest £200 million in R&D on autonomous ships (the ocean-going commercial kind) is noteworthy, as is Norway's creation of a dedicated ocean test site for USV research. Work being done by companies such as ASV Global to "teach" marine robots to follow the rules of the road (COLREGS) reminds us that just because surface systems have it easy with access to satellite navigation they are in no way simple to develop or operate. The people and policy issues on unmanned systems remain important.

Ocean Business celebrated its 10th anniversary in 2017. In addition, the UMV industry has had much to celebrate in the past ten years. Technologies are advancing rapidly, business opportunities are expanding, and global impacts are looming. Everything is going unmanned, and the ride is exciting!

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BlackFish:

Three Decades in the Making

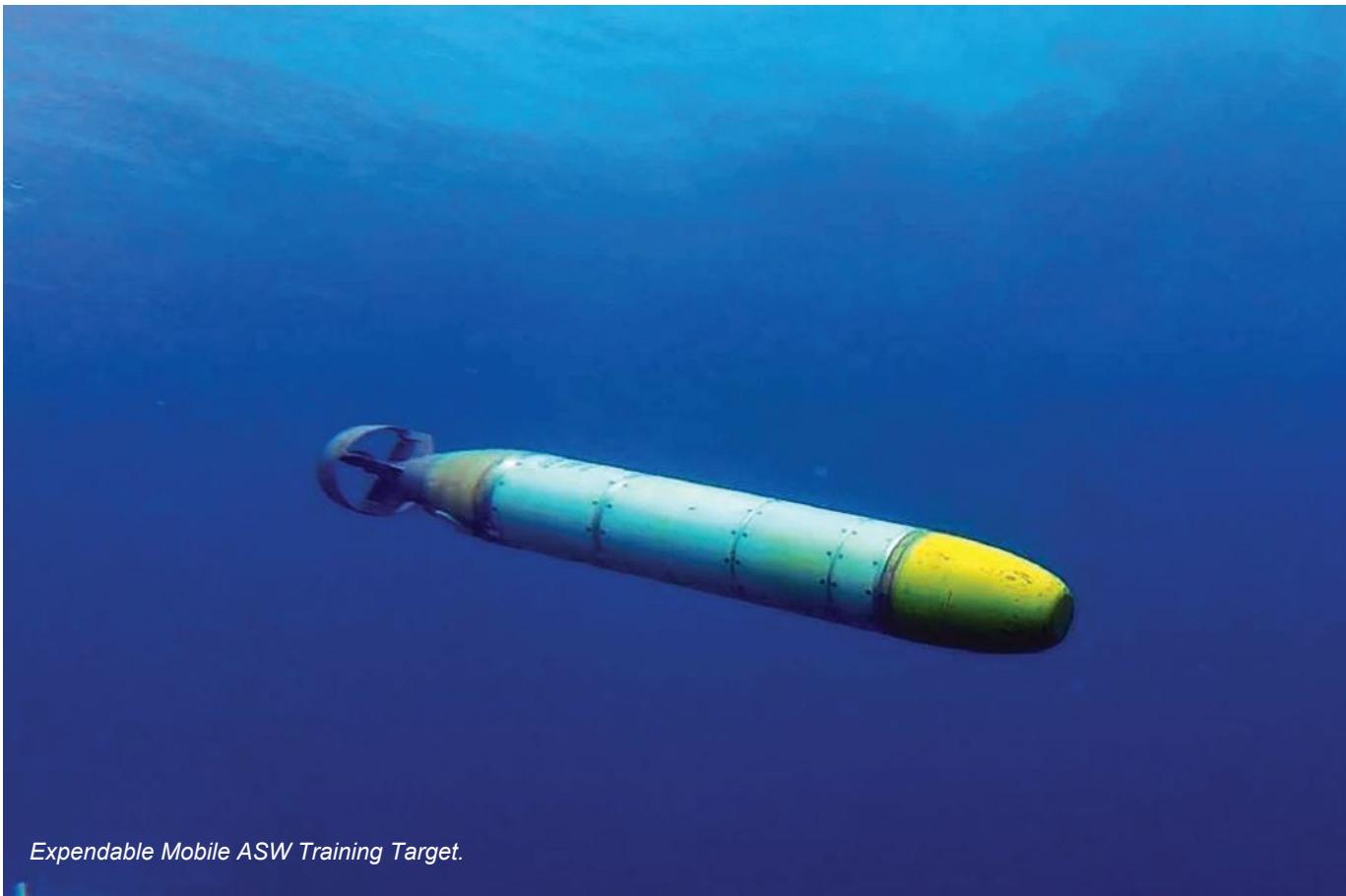
Redefining Low-cost Autonomous Underwater Vehicles



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Ocean News & Technology



Expendable Mobile ASW Training Target.

Lockheed Martin's Marion, Massachusetts facility has been developing and building small A-size (4 7/8-in. diameter, 36-in. length) autonomous underwater vehicles (AUVs) for over 35 years. The A-size form factor has been and will continue to be extremely utilitarian, as it dramatically increases the number of potential deployment mechanisms available to the end-user beyond simple hand delivery. As the size is identical to standard sonobuoy devices, vehicles can be launched from standard sonobuoy launchers on board a wide array of fixed wing and rotary wing aircraft as well as submarines and surface vessels.

Since the early 1980s, Lockheed Martin has been the primary supplier of Expendable Mobile Anti-Submarine Warfare (ASW) Training Targets (EMATTs) to over 20 nations, delivering over 40,000 systems to date for air-launch, surface-launch, and subsurface-launch applications. Understanding that the true value to the customer is in the quality of data acquired, the design of the EMATT has been optimized for training purposes, resulting in a vehicle that is inherently expendable and does not require the user to spend valuable time and resources executing recovery efforts. This optimization was enabled through initial efforts to drive unit price down through a combination of Design for Manufacturing (DFM) techniques and lean production flow.

To accomplish this, Lockheed Martin has implemented a manufacturing capability that provides our customers with the highest quality product at the lowest possible cost. We maintain a highly trained and flexible work force that allows Lockheed Martin to provide a diverse portfolio of products to our customers, maintaining flexible support systems that allow for product tailoring based on customer feedback and mission requirements.

Lockheed Martin has developed all of the production processes and tooling required to produce large numbers of A-size vehicles and is currently in full-rate production, producing vehicles for two dozen nations. These standardized processes include assembly, test, and inspection from material receipt to final product acceptance. As would be expected for any product suitable for military use, all processes and procedures are fully documented with well-defined step-by-step procedures to fabricate the vehicles in accordance with the engineering drawings, associated quality controls in place to define the process for inspection where required, and test instructions to define the necessary factory test process. All manufacturing documentation is controlled through a rigorous configuration management process that ensures consistent production of each individual vehicle. Through years of optimization and production flow modifications, the resulting production line is scalable with production throughput capability currently in excess of 2,500 vehicles per year.

FEATURE STORY

Although Lockheed Martin has been building A-size AUVs continuously for over 35 years, we had been focused on a single mission, continuously refining the vehicle to reduce cost, but at the expense of mission flexibility and modularity. Several years ago, however, that approach was modified, taking into account the high volume production line, standardized manufacturing processes, and mature supply chain. The result was a new concept for a multi-purpose vehicle that leverages the lessons learned and experience gained from 40,000 fielded systems.

The idea of a multi-purpose underwater vehicle is certainly nothing new, especially with the proliferation of vehicle types over the past decade and the exponential increase in undersea mission requirements over that same period. Unfortunately, in most cases, the complexity and size of the required sensor packages has also resulted in AUVs becoming synonymous with being expensive or cost prohibitive. There must, therefore, be a place for a smaller platform that can accomplish a variety mission components at a fraction of the cost.

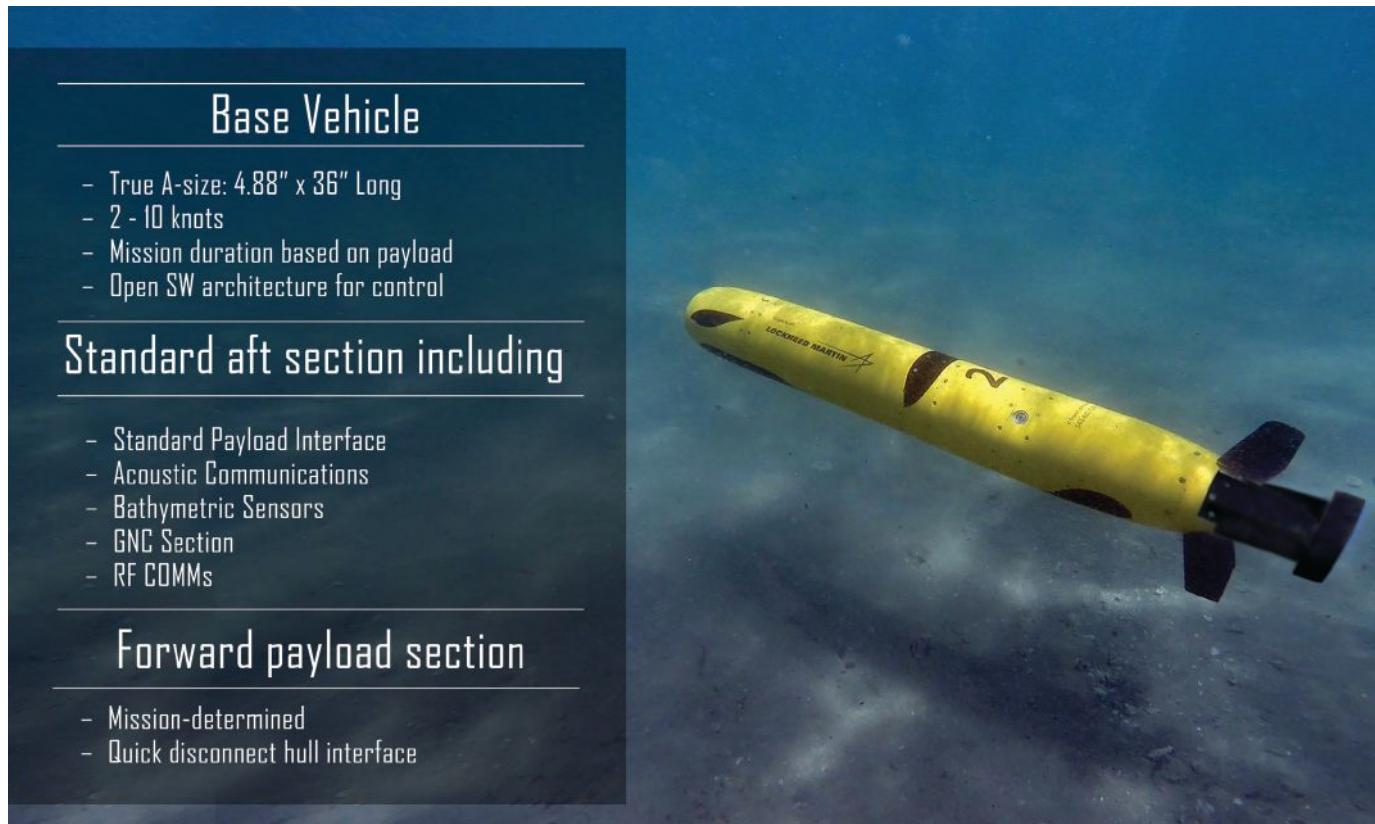
The BlackFish is Lockheed Martin's latest iteration of a mission-reconfigurable vehicle based on generations of field-hardened products combined with state-of-the-art technologies. From concept inception, the BlackFish Design Team had several key underlying requirements from which they could not deviate:

- Vehicle must remain A-size, capable to being shipped and launched from standard Sonobuoy Launch Containers (SLCs);
- Vehicle must be suitable for air-launch, surface-launch, and subsurface-launch applications;
- Vehicle must be user reconfigurable; and
- Vehicle must be comparable in price to existing EMATT vehicles when configured for ASW training missions.

These four simple requirements ensured that throughout the systems engineering and design phases, key characteristics of the vehicle would be constant while other design attributes and capabilities would be variable, allowing for a wide range of innovative configurations while still staying true to the overall end goal.



Production EMATTs and First BlackFish Prototype.



Base Vehicle

- True A-size: 4.88" x 36" Long
- 2 - 10 knots
- Mission duration based on payload
- Open SW architecture for control

Standard aft section including

- Standard Payload Interface
- Acoustic Communications
- Bathymetric Sensors
- GNC Section
- RF COMMs

Forward payload section

- Mission-determined
- Quick disconnect hull interface

Comprising two major sections, the BlackFish leverages capabilities from across Lockheed Martin, including the Missiles and Fire Control (MFC), Advanced Technology Labs (ATL), and C4ISR and Undersea Systems (C4USS) organizations.

The standard aft section of the vehicle includes three “pop-out” control fins, independently controlled by linear actuators; a ducted propulsion system; a multi-purpose ceramic ring transducer paired with WHOI’s μModem drive and processing electronics for acoustic communications; bathymetric sensors (temperature and sound velocity); base battery pack; guidance, navigation, and control suite; GPS receiver; and WiFi capability (Satellite Communications are available as an option). The navigation system leverages generations of proven low-cost navigators on Lockheed Martin missile programs and provides a flexible INS/GPS/USBL/Terrain-aided navigation system with extensions to collaborative and relative navigation. Maintaining this array of sensors as a core set of components facilitates production flow efficiency while simultaneously reducing the resultant unit cost.

Mission execution capabilities are provided by an open architecture, extensible, MOOS-IvP-based autonomous controller with standard interfaces to the BlackFish low-level controllers. This flexible architecture allows for autonomy that is tailored to mission CONOPS, including the ability to override the base autonomous control

with a payload-borne backseat driver operating over the same standard interface. An operator interface is provided for mission planning and mission monitoring, but plugins are available/planned for standard U.S. Navy user interfaces such as topside. Whereas the aft section of BlackFish is standardized and optimized for low cost, the forward payload section is reconfigurable by Lockheed Martin or the end user, utilizing a standard interface to the aft section for communication, data transfer, and power transfer. Various implementations of this section include side-scan sonar, thrusters for improved slow/zero speed maneuvers, additional battery modules for increased endurance, or any number of other sensors required for a given concept of operations.

Developed on the back of three decades of advanced development, low-cost production, and fielded test data, Lockheed Martin has extended the boundaries of the A-size vehicle. Whether the tasking centers on bathymetric surveys, infrastructure inspections, ASW training, or collaborative swarms of vehicles, BlackFish enables users to customize their product to fit their needs, increasing or decreasing inherent capabilities as required while utilizing a robust, quality-driven, cost-effective product to complete their mission.

For more information regarding A-size vehicles or potential mission capabilities, contact Kate Houdelette, kate.e.houdelette@lmco.com or visit Lockheedmartin.com/Asize.

Seafloor Erosion in Coral Reef Ecosystems

In the first ecosystem-wide study of changing sea depths at five large coral reef tracts in Florida, the Caribbean, and Hawai'i, U.S. Geological Survey researchers found the seafloor is eroding in all five places, and the reefs cannot keep pace with sea level rise. As a result, coastal communities protected by the reefs are facing increased risks from storms, waves, and erosion.

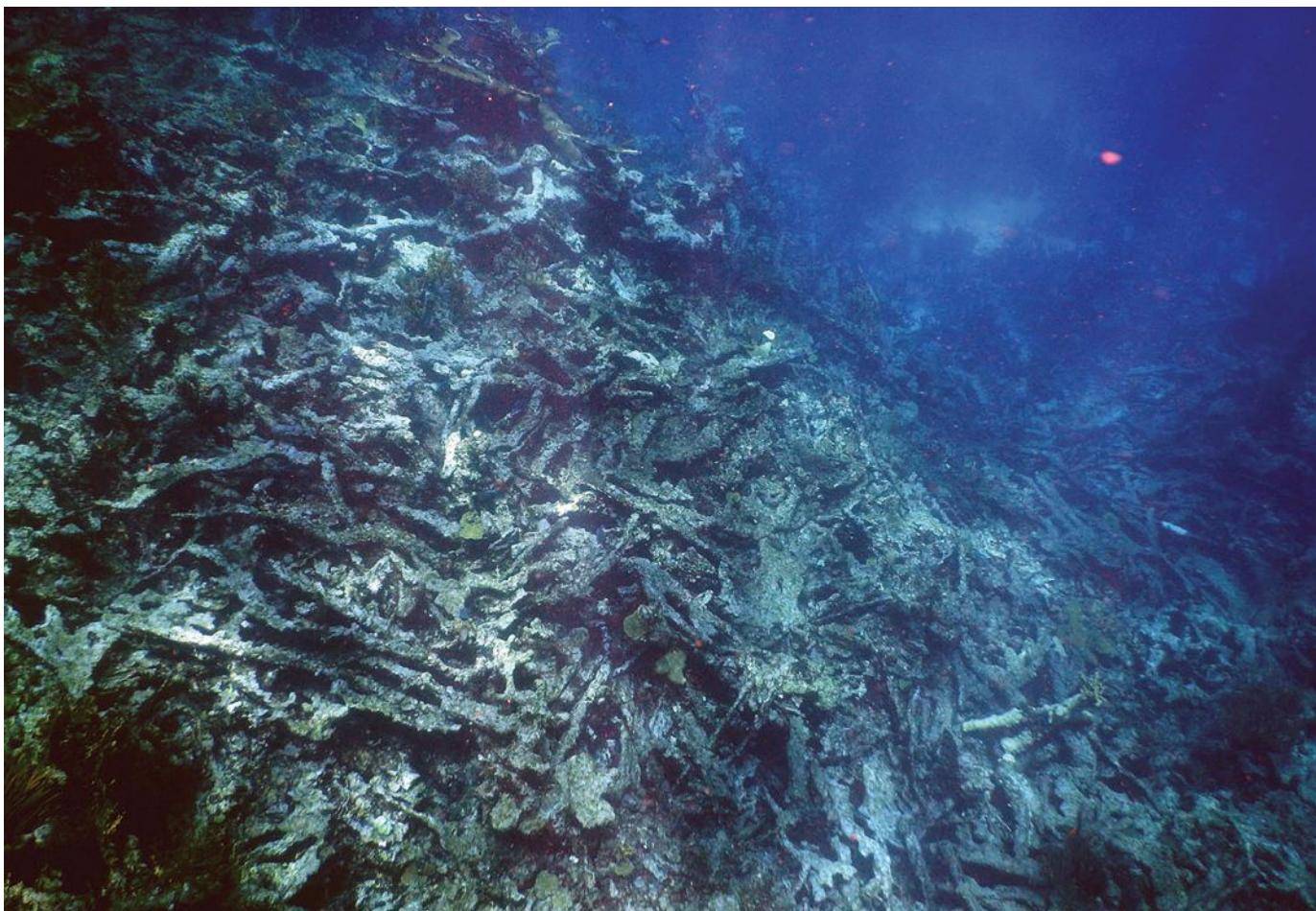
In the Florida Keys, the U.S. Virgin Islands, and Maui, coral reef degradation has caused seafloor depths to increase as sand and other seafloor materials have eroded over the past few decades, the USGS study found. In the waters around Maui, the seafloor losses amounted to 81 million cubic meters of sand, rock, and other material—about what it would take to fill up the Empire State Building 81 times, the researchers calculated.

As sea levels rise worldwide due to climate change, each of these ecologically and economically important reef ecosystems is projected to be affected by increas-

ing water depths. The question of whether coral colonies can grow fast enough to keep up with rising seas is the subject of intense scientific research.

But the USGS study, published 20 April 2017 in the journal *Biogeosciences*, found the combined effect of rising seas and seafloor erosion has already increased water depths more than what most scientists expected to occur many decades from now. Other studies that do not factor in seafloor erosion have predicted seas will rise by between 0.5 and 1 m, or between 19 in. and 3 ft 3 in. by 2100.

"Our measurements show that seafloor erosion has already caused water depths to increase to levels not predicted to occur until near the year 2100," said biogeochemist Kimberly Yates of the USGS' St. Petersburg Coastal and Marine Science Center, the study's lead author. "At current rates, by 2100 seafloor erosion could increase water depths by two to eight times more than what has been predicted from sea level rise alone."



These Elkhorn corals (*Acropora palmata*) near Buck Island, U.S. Virgin Islands have died and collapsed into rubble. As coral reef structure degrades, valuable habitat for marine life is lost and nearby coastlines become more susceptible to storms, waves, and erosion. Photo credit: Curt Storlazzi, USGS. Public domain.

The study included areas of the reef tract in Florida's Upper Keys and Lower Keys; looked at two reef ecosystems, St. Thomas and Buck Island, in the U.S. Virgin Islands; and also included the waters surrounding Maui. The researchers did not determine specific causes for the seafloor erosion in these coral reef ecosystems. But the authors pointed out that coral reefs worldwide are declining due to a combination of forces, including natural processes, coastal development, overfishing, pollution, coral bleaching, diseases, and ocean acidification (a change in seawater chemistry linked to the oceans' absorption of more carbon dioxide from the atmosphere).

For each of the five coral reef ecosystems, the team gathered detailed seafloor measurements from the National Oceanic and Atmospheric Administration taken between 1934 and 1982, and also used surveys done from the late 1990s to the 2000s by the USGS Lidar Program and the U.S. Army Corps of Engineers. Until about the 1960s, seafloor measurements were done by hand, using lead-weighted lines or sounding poles with depth markings. From approximately the 1960s on, most measurements were based on the time it takes an acoustic pulse to reach the seafloor and return. The USGS researchers converted the old measurements to a format comparable to recent lidar data.

They compared the old and new sets of measurements to find the mean elevation changes at each site. The method has been used by the U.S. Army Corps of Engineers to track other kinds of seafloor changes, such as shifts in shipping channels. This is the first time it has been applied to whole coral reef ecosystems. Next, the researchers developed a computer model that used the elevation changes to calculate the volume of seafloor material lost.

They found that overall, seafloor elevation has decreased at all five sites, in amounts ranging from 0.09 m (about 3 ½ in.) to 0.8 m (more than 2 ½ ft). All five reef tracts also lost large amounts of coral, sand, and other seafloor materials to erosion.

"We saw lower rates of erosion—and even some localized increases in seafloor elevation—in areas that were protected, near refuges, or distant from human population centers," Yates said. "But these were not significant enough to offset the ecosystem-wide pattern of erosion at each of our study sites."

Worldwide, more than 200 million people live in coastal communities protected by coral reefs, which serve as natural barriers against storms, waves, and erosion. These ecosystems also support jobs, provide about one-quarter of all fish harvests in the tropical oceans, and are important recreation and tourism sites.

"Coral reef systems have long been recognized for their important economic and ecological value," said John Haines, Program coordinator of the USGS Coastal and Marine Geology program. "This study tells us that they have a critical role in building and sustaining the physical structure of the coastal seafloor, which supports healthy ecosystems and protects coastal communities. These important ecosystem services may be lost by the end of this century, and nearby communities may need to find ways to compensate for these losses."

The study brought together ecosystem scientists and coastal engineers, who plan to use the results to assess the risks to coastal communities that rely on coral reefs for protection from storms and other hazards.

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NOC Engages in Deep-Sea Mining Research

The National Oceanography Centre (NOC) is engaged in research into the potential risks and benefits of exploiting deep-sea mineral resources, some of which are essential for low-carbon technology, as well as using ocean robots to estimate the environmental impact of these potential deep-sea mining activities.

Late last year, the NOC led an expedition on the RRS James Cook that found enough of the scarce element Tellurium present in the crust of a submerged volcano that, if it were all to be used in the production of solar PV panels, could provide two-thirds of the UK's annual electricity supply. Recently, the NOC also led an international study demonstrating deep-sea nodule mining will cause long-lasting damage to deep-sea life, lasting at least for decades.

These nodules are potato-sized rocks containing high levels of metals, including copper, manganese, and nickel. They grow very slowly on the seabed, over millions of years. Although no commercial operations exist to extract these resources, many are planned.

Professor Edward Hill, executive director at the NOC, commented, "By 2050, there will be nine billion people on earth and attention is increasingly turning to

the ocean, particularly the deep ocean, for food, clean supplies of energy, and strategic minerals. The NOC is undertaking research related to many aspects and perspectives involved in exploiting ocean resources. This research is aimed at informing with sound scientific evidence the decisions that will need to be taken in the future, as people increasingly turn to the oceans to address some of society's greatest challenges."

Part of the NOC's research into this area involves leading major research programmes into the exploration of potential resources. This includes seafloor massive sulphides, which provide ores rich in copper, zinc, and gold, and iron-manganese crusts rich in cobalt, tellurium, and rare-earth metals. NOC scientists have also carried out multiple research expeditions to study the environment around areas with resources that may be the target of future mining. This includes the Clarion-Clipperton zone in the eastern Pacific, the Mid-Atlantic Ridge, and Atlantic Seamounts. This research is revealing extremely high diversities of deep-sea life as well as a surprising variation of subsea landscapes, each containing different lifeforms.

Dr. Daniel Jones from the NOC, the lead author of the study, said, "the deep-sea is a remote, cold, and dark

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One of the many samples NOC have recovered during dives (laser dots are 10 cm apart). Photo credit: NOC.

environment kilometers below the surface of the ocean, yet it is home to a wide variety of marine life, much of which is very poorly understood. This research analyzed all available studies on impacts to ecosystems in nodule areas and shows mining for nodule resources on the seafloor is likely to be highly destructive in the mined area, with long-lasting impacts. We also think that these studies will underestimate the impacts of mining. Many would not even represent one month's work for a full-scale commercial operation, which might last for 20 years."

"This study helps provide the best available information on the potential impacts of mining disturbance. This information is important to inform decisions on how these mining activities should be carried out."

The NOC-led MarineETech expedition on board the RRS James Cook aimed to improve understanding of what controls the formation and accumulation of cobalt-rich crusts on seamounts. These crusts are rich resources for scarce elements that are critical to securing a low-carbon future, through technologies such as solar photovoltaic, wind turbines, and electric vehicles. The results show the accumulation of the cobalt-rich crusts on the sea-mount depends on the direction and strength of currents and deep-water tides, the depth of the water, and biological activity.

Dr. Bramley Murton from NOC, who led this expedition, explains the thinking behind the research: "The fate of modern civilization and our ability to secure a low-carbon future depends on the supply of raw materials including base metals and elements critical to new technologies. While the demand for raw materials, has grown exponentially, the terrestrial grade has diminished and threatens global supply."

To find out more or watch the BBC report on this topic, featured on BBC news visit, www.bbc.com/news/science-environment-39347620.



Total Autonomy



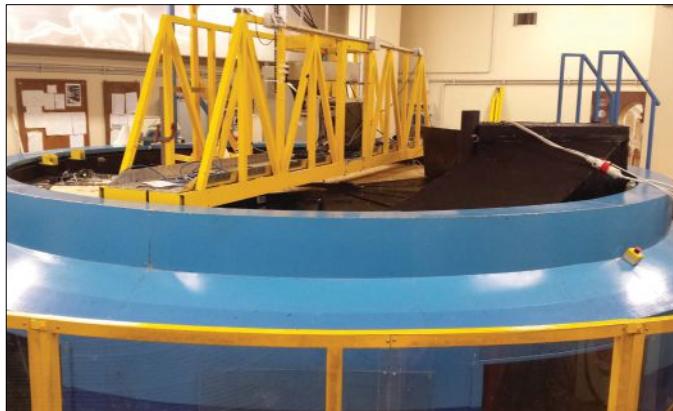
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Unique Wave Tank to Understand Threat of Rogue Ocean Waves

A team of scientists from Australia, Belgium, Italy, and the UK have demonstrated how ocean winds can generate spontaneous rogue waves, the first step to predicting the potentially dangerous phenomena. Rogue or freak waves are extremely high, steep waves appearing in deep ocean, surging without warning and seemingly at random. These events might cause severe damage to ships and structures like oil or gas platforms. The ability to forecast them would be hugely beneficial, but little is currently understood about what generates them.

<http://ont.news/2qbnR2b>

Wärtsilä to Power World's First LNG-Fueled Offshore Construction Vessel

The technology group Wärtsilä is to supply the engines and other propulsion machinery for a new offshore construction vessel being built at the Cosco shipyard in China. The ship owner is Belgian operator Dredging International (DEME). This will be the first vessel of its kind to be fueled by liquefied natural gas (LNG) and, in addition to the dual-fuel engines, Wärtsilä will also provide its LNGPac fuel storage and supply system and propulsion systems.

<http://ont.news/2oNrsBG>



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SHARK MARINE
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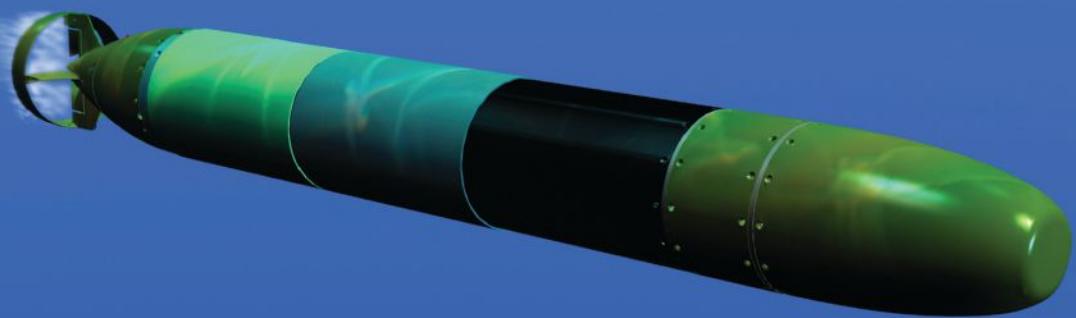
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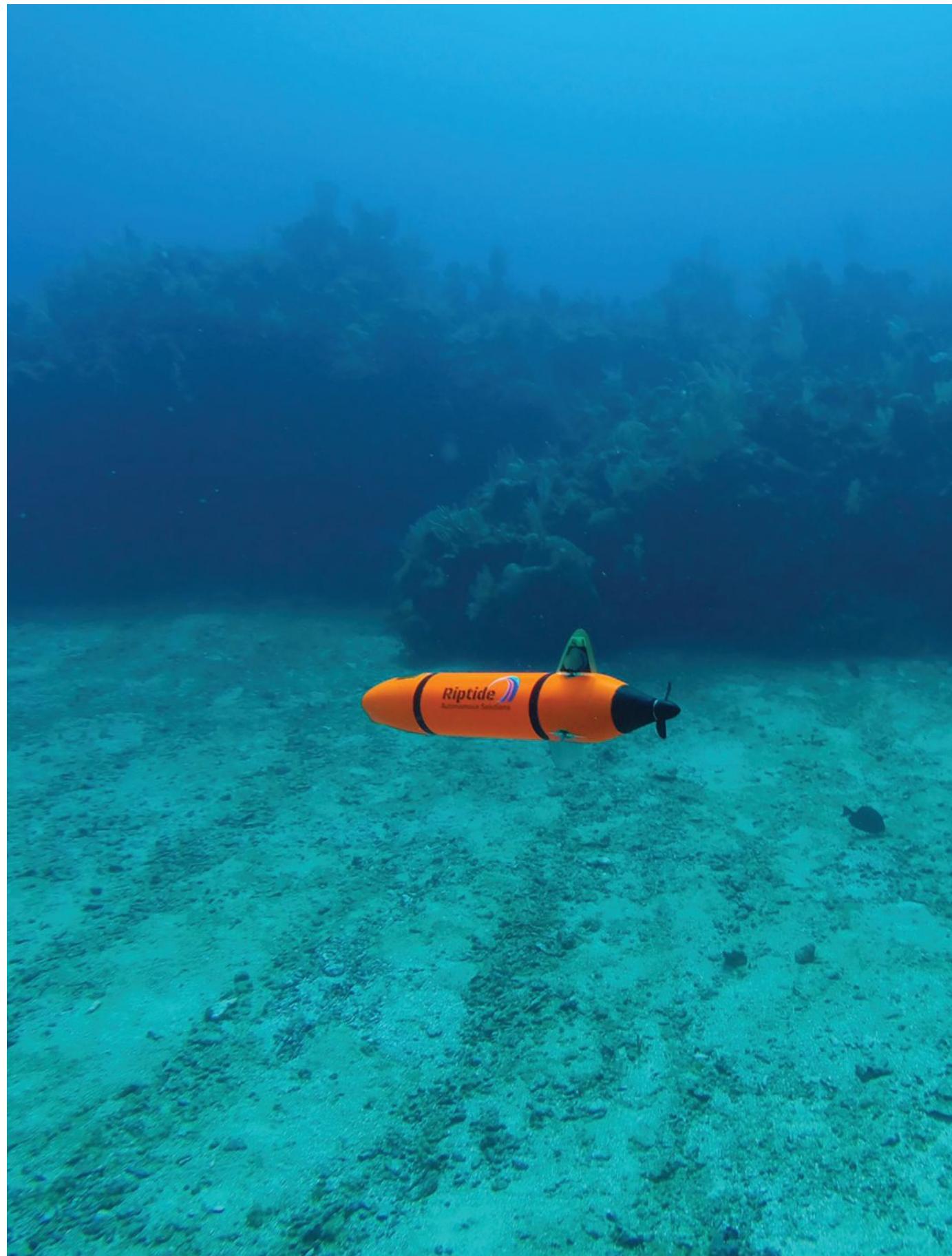
EMATT is one of the highest volume unmanned underwater vehicles (UUV) in production ever built. With over 2,000 units per year and 35,000 fielded systems EMATT has a well-established, proven manufacturing process optimized for mission requirements and low cost. EMATT is the only "A" size UUV certified for launch from surface, subsurface and air. Leveraging more than 30 years of experience in the design, development and deployment of the EMATT vehicle, Lockheed Martin is now evolving that platform from a single-use UUV into a modular, multi-mission "A" size vehicle suitable for a wide array of user-reconfigurable applications.

Learn more at lockheedmartin.com/EMATT

LOCKHEED MARTIN 

The Lockheed Martin logo consists of the company name in a bold, sans-serif font, followed by a stylized 'A' symbol composed of three intersecting diagonal lines.

EDITORIAL FOCUS



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Ocean News & Technology

Development of a Family of Flexible UUVs

Micro-UUV Technology is Flexible and Fast

In 2015, several veterans of the conventional Unmanned Undersea Vehicle (UUV) sector set out to change the dynamics of the industry, founding Riptide Autonomous Solutions. Riptide's first product was the micro-UUV, a new, highly flexible, open-source autonomous undersea vehicle that provides a state-of-the-art, low-cost solution ideally suited for developers of autonomy and behaviors, power systems, subsea sensors, and other new payloads. The micro-UUV features open hardware and software interfaces, giving users a reliable and robust platform to advance technology development. The vehicle design is optimized for high efficiency, with the best hydrodynamic signature in its class. The base micro-UUV is 4 ½ in. in diameter, 40 in. in length, and weighs 22 lb. The standard system is rated to a depth of 300 m.

Riptide's micro-UUV features three individually actuated control fins providing active roll stabilization. An active GPS antenna, WiFi communications, and vehicle recovery strobe LEDs are integrated into the vertical control fin, reducing the vehicle's hydrodynamic signature for maximum efficiency. Its open system design allows for easy user modification and customization, making this an ideal platform for a wide variety of development needs. Multiple energy source options allow maximum flexibility for endurance, safety, shipping, and mission optimization.

In contrast to typical proprietary architectures, the mi-

cro-UUV features a flexible software architecture leveraging a large amount of open-source software. The goal is to foster an active and vibrant user community who will be provided with source code under a standard open-source license. The micro-UUV architecture maximizes the use of existing open-source software, both to provide a mature platform and to tap into existing energetic user communities. In the initial release of micro-UUV software, Riptide is providing code for the Arduino and Beaglebone Black development platforms as well as support for the MOOS-IvP robot control engine. Future releases are planned to include support for ROS (the Robot Operating System) and streamlined user interfaces.

In addition to embracing current software development trends, the micro-UUV has been developed using a large quantity of 3D printing, which enabled affordable and quick evaluation of numerous design considerations. This rapid manufacturing capability has also enabled Riptide to quickly field production vehicles. This approach is not just for engineering the models—products capable of withstanding the pressures and harsh environment of UUV operations are also being produced this way. The use of modern design and manufacturing techniques has also enabled the development and delivery of numerous micro-UUV configurations. A variety of sensors, as well as wet and dry payload bays, have been rapidly developed and successfully delivered—and all within 15 months of the first conceptualization of the product.



A micro-UUV. The antenna is embedded in the fin for improved hydrodynamics.

Reducing Expense, Easing Logistics

This new generation of micro-UUVs has drawn on the successes and failures of earlier generations that were large, expensive, logically cumbersome, and limited in endurance. Drawing on these experiences, UUV developers have evolved vehicle designs that optimize configuration flexibility and utilize rapid manufacturing capabilities to minimize the cost of the vehicle. In fact, given its entry price point of \$10,000, the micro-UUV could, in certain applications, be considered expendable and abandoned after completion of the mission.

Earlier generation UUVs reflected the constraints of the requirements, technologies, and environment that fostered their creation. Costs were often based on the need to get the job done the best way possible. Once designed, manufactured, and sold, there was little incentive to reduce the costs. Consequently, a clean departure from earlier UUVs was required to make vehicles more conducive to low-cost manufacture and sale. It is this class of vehicle that has overcome the “expense” limitation and brought to market a step change in logistics that now makes new applications feasible.

Increasing Endurance

Full consideration of the drag/power/endurance relationship along with extensive hydrodynamic computer modeling can produce minimum hull drag and optimize

fluid flow for extended endurance. In addition, the use of low-power electronic design permits optimization of propulsion and hotel power loads for minimum power consumption. What this means is that the micro-UUV can operate up to 48 hours at 2 knots on a battery comprised of AA alkaline cells. These endurance figures are quoted without a payload because endurance will be payload specific and endurance without payload provides a metric for direct comparison of vehicle capabilities. A sensor payload will reduce the overall endurance, depending on power requirements.

Batteries utilizing Lithium chemistry have improved endurance. Yet, even the capacity of these advanced chemistry batteries has provided limited improvements in the overall endurance of the UUV field while introducing safety and handling issues aboard ships prior to UUV launch.

Through the use of advanced power source technologies such as the aluminum seawater battery from Open Water Power, the Riptide micro-UUV has the capability to operate for over 500 hours at 2 knots (without payloads), enabling significant range and time on mission. Riptide has an exclusive agreement with Open Water Power for use of their aluminum seawater battery in micro-UUVs and anticipates fielding the initial installation in late 2017.



The micro-UUV is portable enough to be deployed by hand by a single person; no cranes required.



Expanding the Family

Building upon the successful micro-UUV, two new vehicles have been developed. The new 1-Man and 2-Man Portable UUVs use the same technical architecture, proven hydrodynamic hull shape, and high-efficiency electronics as the original micro-UUV. Drawing upon advanced manufacturing, modern electronics, and open-source concepts, these larger vehicles will deliver the same flexible solution already favored by Micro-UUV users. The 1-Man Portable UUV offers a 7.5 in. (19 cm) diameter and base weight just over 60 lb (27 kg) with a depth rating of 300 m. The 2-Man Portable UUV has a 9.375 in. (24 cm) diameter and a base weight of roughly 120 lb (55 kg) with a depth rating of 600 m.

These new form factors will support new payloads and expanded mission possibilities. Introduced in April 2017, the expanded family of Riptide UUVs will enable new approaches to undersea operations.

Riptide Autonomous Solutions

www.RiptideAS.com

Standard μUUV
~22 lbs/ 300m
Diameter – 4 7/8"

Standard 1MPUUUV
~62 lbs/ 300m
Diameter – 7.5"

Standard 2MPUUUV
~140 lbs/ 600m
Diameter – 9 3/8"

Wind-Powered Oil Recovery Concept Moves Closer to Implementation

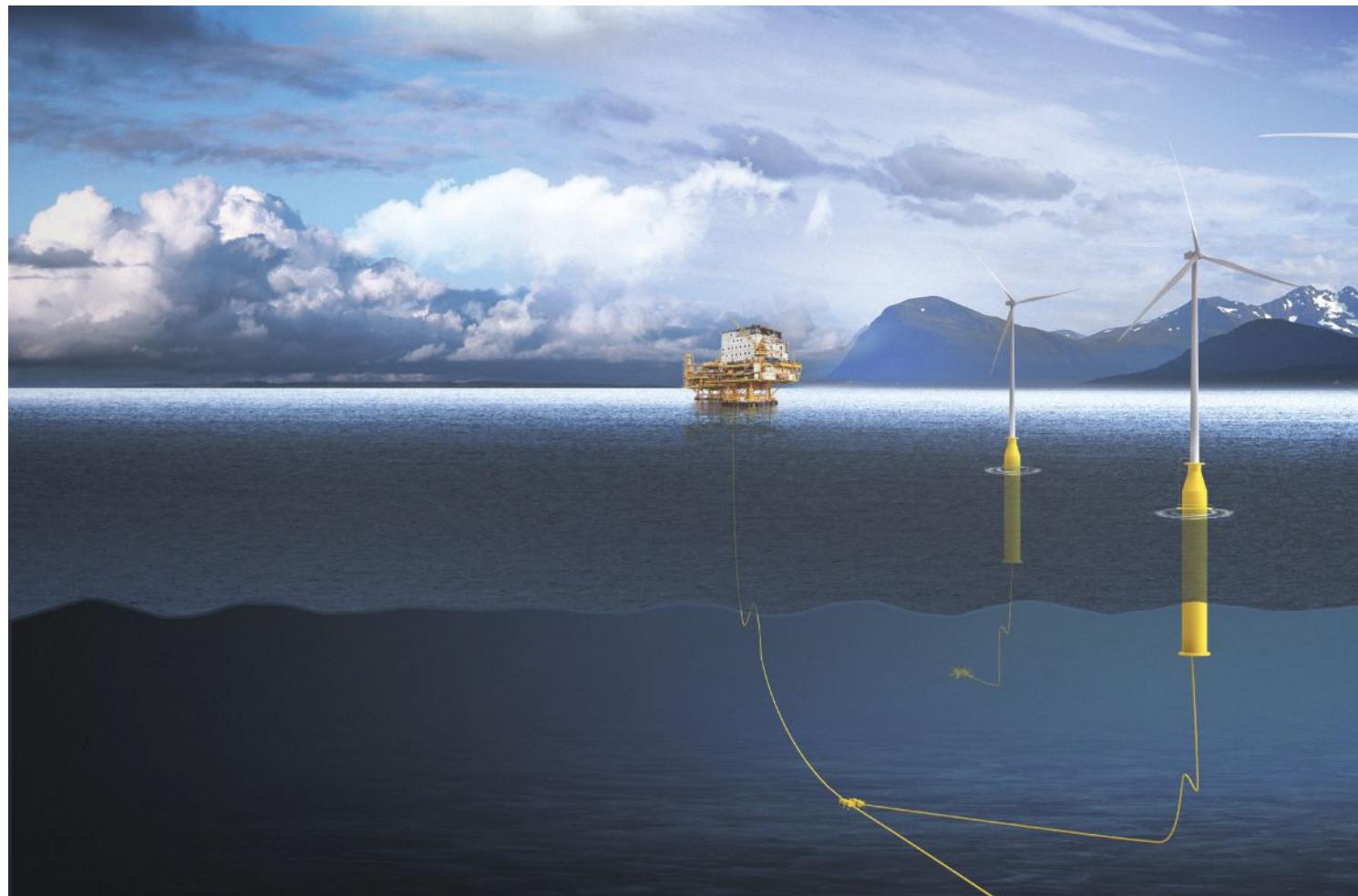
The DNV GL-led joint industry project, WIN WIN (WINd powered Water INjection), has completed its first phase and determined that wind power could be used to power offshore water injection. The project is currently moving into its second phase, which includes refining and testing the electrical systems and investigating possibilities for broader applications. The project consists of four partners: DNV GL, ExxonMobil, and ENI Norge—all part of the first phase—and the Norwegian Research Council—a new participant for this second phase.

The first phase of the project determined the concept is technically feasible, capable of meeting performance targets, and cost-competitive with conventional water injection solutions. The WIN WIN concept includes a floating wind turbine, which supplies power to a typical water injection process that includes pumping and basic water treatment. The second phase will focus on extensive physical lab testing of the electrical systems at the DNV GL power laboratories in Arnhem, the Netherlands, thereby maturing the technical concept and expanding the system performance.

"In this next phase of the project, we'll use a small-scale physical set-up to conduct tests on the systems," explains project manager Johan Slätte. "We aim to instill confidence in the industry that the system and components in this configuration will perform well over time with a variable power input. While phase one was a desktop study, this phase is a natural step before going into piloting with real prototypes. The second phase of WIN WIN is expected to run over the course of one to two years and will result in an application guideline document for the industry. If all tests are successful, a realistic timeline for a first full-scale prototype could be around 2020."

The next phase of WIN WIN will also help to further develop the economic feasibility of wind and potentially other renewables in complex environments with demanding functional requirements. The concept showcases alternative sources of energy and its reliability for off-grid situations.

"The WIN WIN project has shown great potential for



the oil and gas industry to lower costs and increase efficiency, while also reducing its environmental footprint," says project sponsor Johan Sandberg. "Proving that large-scale renewable units can be integrated well into oil and gas systems will also expand the industry's toolbox of technology solutions. It is a win for society with regards to emissions, and for the oil companies who can lower their costs on both equipment and operations."

"We are encouraged by the success of the first phase and look forward to continued collaboration as the project progresses," said Tom Schuessler, president, ExxonMobil Upstream Research Company. "Recent advancements in wind technology, particularly in offshore oil and gas applications, are improving the economic feasibility and allowing for wind to contribute to the overall energy mix at a time when demand continues to rise."

"Eni is delighted to be part of the WIN WIN joint industry project to explore a step deeper the potential of a stand-alone wind powered water-injection system," said Redha Safer, senior R&D engineer, Eni Norge. "Such a self-contained system could provide an unrivalled flexibility while still being cost effective compared to conventional solutions. Moreover, its inherent low-carbon emissions would clearly meet our company's targets for a reduced CO₂ footprint."

For more information, visit www.dnvgl.com.



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Norwegian Authorities Approved Plan for Development and Operation

Norwegian authorities have approved the Plan for Development and Operation (PDO) of the Trestakk discovery on the Halten Bank in the Norwegian Sea. Investments are calculated at NOK 5.5 billion, almost half of the original estimate.

Trestakk was discovered in 1986, and expected recoverable volumes are 76 million barrels of oil equivalent, mainly oil. Tied into the Åsgard A production vessel, Trestakk is expected to come on stream in 2019.

On behalf of the license owners, Statoil submitted the PDO to the Minister of Petroleum and Energy, on 1 November 2016. The costs of developing the Trestakk discovery have been reduced by nearly 50% since project start-up.

"This is a good example of what we are able to achieve in collaboration with our license partners and suppliers by innovative thinking and spending enough time on maturing the best concept choice. Trestakk is an important contribution in maintaining activities on the Norwegian continental shelf," says Torger Rød, head of project development in Statoil.

The first estimates for developing Trestakk were around NOK 10 billion. At the time of concept choice in January 2016, the costs had been reduced to NOK 7 billion. Based on further improvements and concept adjustments up till investment decision, the costs were reduced to NOK 5.5 billion. Furthermore, Statoil and its partners expect to recover much more oil than originally anticipated.

The field development comprises a subsea template and a tied-in satellite well. Three production wells and two gas injection wells will be drilled.

"The Trestakk volumes are an important contributor in maintaining profitable operation of the Åsgard A vessel up to 2030. It also enables us to extract more of the original Åsgard field volumes," says Siri Espedal Kindem, head of the operations north cluster in Statoil.

Cost reductions have been achieved by a novel approach to concept choice, simplification, and optimized scope in addition to benefitting from ongoing efficiency measures.

"This shows what the industry has achieved in just a few years. The Norwegian supplier industry has demonstrated its ability to help find high-quality and cost-efficient solutions that enable us to realize projects like Trestakk, even in a low oil price environment," Rød concludes.

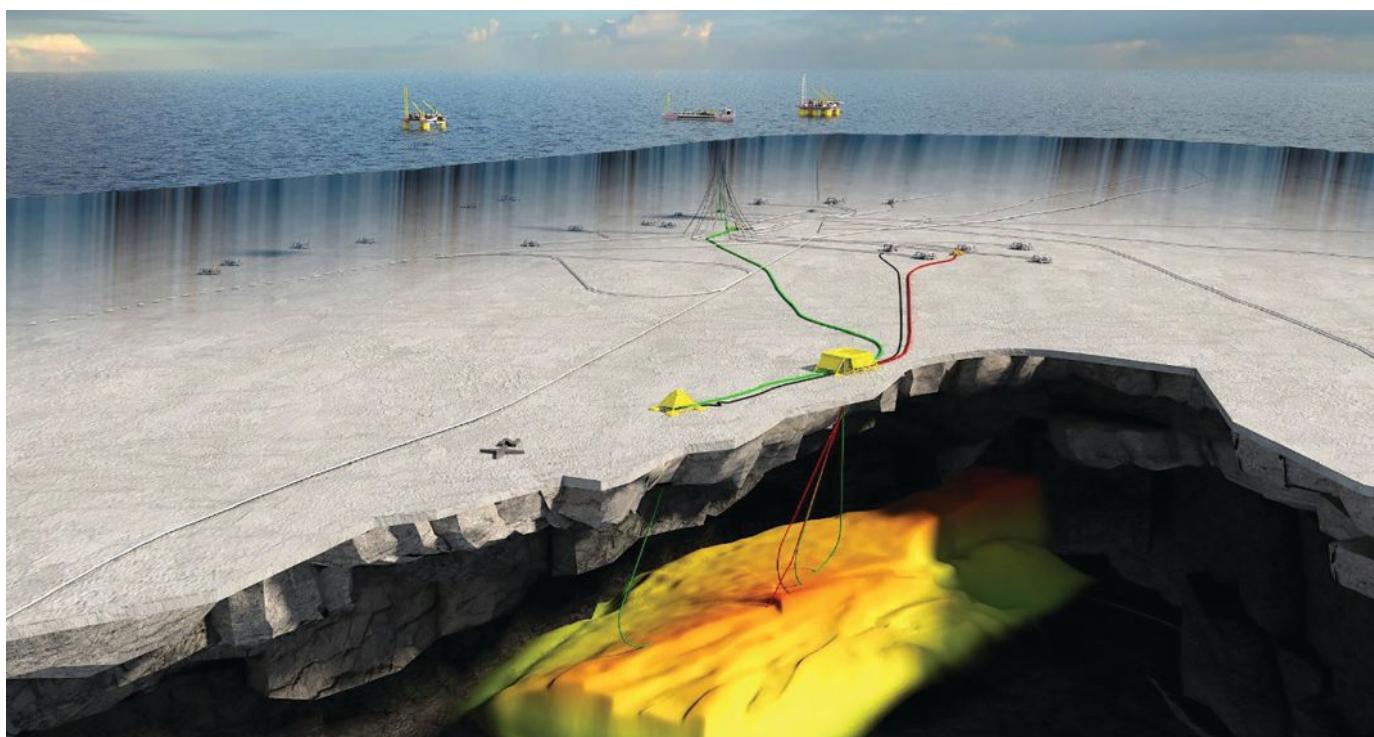
Facts

License owners: Statoil (59.1%, operator), ExxonMobil Exploration and Production Norway AS (33%), Eni Norge (7.9%).

Location: Approximately 20 km south of the Åsgard field
Water depth: Approximately 300 m.

The reservoir is located at a depth of around 3,900 m.

For more information, visit www.statoil.com.



Riptide set out to change the undersea vehicle market by combining best in class hydrodynamics, ultra low power processing, and game changing new energy technology, while significantly reducing vehicle costs. To accomplish this, we introduced the small, yet highly-capable micro-UUV.

And now, the Family just got **BIGGER**

Introducing the Riptide Family of Low-Logistics, Man-Portable UUVs



Micro-UUV
4.875" Diameter
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300m rated



1 Man-Portable UUV
7.5" Diameter
~65 lbs
300m rated



2 Man-Portable UUV
9.375" Diameter
~120 lbs
600m rated

Riptide
Autonomous Solutions

Email: info@RiptideAS.com • Website: www.RiptideAS.com
Phone: +1 617-820-4586 • Address: 36 Farmside Drive, Pembroke MA, 02359 USA

OFFSHORE ENERGY



GE and Noble Announce a Partnership to Collaborate on the Digital Rigsm

GE and Noble Corporation plc jointly announces a partnership to collaborate on the Digital Rigsm solution, enabling data-driven operational efficiency by using data analytics, with the target of a 20% reduction in operational expenditure across the rigs. Within the agreement, GE will initially deploy its latest marine Asset Performance Management (APM) system, powered by Predix*, on four of Noble's drilling rigs. The partnership will allow data-driven operations intelligence to provide broad-ranging benefits for the selected assets on the program's rigs.

<http://ont.news/2oIMX7o>

Hydro Group Successfully Completes Significant MeyGen Contract

Hydro Group has completed a major contract with technology developer and supplier of tidal turbines, Andritz Hydro Hammerfest (AHH). The agreement saw Hydro Group supply complete connection systems for three turbines on the world's most advanced multi-turbine tidal stream energy development. This second MeyGen contract followed on from an announcement in November 2015 regarding a contract with Atlantis Resources—86% owner of MeyGen Limited—for which Hydro Group supplied the complete export connection system for one of the tidal turbines.

<http://ont.news/2pioMQ2>



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MONTH IN REVIEW

EIA: U.S. Gulf of Mexico Crude Oil Production Sets Annual High

U.S. crude oil production in the GOM set an annual high of 1.6 million barrels per day (b/d) in 2016, surpassing the previous high set in 2009 by 44,000 b/d.

<http://ont.news/2oMWTk6>

ExxonMobil Announces New Oil Discovery Offshore Guyana

ExxonMobil Corporation has announced positive results on the Snoek well offshore Guyana, confirming a new discovery on the Stabroek Block.

<http://ont.news/2oYTLoc>

Ocean Energy Industry Begins Take-off in 2016

2016 saw an unprecedented number of ocean energy deployments in Europe, according to a report published by Ocean Energy Europe.

<http://ont.news/2oVNK45>

Trelleborg Awarded Contract for Catcher FPSO Project

Trelleborg's engineered products operation completed a milestone project for BW Offshore for the design and fabrication of FPSO elastomeric bearing structures.

<http://ont.news/2oZ2O1R>

Active Heave Compensated (AHC) Drilling Platform from MacArtney

Newly launched multipurpose drill ship FREJA integrates a high-performance active heave compensated drilling platform manufactured by MacArtney.

<http://ont.news/2oNhEfE>

Report Highlights Economic Benefits of Marine Energy Industry in Wales

The marine renewable energy industry is bringing increased investment and jobs to Wales, and this is demonstrated in a new report from Marine Energy Wales.

<http://ont.news/2pxWbqn>

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GOING DEEP

A Hydroid employee preps the REMUS 100 Autonomous Underwater Vehicle (AUV) for testing in the subsea Hyperbaric Testing System (HTS) at Hydroid's Pocasset, MA facility. The HTS simulates hydrostatic pressures found at depths of up to 6,000m and is used to test all of Hydroid's autonomous underwater vehicles (AUVs) and other marine robotics products to ensure their integrity at a rated depth. This in-house capability allows for a customized testing routine and a real-time connection with the vehicle while it is undergoing testing.

"The level of advanced testing this system provides is crucial in ensuring that our vehicles meet and exceed the highest standards for subsea missions," said Duane Fotheringham, President of Hydroid. "It is our goal to continue to maximize our vehicles' capabilities, and advance marine robotics technology."

Learn more about Hydroid's AUVs & capabilities at www.Hydroid.com

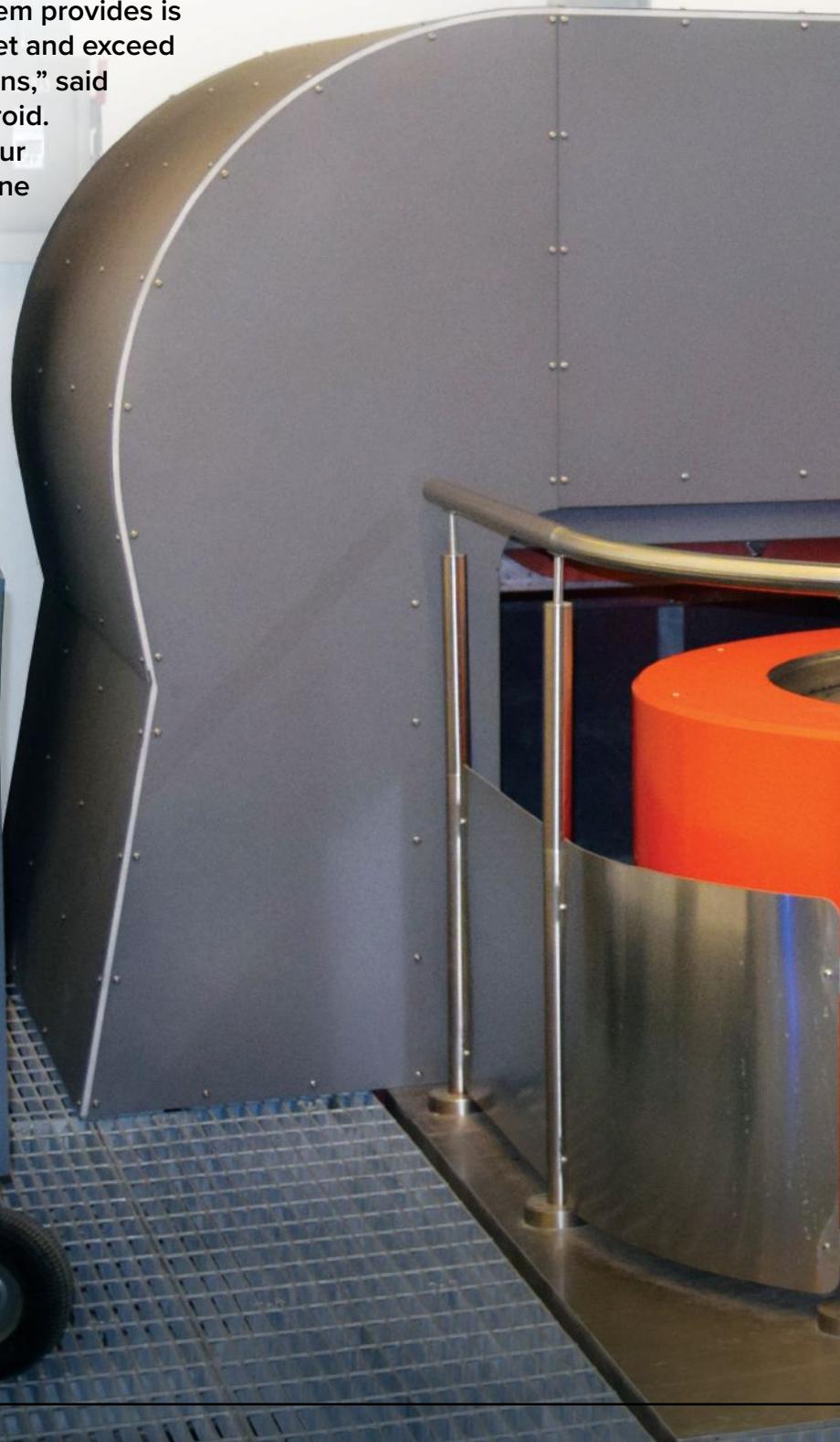
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Tecnadyne: Propulsion Systems for AUVs

More than 30 years ago, Tecnadyne delivered its first thrusters to Mitsui Engineering and Shipbuilding in Tokyo. Since then, the company has manufactured and delivered over 8,000 thrusters. The primary focus of the company has been underwater propulsion, motion control, and related technologies for remotely operated vehicles (ROV). Headquartered in San Diego, California, Tecnadyne's manufacturing facility is involved in design, fabrication, assembly, and development of customized subsea systems. The company more recently has increased its focus to include propulsion systems AUVs. ON&T talked with founder and president Tecnadyne, Andrew Bazeley.



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ON&T: Could you give us some background on your AUV propulsion systems?

Bazeley: We have a fairly new application, which is building thrusters for AUVs. When I started the company 34 years ago, we were building thrusters for just ROVs. The thruster for an ROV is more of a general thing. You're just concerned with how much push you can get out of that thruster—you really want the most bang for your buck. When you make a thruster for an ROV, it's a more compact thing, it produces a lot of thrust but isn't very efficient.

ON&T: Now you are designing thrusters for AUVs. How is that different?

Bazeley: Every single AUV is different in its requirements for the propulsion, and it is different in how they move through the water at a forward speed or velocity. Sometimes they move quite fast. They need a thruster or propulsion system that allows them to move through the water at the speed that they need to move. They also need to do so as efficiently as possible. It has to be efficient because, in almost all cases, a battery powers AUVs. In order to stay underwater to complete a mission, you are juggling the amount of power in the battery and the power of the thruster.

ON&T: So, you are dealing with a much different case in AUV thruster design.

Bazeley: Yes, a special or purpose analyzed and design thruster needs to be built for each AUV. We have to look at how much power that AUV can deliver, but we need to look at what speed it needs to move through the water

and how much thrust it's going to take to move that AUV through the water at that speed. We have developed some very good analytical tools to model appropriate propulsion. We can play with a lot of propeller characteristics. This isn't something that is totally new and unique because modeling propellers for optimum efficiency has been going on in the shipping industry and the ship building industry since the beginning of propeller-driven cargo ships. In their case, they are crossing big oceans and want to do it as efficiently as possible. It is not that they have limited power on the ship, but they want to use as little as they can and as cheaply as they can to maximize their profits. The difference is that an AUV operates submerged, while surface cargo ships have to take into consideration the air/water interface.

We have developed some very good analytical tools that not only allow us to optimize the propeller design, but also optimize the propeller design working in concert with an electric motor and, in most cases, a gear box to reduce the speed from the electric motor for a proper speed for the propeller. We are now able to very accurately model the entire propulsion system for an AUV. We can analyze, design, manufacture, and deliver an AUV propulsion system that meets the performance and mission requirements of that particular AUV.

ON&T: Could you talk a little more about the tools used in your process?

Bazeley: The analytical tools we have are all software. The design of the thruster uses fairly well established hydrodynamic principles. The data have changed over time, but knowing how to use those data, information,

and know how is another matter. Especially when applied to the AUV case, which is a little bit different from the established applications. We also have the ability to model the electric motor and gearbox with the propeller and are able to treat that entire propulsion system as a single black box. The client puts in power on one side, and we deliver propulsion or thrust on the output.

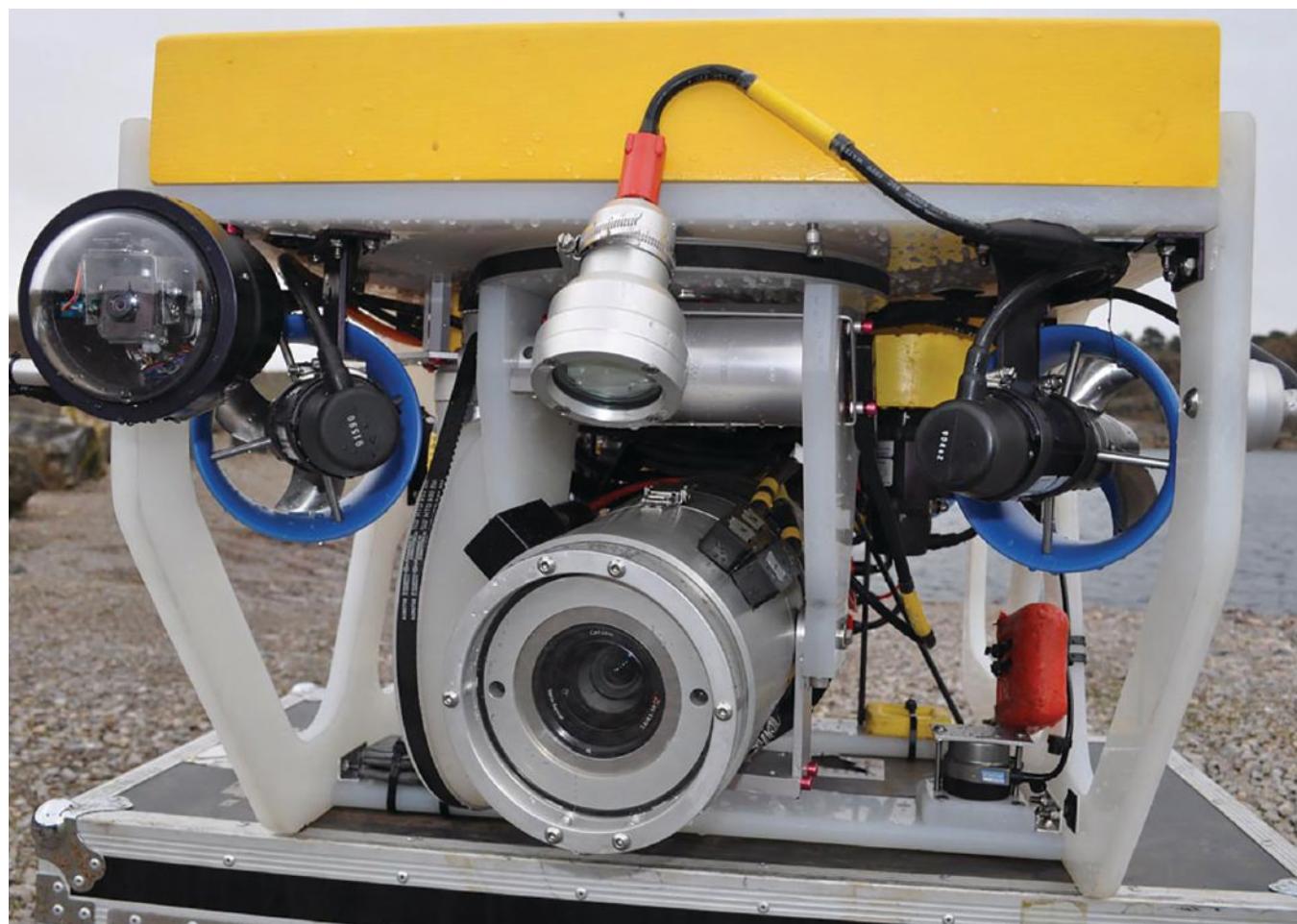
In addition to those analytical tools that we have which are all software based, we have pretty sophisticated testing abilities. We are able to test the performance of these propulsion systems and thrusters that we build. We are able to do that in a pretty timely and cost effective way. Part of the reason we are able to do that is because we rely on many of the building blocks we have designed over the 34 years that we built thrusters for ROVs. We are able to choose from a dozen motor frame sizes that we already have comprehensive performance data on and that we have in stock. We are also able to select from maybe 18 or 20 gearbox configurations that we have already built and tested and generated the performance data. We have the ability to take these different components off the shelf, and that is what we do when we are doing the analytical work. We are just using those building blocks that we have and have developed over 34 years. We have them all on the shelf.

ON&T: So, you are creating new designs for AUV applications built on time-tested components.

Bazeley: Yes, we are able to marry that to new propeller designs so that we can do rapid prototyping. Depending on the size and complexity of the propeller we will, at least at the prototype level, print the propeller in 3D or an investment cast of the propeller out of stainless steel.

ON&T: You're also providing the client with a one-stop-shop experience.

Bazeley: Because of our experience and vast array of building blocks, we are able to build the entire propulsion system in one black box assembly. It is not a matter of a customer going to a company to design a propeller for them and then going to another company for the motor and then another company to bring the two together and then realizing for one reason or another the performance doesn't meet the needs for the propeller. That happens a lot, believe it or not. We are able to conceptualize, design, develop, and manufacture these propulsion systems and get them in the customers hands in a relatively finite and reasonable amount of time with a pretty high degree of confidence that the performance they see when they get that thruster is the performance they were anticipating.



DC Brushless Thruster Model 560.

CSA Exhibits Advancements in Underwater and Aerial Imaging

The Esri's Public Sector GIS Conference (formerly the Southeast User Conference) in West Palm Beach, Florida, was an ideal setting for CSA Ocean Sciences Inc. (CSA) to share their advancements using Geographic Information Systems (GIS) tools integrated with customized hardware to collect and analyze video imagery, both subsea and aerial. On April 11 and 12, CSA analysts and scientists who specialize in the use of GIS tools in projects serving the public sector exhibit at the conference held at the Palm Beach County Convention Center.

Identifying emerging technologies and their potential applications in examining environmental issues is a core component of CSA's Environmental Data and Geospatial Services (EDGS). CSA's EDGS team uses the Esri technology stack, including Full Motion Video (FMV), integrated with other customized hardware, software and web-based mapping portals, to examine local and regional environmental issues along Florida's shorelines and waterways. CSA's recent partnership with Morgan & Eklund Inc. (M&E), a hydrographic and land survey firm based in Wabasso, Florida, offers a comprehensive package of environmental and survey services to examine, plan, and execute projects for the public sector. For more on this partnership, visit www.csaocean.com/press-releases/morgan-eklund-joins-continental-shelf.

"Integrating cameras, imaging platforms, and geopositioning equipment with advanced survey capabilities offers a great opportunity," stated Dustin Myers, one of CSA's leading GIS analysts who specializes in emerging technologies applied to local and regional problems.

"Our objective is to provide image collection and analysis services that are platform agnostic, whether using autonomous vehicles, remotely operated vehicles, manned aircraft, divers, or land surveyors as the field platform."

At the conference, CSA exhibited, examples of recent projects using various platforms, both underwater and aerial, to col-

lect FMV-compliant imagery that is then used to create orthomosaics, run image classifications, and play video over spatial data layers in a web-based platform.

CSA brings 47 years of specialized experience in marine environmental consulting, conducting environmental assessments worldwide through offices in the United States, the Eastern Mediterranean, Qatar, Trinidad, Brazil, Singapore, and Australia. CSA's expertise with coastal, marine, and deep ocean surveys, including sampling, monitoring, assessment, and mitigation, is built on the integration of science, operations, and an understanding of environmental data collection, management, and analysis within geospatial domains.

More information on the conference can be found at www.esri.com/events/public-sector. For more on EDGS, please visit www.csaocean.com/services/environmental-data-and-geospatial-services-edgs.



MacArtney Delivers Survey System to Hamburg Port Authority

Conducting around 900 surveys per year in the port of Hamburg, Hamburg Port Authority (HPA) requires high-end products for their multi-sensor systems and survey vessels.

The vessel Deepenschriewer IV is the smallest survey vessel of HPA and intended to carry out multibeam surveys for depth control and documenting in shallow water areas. For this purpose, MBT, MacArtney Germany, has effected supply, installation, and setting-to-work of a dual head multibeam echo sounder system suitable for hydrographic survey applications.

Dual Head Installation

This solution comprises the following products: high-resolution multibeam echo sounder Teledyne RESON SeaBat® T20-R, a Valeport SWIFT sound velocity profiler, and a Valeport UltraSV.

Scope of Supply

The dual head Teledyne RESON SeaBat® T20-R multibeam echo sounder configuration provides uncompromising survey data in a highly compact package designed for small vessel use. It is an all-in-one, fully flexible and fully integrated survey system allowing for fast mobilisation, minimal interfacing, and low space requirements. It is fully frequency agile from 190 to 420 kHz, which ensures improved swath performance and reduced survey time.

Representing a seamless workflow, the Valeport SWIFT sound velocity profiler features rechargeable battery and LED status indicators for easy and fast downloading, reviewing, and translation of data into common SVP formats wirelessly. The Valeport UltraSV offers an advanced and exchangeable sound velocity sensor and is ultra-fast, ultra-compact, and ultra-dependable.

The scope also consists of RTK GNSS and inertial sensor as well as a QINSy hydrographic data acquisition, navigation, and processing software package.

Ultimate Flexibility

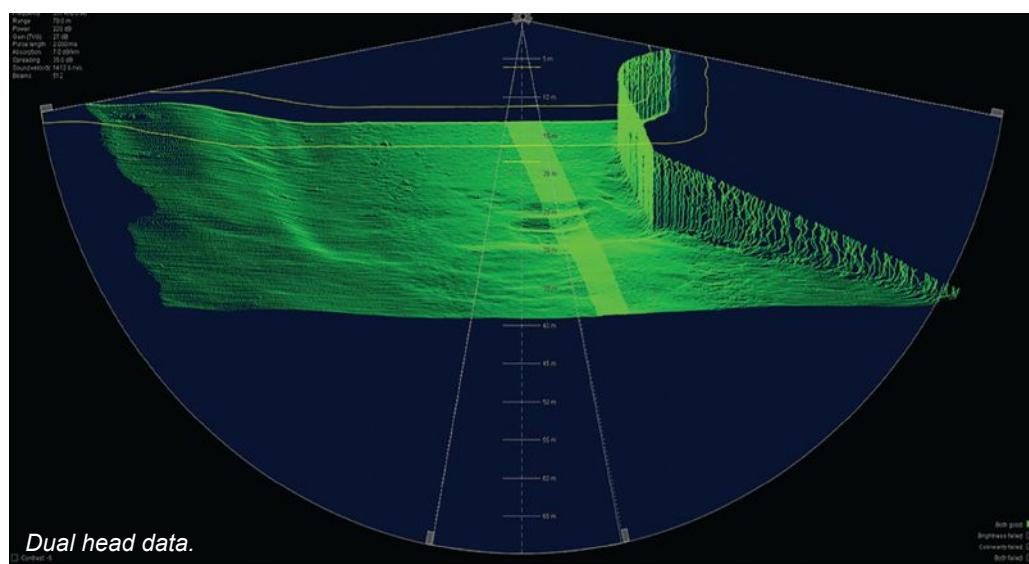
The units are intended for coastal, harbour, and inland hydrographic survey use. Featuring superior acoustic quality and high accuracy, this dual head survey system enables easy and quick downloading and sharing of data relevant to hydrographic surveying.



Dual head installation on survey vessel.

Quality testing to meet the most demanding standards ensures optimum performance, thus allowing for good swaths in very shallow water as well as comprehensive surveys in big areas in a short time, especially in shallow areas, and thorough testing during dredging operations.

For more information visit www.macartney.com.



Dual head data.

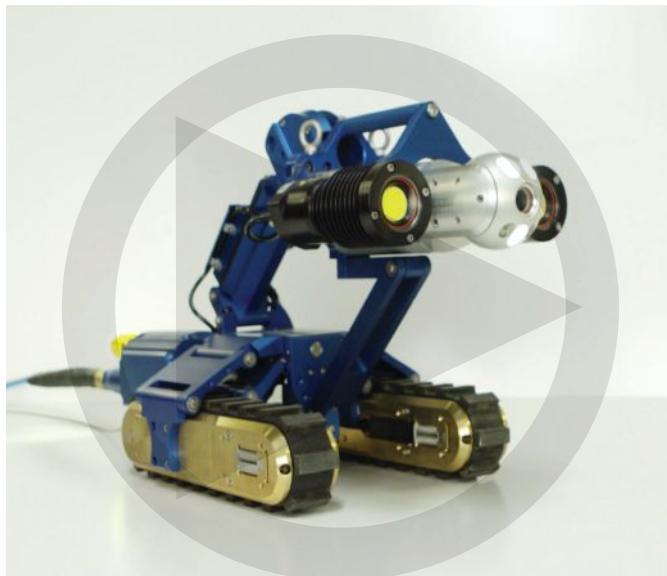
Next Generation of the Versatrax 150™

Inuktun Services Ltd., a leading designer and manufacturer of robotic camera and crawler inspection technologies, introduces the next generation of the Versatrax 150™ pipe inspection crawler, the Mark II.

Expanding on the capabilities of the proven Versatrax 150™, the Mark II travels up to 1,000 m (3,300 ft), in air or underwater, in pipes as small as 150 mm (6 in.) in diameter. The standard system incorporates a highly durable copper umbilical, with options for even longer cable lengths using fiber optics. With the integrated PTZ camera mounted on a remotely operated lift mechanism, the Mark II offers highly detailed inspections of even the most challenging pipelines. Additionally, the Versatrax 150™ Mark II easily integrates with existing sonar systems, retrieval tools, laser profilers, and nondestructive testing (NDT) sensors for advanced data collection.

The Versatrax 150™ Mark II is well suited to a variety of inspection applications, including sewers, storm drains, hydroelectric penstocks and fish bypass lines, petrochemical and power plant intake pipelines, and difficult-to-pig pipelines across a wide spectrum of industry sectors. Like all of Inuktun's OnDemand Specialty Systems, the Mark II is available for rent or purchase through its network of global offices.

For more information on the Versatrax 150™ Mark II and the rest of Inuktun's Multi-Mission Modular (IM3) technology for remote inspection and nondestructive testing in confined spaces and hazardous environments, contact their friendly and knowledgeable team at content@inuktun.com, toll-free (North America) at 1-877-INUKTUN (468-5886) or 1-250-729-8080.



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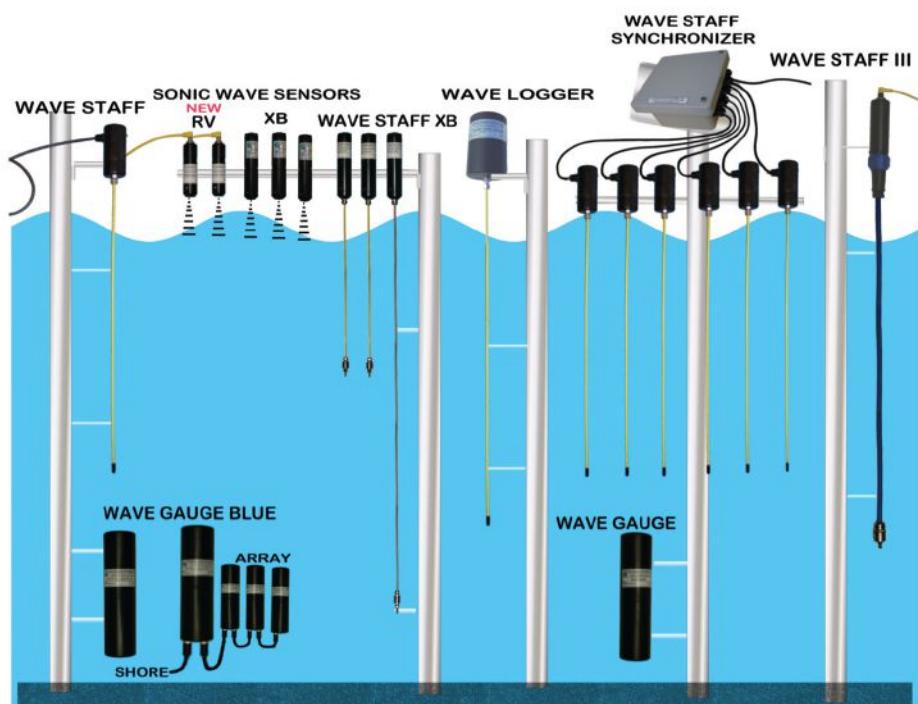
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PRODUCT SPOTLIGHT

Kongsberg Maritime



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AUVs for all Applications

Kongsberg Maritime's Marine Robotics (MARO) team is the driving force behind the most extensive portfolio of autonomous underwater vehicle (AUV) technology in the world. The company's HUGIN AUVs have forged a path for the acceptance of this advanced technology as a viable, optimal survey and inspection platform since 1993, while the MUNIN AUV offers the same advantages, but in a more compact platform.

HUGIN is KONGSBERG's original AUV and through constant development is still recognised as a state-of-the-art, highly reliable and effective platform. Combining IHO-quality positioning with low noise and the highest resolution survey sensors available, HUGIN is the most complete platform for seabed mapping, pipeline inspection, and mine countermeasures. Capable of operating at depths to 6,000 m with mission durations of more than 75 hours, HUGIN's size and flexible configuration options enable it to collect data from diverse sensors, resulting in a complete data set from a single mission.



HUGIN can operate at depths to 6,000 m for over 75 hours at a time.

Launched in 2013, MUNIN is capable of missions of up to 24 hours in water as deep as 1,500 m. Measuring between 3 and 4 m in length with a 34-cm diameter, the 600-m rated MUNIN weighs less than 300 kg, making it one of the most compact and yet highly capable commercial AUVs available today. It features a modular construction, enabling operators to mobilize the system quickly without the need for calibration. It is also compatible with KONGSBERG's pipe tracking software, using the side-scan sonar to autonomously track alongside a pipe.

While HUGIN, MUNIN, and Kongsberg Hydroid's Remus AUVs continue to be the first choice in the offshore, research, and naval sectors, the MARO team has diversified KONGSBERG's AUV offering in recent years, most notably through the Kongsberg Seaglider platform and a collaboration with NTNU and Statoil to develop the unique Eelume solution.

Seaglider is an autonomous underwater glider developed for continuous, long-term measurement of oceanographic parameters. Rather than an electrically driven propeller, the vehicle uses small changes in buoyancy and wings to achieve forward motion. The system's pitch and roll are controlled by moving the battery mass inside the vehicle.

Eelume is a radical re-imagining of the accepted AUV standards. Featuring a ground-breaking, futuristic design based on a unique flexible and adaptable body, Eelume is designed to live permanently underwater and carry out underwater inspection and intervention tasks that would normally require the mobilisation of expensive ships for divers or the launch and retrieval of other ROVs.

In addition to its superior manoeuvrability, Eelume is a highly stable sensor and actuator platform offering unmatched access to confined areas inside subsea structures enabling diverse operations. The Eelume solution will dramatically reduce costs and the environmental impact associated with having a ship overhead as is normal for traditional underwater intervention operations. It can be installed on both existing and new fields where typical jobs include visual inspection, cleaning, and operating valves and chokes. These tasks account for a large part of the total subsea inspection and intervention spend.



Eelume features a flexible, modular design that introduces new possibilities underwater.

Eelume represents a radical diversion from the standard approach to developing AUVs, ROVs, and other marine robots. It will deliver significant new capabilities when it becomes commercially available in 2018. While Eelume brings a new approach, as a leading AUV developer Kongsberg Maritime continues to offer the largest, most advanced portfolio of tried and tested AUV platforms for all applications.

SUBSEA INTERVENTION & SURVEY



EvoLogics Presents Recent Product Developments at Ocean Business

EvoLogics GmbH from Berlin, Germany, designs and manufactures underwater communication and positioning systems as well as smart robotic solutions. The company's core technologies stem from bionic concepts that fuse state-of-the-art engineering with the best ideas found in nature. EvoLogics "ecosystem" of products includes several series of underwater acoustic modems, underwater positioning systems (USBL, LBL, SBL), and an advanced framework for developers.

<http://ont.news/2oOmZy>

Forum Sells Two Comanche ROVs to International Diving Contractor

Forum Energy Technologies, Inc. announces the sale of two Sub-Atlantic™ Comanche ROVs to international diving contractor Baltic Taucherei- und Bergungsbetrieb Rostock GmbH (Baltic Diver Germany). The deal, supported by distributor Scholz Ingenieur Büro, will see both systems delivered at the beginning of May 2017 following an optimized manufacturing schedule. The Forum Sub-Atlantic Comanche was chosen due to its high thrust-to-weight ratio and compact laydown requirements, which make it ideally suited for the operating environments expected by Baltic Diver.

<http://ont.news/2pEG6jm>



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A Big Future for Micro Technology and ecoSUB Robotics



Hand Launch of ecoSUB-μ. Photo credit: Planet Ocean Ltd and National Oceanography Centre.

As the data gatherers of the sea, autonomous under-water vehicles (AUV) are the go-to technology for those seeking knowledge from under the waves. Many vehicles are now able to travel vast distances across the world's oceans, collecting valuable data for users in science, military, and commercial sectors. The technology has advanced substantially over the last decade as sensors become smaller, autonomy becomes smarter, and vehicles become more powerful, widening the net for more applications and opening doors to multi-use missions. And now, the latest trend in micro AUV platforms means this new cutting-edge technology and smarter systems will be more accessible than ever before. ecoSUB Robotics Limited is a brand-new company delivering advanced, low-cost micro AUVs. The innovative ecoSUB range will not only help provide access to superior data sets but could also lead the marine sector into a new age of advanced ocean knowledge.

The innovative system was born from an idea within the National Oceanography Centre (NOC) and nurtured in the head office of Planet Ocean Limited, a UK-based marine science technology specialist. After extensive collaboration with the UK's Marine Autonomous Robotics Systems (MARS) group at NOC, the ecoSUB micro AUV range was launched.

Terry Sloane, CEO of Planet Ocean Ltd and ecoSUB Robotics Ltd, is confident that these low-cost platforms will help many more users across research, academia, and teaching access marine autonomous systems (MAS) and apply the benefits of collecting wide spatial and temporal data. "We wanted to create a capable vehicle that would draw upon the latest sensor, energy, and materials technology to democratise the use of AUVs. It was important to us that the system was easy to use, performed worthwhile missions without compromise of specifications, and, above all, it had to be affordable."

The ecoSUB programme officially began in 2015 after a successful Planet Ocean bid won funding by Innovate UK and DSTL. The project aimed to develop the launch and recovery of multiple AUVs from an Unmanned Surface Vessel (USV). In turn, this stimulated the development of the micro AUVs based on an original NOC concept vehicle.

By November 2016, the micro AUV platform was finally revealed and launched as "ecoSUB- μ " at the NOC MARS Innovation Showcase. Early in the project, BP showed significant interest and funded the parallel development of a second AUV—a vehicle that can dive deeper with a larger payload capability. The 8-month project resulted in the slightly larger, but still one-man deployable "ecoSUB-m," which was also uncovered at the MARS Showcase event last year.

Sloane said, "Micro AUVs have several benefits that stand out over larger AUVs. Cost is an important one, which by default leads to several others. The small size means that manufacturing costs can be less, but perhaps more importantly, the cost of ownership is less. There are no expensive mechanical handling systems required

to support launch and recovery, and they can be transported cheaply. Furthermore, maintenance and support costs are lower, and there is less time needed for training and familiarisation compared to larger systems."

The benefit of a low-cost system means that several vehicles can be deployed on a single mission to produce far higher temporal and spatial data sets than would be obtained with a single, more expensive AUV or glider. While the small size means that users are not yet able to carry large suites of sensors on a single vehicle, users can equip multiple vehicles with different sensor combinations to achieve the same results.

"The future for ecoSUB is very exciting."

- Terry Sloane, CEO of Planet Ocean Ltd

"Because the vehicles are small, we have had to work smarter to achieve meaningful mission capability in the absence of expensive components such as DVLs or USBL positioning systems. The small size means that the μ version is capable of being air launched from small, fixed-wing autonomous aircraft (UAV) or indeed multi-rotor platforms. The University of Southampton are actively engaged in a programme to demonstrate this."

The ongoing programme is a collaboration with Planet Ocean Ltd, NOC, ASV Ltd, and the University of Southampton. ASV Ltd have developed an automated launch and recovery system, while a team of engineers from Planet Ocean and the NOC MARS group worked together to build a micro AUV platform capable of serving a broad range of sectors. The resulting systems have the capability to deploy advanced sensors such as high accuracy CTDs, dissolved oxygen, and fluorometers.

"Our academic partner, the University of Southampton, have provided their new wave tank for initial response testing. Of course, being located in the NOC innovation centre has also allowed us to benefit from the considerable test facilities located there—we have been testing and developing behaviours and refining control systems in closed, freshwater facilities that allow us to undertake these tests in controlled conditions," explained Sloane.

During the ecoSUB programme, engineers have had to overcome several challenges, including lack of available high-performance sensors compatible with the needs of a micro platform. Power supply chemistry was also a critical issue so that they can achieve the desired speed and endurance as was incorporating the required intelligence to achieve high levels of autonomy in such a small body. Use of advanced 3D printing technology has accelerated the design process and allowed the teams to evaluate several solutions quickly and economically.

EDITORIAL FOCUS

Now, ecoSUB is currently entering the open-water test phase where the vehicles and sensors will be put through their paces in real mission scenarios.

Introducing Micro Platforms to the Industry

Around the world, there are a huge number of potential users of AUV technology in the areas of science, defence, oil and gas, and commercial sectors. But, not everyone could access the technology. The ability to afford or even to evaluate AUVs as a useful addition created an obstacle that, until now, prevented many users from incorporating the technology within their work.

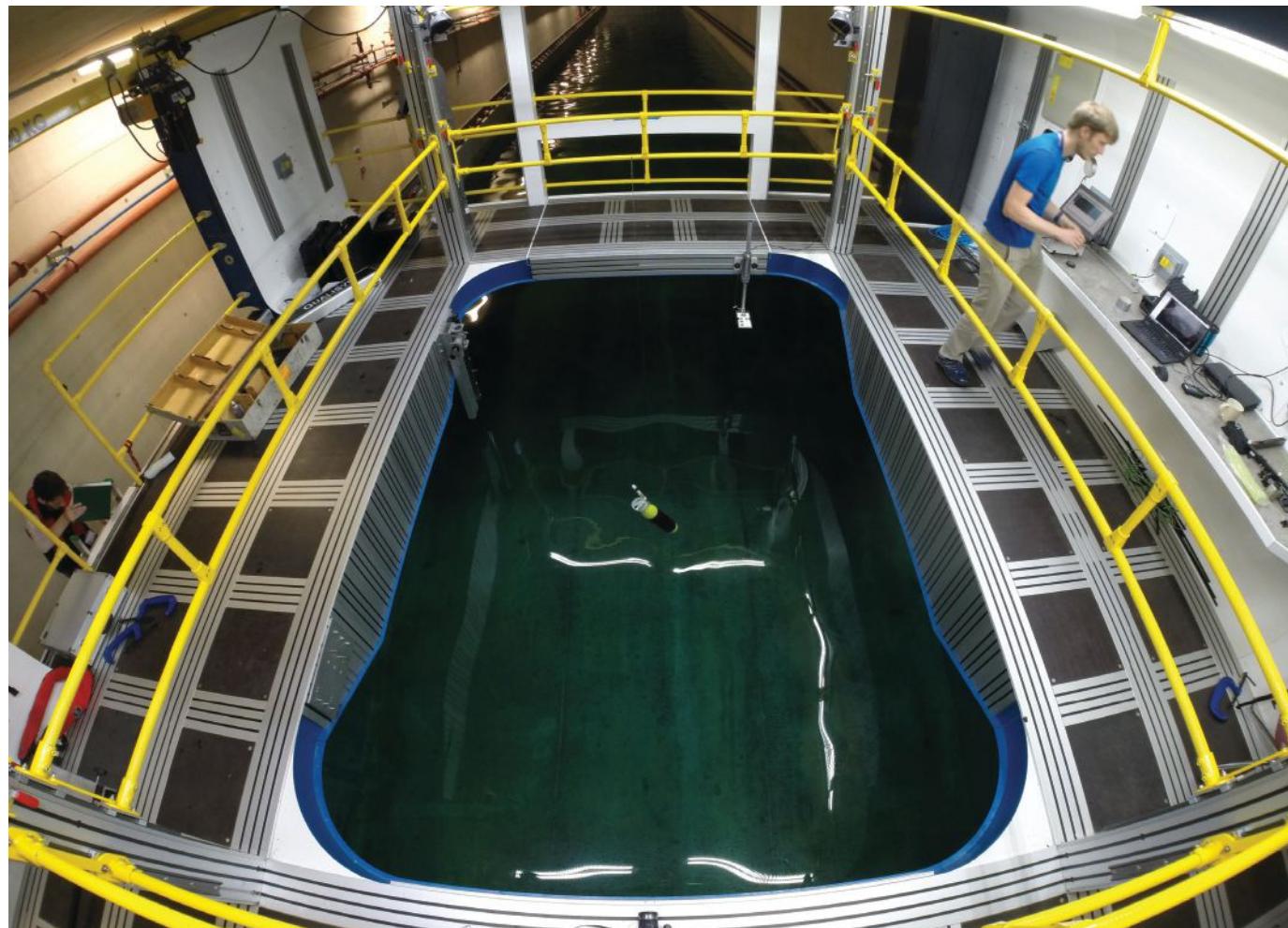
"We engaged with potential end users in the first year of the project and their input, encouragement, and backing has been extremely useful—it has helped shape the project. Since the launch, feedback has been exceptional. We have received orders for five advanced prototypes and additional funding to supplement the Innovate UK investment. There is also considerable interest from collaborators in future R&D activity to expand the capabilities of the vehicles. So, already we can say that the future for ecoSUB is very exciting," said Sloane.

There are several key applications ecoSUB Robotics envisages for the new micro AUV range. Whilst micro

AUVs are not seen as replacements for the larger, more capable platforms, it is likely these systems will be able to complete missions that a traditional AUV or glider cannot. And, because of size and cost, there will be new options in terms of how missions are structured using "shoals" of vehicles instead of just one or two large platforms.

Sloane said, "Of course, we have had a lot of applications suggested to us by potential users, some of which we had considered, but many which we had not. This provides us with a healthy development path going forward—the challenge is deciding which to tackle first. Many like-minded groups are operating in the UK and elsewhere that are developing technology which will enhance the capabilities of ecoSUB in the coming months and years. We find this very exciting, if not a little challenging."

The defence sector already recognises the potential for autonomous system use in their situational awareness and tactical operations. ecoSUB hopes to dramatically reduce barriers to MAS use in this sector by significantly diminishing logistical challenges of launch, recovery, and operations. There is also scope for integrated mission control and useful, focused data products to deliver key information when and where it is needed.



Testing of ecoSUB- μ in University of Southampton wave tank facility. Photo credit: University of Southampton.



Dr Alex Phillips, lead designer, with ecoSUB- μ against some of the NOC Glider fleet. Photo credit: Planet Ocean Ltd and National Oceanography Centre.

“All of the team believe in great design and challenging the status quo.”

- Terry Sloane, CEO of Planet Ocean Ltd

Commercial operators, especially in the oil and gas sector, see enormous potential in the affordable use of MAS for a whole range of activity, including a rapid environmental assessment, subsea inspection, and asset monitoring and support.

Most importantly, the initial low-cost investment will also help users test the system capabilities in a variety of conditions and scenarios without the financial burden and risks associated with the larger alternatives. This will not only help to build the trust required in the technology before use in live missions, but also gives rise to new opportunities to use these systems in applications where AUV use was not possible, or even considered, until now.

A Big Future for Micro AUVs

As technology in this sector continues to advance at an astonishing rate, the industry will likely see smaller, lower power, and more accurate sensors arriving. This

will not only improve what micro AUV platforms can offer, but enable users to measure more parameters in the future. And, so that more complex missions can be undertaken, vehicle-to-vehicle and vehicle-to-surface communications should develop quickly along with improvements in navigation.

“In the next 5 years, we will see much more integration of micro-AUVs with larger AUVs, ASVs, and UUVs in everyday data-gathering activities and hopefully advances in energy technology—given the levels of investment being put into this area currently. At the moment, satellite communication bandwidth can be a limiting factor in some instances so there needs to be some improvement in this area if the technology is going to advance any further,” commented Sloane.

“It is great to see a few new players in this emerging sector, each taking slightly different approaches, but, overall, this validates our thinking. This process has been challenging, but also exciting, fast, slow, thought provoking, and creative. All of the team believe in great design and challenging the status quo. ‘Disruptive technology’ is an overused term, but not in this context! But, what can the industry expect to see for ecoSUB in the coming years? I’m not saying just yet.”

Acknowledgements

Terry Sloane, CEO of Planet Ocean Ltd and ecoSUB Robotics Ltd, UK.

Nexans Celebrates 40th Anniversary of the Skagerrak Interconnector

For decades, high-voltage direct current (HVDC) mass impregnated (MI) cables have been the preferred solution for long-distance submarine transmission. This year, Nexans is celebrating 40 years since its HVDC MI cables were first put into commercial service at the Skagerrak Interconnector submarine HVDC link between Denmark and Norway. In 1977, the Skagerrak link, which is owned and operated by Energinet.dk in Denmark and Statnett SF in Norway, represented the first time high-voltage cables were installed for such a long distance sea crossing (130 km) at a water depth of 550 m.

In operation, the links of the Skagerrak Interconnector enable additional renewable energy to be integrated into the power mix and more efficient use of electricity by connecting the Norwegian grid, which is largely hydroelectric based, with the Danish grid, which is primarily thermal and wind power based. With 40 years of service and counting, the Skagerrak Interconnector's HVDC MI cable systems from Nexans have definitely proven their strong reliability and longevity.

Nexans' Skagerrak 1 and 2 HVDC MI cables are operating at 250 KV, and each cable has a power rating of 250 MW. As the demand for energy between the countries increased, additional power transmission has been installed. Today, four cables have a total power rating of 1,700 MW, which rep-

resents the energy needs of nearly 25,000 typical Scandinavian households.

HVDC MI cables from Nexans are used for transmission links worldwide, including the Skagerrak line and other interconnectors such as Sweden-Finland (Fenno-Skan) and Estonia-Finland (EstLink 2). They also are being used for the upcoming HVDC links between Italy and Montenegro (Mon.Ita), Norway and Germany (NordLink), and Norway and the United Kingdom (NSL).

"Through decades of research and development in design, materials, testing, manufacturing processes and installation techniques, Nexans has been able to push the limits for voltage levels, power transmission capacity, and installation depth for MI cable systems. Ongoing research and development activities for MI cable systems focus on even higher voltage levels and increased transmission capacity, resulting in new possibilities for bulk transmission of vast amounts of electrical energy over long distances," says Vegar Syrtveit Larsen, technical director, Nexans Norway. "We are proud to say that, as of today, Nexans has more than 2,600 km of MI cables in service, and with the upcoming links, this figure will be almost doubled by the end of 2021."

For more information, visit www.nexans.com.



COMPANY SPOTLIGHT

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For over 20 years, U.S. Underwater Services, LLC has provided commercial diving, inspection, repair, and maintenance services to industry sectors such as oil and gas, shipping, municipal works, power generation, construction, engineering, defense, and marine infrastructure.

From its 50,000 sq. ft facility in Mansfield, Texas, U.S. Underwater Services manages all of its business operations, sales, equipment maintenance, and product fabrication. The facility also boasts a 22,500 gallon multi-level training tank that is used for certifying underwater welders, ROV and non-destructive testing training operations, underwater videography techniques, equipment and product testing, emergency drills, and demonstrations. This training tank has also been utilized by other companies for the purposes of R&D, product demonstration, and to familiarize company representatives on safe diving techniques. Visitors and client representatives have the opportunity to view these activities from several vantage points—via large portholes, live feed video, or from the surface.

Safety First

Since 1996, U.S. Underwater Services has been an active member of the Association of Diving Contractors International (ADCI), a professional association that promotes best industry practice with respect to the health and safety of commercial divers and underwater operations worldwide.

Additionally, the company is involved in several industry groups that focus on diver safety and training. One example is the U.S. GoM Diving Safety Workgroup, a non-competitive and non-commercial group of oil and gas operators, transmission companies, commercial diving companies, and industry stakeholders that promote safe diving practices in the Gulf of Mexico.

U.S. Underwater Services has been audited by several major oil and gas operators as well as drilling contractors, power generation companies, and government entities to ensure that their operations meet the industry's most stringent safety standards.

Experience Matters

For over 15 years, U.S. Underwater Services has been the leader in MODU inspection, repair, and maintenance services in the Gulf of Mexico.



However, some of the other services that they provide include certified underwater welding; platform and pipeline inspection and repair; site surveys; site clearance and debris removal; NDT services; vessel husbandry; diver-supported dredging; and the refurbishment of coastal structures such as docks, piles, and piers.

The company continually invests in its equipment, training, and facilities in order to expand its capabilities and maintain its reputation as a leading and trusted provider of commercial diving services, both inland and offshore. Combining state-of-the-art equipment and extensive industry experience, U.S. Underwater Services has the capability to complete projects of any scale.



COMMUNICATION & SUBSEA CABLES



Turnkey Network Development Agreement for South America Pacific Link

Ocean Networks, Inc. and Ocean Specialists, Inc. (OSI) announced that they have entered into an agreement for the further development and implementation of the South America Pacific Link (SAPL) Submarine Cable Network. The SAPL Network is being developed in two phases, Phase-1 connects Valparaiso (Chile), Manta (Ecuador), Balboa (Panama), and Jacksonville (Florida, USA). Phase-2 extends the network to Hawaii, where it will interconnect with Asia and Pacific networks, creating a much-needed direct connection between those key traffic points and the west coasts of Central and South America.

<http://ont.news/2p92zUh>

TE SubCom Sets Record for Transmission Capacity

TE SubCom, a TE Connectivity Ltd. company, announced that it has demonstrated a new transmission record of 70.4 Tb/s capacity over 7,600 km. The record transmission is made possible utilizing SubCom's newly available C+L technology, which includes amplifiers with nearly 10 THz of usable optical bandwidth, a transmission line designed to minimize noise accumulation and maximize performance, a new transmission format using multi-dimensional coded modulation with hybrid probabilistic and geometrical constellation shaping, and digital signal processing featuring several stages of non-linear compensation.

<http://ont.news/2pxdO9N>



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MONTH IN REVIEW

Inmarsat FleetBroadband Takes Major Step to Formal GMDSS Approval

The role of Inmarsat as the sole provider of satellite technology performing to Global Maritime Distress and Safety System standards is set for advancement.

<http://ont.news/2qdOuX3>

KVH Ships its 7,000th mini-VSAT Broadband System

Designed and manufactured by KVH, the TracPhone systems provide satellite broadband connectivity to yachts and commercial vessels around the world.

<http://ont.news/2qdhmOW>

Seaborn, Grupo Werthein to Build ARBR Cable

Seaborn Networks and Grupo Werthein announced a binding agreement to build a new subsea fiber-optic cable system connecting Argentina with Brazil (ARBR).

<http://ont.news/2pnkZPJ>

Ingenu Brings IoT Connectivity to Ships

Ingenu announced that it will be enabling Orolia's McMurdo Omnicom Solar Fishing Beacon to assist in vessel communication and fisheries monitoring.

<http://ont.news/2qdtjUY>

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HII Completes CVN 78 Builder's Sea Trials

Huntington Ingalls Industries (HII) announced that its Newport News Shipbuilding division has successfully completed builder's sea trials of the aircraft carrier Gerald R. Ford (CVN 78). The first-of-class aircraft carrier Gerald R. Ford (CVN 78) left Newport News on 8 April and returned to Naval Station Norfolk on 14 April.

Builder's sea trials test the ship's systems, components, and compartments at sea for the first time. The trials also include high-speed runs and demonstrate many of the carrier's other capabilities.

"In my 36 years with Newport News Shipbuilding, I've ridden many sea trials," said president Matt Mulherin. "While they have all been great experiences, this one was especially rewarding. I've been with this ship since 2001, when she was still just a design concept. To see her come to life and perform as she was designed and built to do is awe-inspiring and a testament to her shipbuilders and Navy crew."

Newport News shipbuilders partnered with Gerald R. Ford sailors and personnel from Naval Sea Systems Command to perform the sea trials tests. Among the sea trial participants were Adm. James Caldwell, director, Naval Nuclear Propulsion Program, and Rear Adm. Brian K. Antonio, program executive officer, aircraft carriers.

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"Everybody has to work together to really exercise the ship and take it through its final paces," said Rolf Bartschi, Newport News Shipbuilding's vice president, Gerald R. Ford (CVN 78) carrier construction. "We work to test the systems and actually operate the ship out here at sea. It's fantastic to be out and really see this ship come to life."

Susan Ford Bales, ship's sponsor and President Gerald R. Ford's daughter, was unable to participate in sea trials but shared in the excitement. "Completion of builder's sea trials for Dad's namesake aircraft carrier is the magnificent culmination of years of hard work," she said. "I'm ecstatic and could not be prouder of the ship's successful per-

formance. CVN 78 is the mightiest ship ever built, and you can draw a straight line—a very straight line—as to why that is so: The ship is built by the greatest ship-builders in the world, my fellow Newport News shipbuilders. I'm thrilled to add my congratulations and heartfelt thanks—as Dad most certainly would—to the entire Newport News Shipbuilding team and to the remarkable crew of the Ford, for their patriotic commitment to excellence and for a job well done—very well done. As the ship's sponsor, I look forward with great excitement to commissioning the USS Gerald R. Ford into the fleet very soon."

Prior to delivery, the ship will undergo acceptance trials, conducted by U.S. Navy Board of Inspection and Survey representatives, to do a final test and evaluation of the ship's systems and performance.

Gerald R. Ford is the first in a class of next-generation aircraft carriers designed to replace Nimitz-class aircraft carriers. The Ford-class features a new nuclear power plant, a redesigned island, electromagnetic catapults, improved weapons movement, an enhanced flight deck capable of increased aircraft sortie rates, and growth margin for future technologies. Each Ford-class ship will operate with a smaller crew than a Nimitz-class carrier and provide a \$4 billion total ownership cost savings for the Navy.

For more information, visit www.huntingtoningalls.com.



The first-of-class aircraft carrier Gerald R. Ford (CVN 78) left Newport News Shipbuilding on 8 April for builder's sea trials and returned to Naval Station Norfolk on 14 April. Builder's sea trials test the ship's systems, components, and compartments at sea for the first time. Photo credit: Matt Hildreth/HII.

U.S. Navy Divers Achieve Milestone, Embark Aboard Korean Ship

U.S. Navy and Republic of Korea (ROK) Navy diving and salvage experts wrapped up nearly two weeks of advanced training during Salvage Exercise (SALVEX) Korea 2017, 30 March.

The bilateral exchange began 21 March and featured joint diving and salvage operations, both in port and at sea. During the underway phase, U.S. Navy divers assigned to Mobile Diving and Salvage Unit (MDSU) 1 embarked on the salvage ship ROKS Tong Yeong (ATS 31) alongside their Korean Navy counterparts, a first for this annual exercise.

The training focused on combined diving and salvage operations and subject-matter expert exchanges. Divers from both navies also operated together under complex, realistic training scenarios in waters near the Korean peninsula. These evolutions exemplified the merits of diving and salvage interoperability between the U.S. and ROK navies.

"SALVEX enables our divers to become familiar with each other's equipment and capabilities, making it easier for us to work together in the future if a real-world contingency operation were to happen," said master chief diver Joshua Dumke.

SALVEX 2017 marks the 33rd year of the bilateral SALVEX, dating back to 1985. The long-standing

exchange has fostered supreme trust and deepened cooperation between the two navies.

"We have a waiver to dive with Korean Navy systems," said Lt. Cmdr. Tim Emge, diving and salvage officer for Task Force 73. "This is a significant milestone. It gives us the ability to deploy divers with limited amounts of gear and perform interoperable dive operations with our partners."

Emge said the complexity and the tangible value of the training scenarios get better each year due to the planning, teamwork, and innovation of sailors from both nations.

"This exercise allows both navies to enhance our diving and salvage capabilities in a very meaningful way," said Emge. "Our partnership with ROK Navy divers has been a huge success."

SALVEX Korea 2017 is part of Exercise Foal Eagle, an umbrella of regularly-scheduled, annual exercises that are the culmination of many months of planning and based on realistic training scenarios. The naval portion of the Foal Eagle exercises take place in international waters around South Korea and features a full spectrum of maritime operations.

For more information, visit www.navy.mil.





L3 Acquires AUV Maker OceanServer Technology

L3 Technologies announced that it has acquired OceanServer Technology, Inc. The acquisition was completed on 17 March 2017, and the terms were not disclosed. The business was renamed L3 OceanServer and will be integrated into the company's Sensor Systems segment. The L3 OceanServer-designed Iver is the first commercially developed low-cost Autonomous Underwater Vehicle (AUV). Iver is ideal for coastal applications such as sensor development, general survey work, subsurface security, research, and environmental monitoring. The AUV is single man-portable and features simple point-and-click mission planning.

<http://ont.news/2oCa2fR>

Norway Procures Kongsberg HUGIN Autonomous Underwater Vehicles

Kongsberg Maritime has signed a contract with the Norwegian Defence Materiel Agency (NDMA) for delivery of four complete HUGIN AUV systems for detection, classification, and identification of mines. The HUGIN AUVs will have a depth rating of 3,000 m and will be equipped with advanced sensors for modern mine hunting. The deliveries include systems for planning, execution and analysis of missions and launch and recovery systems both for the Navy's mine hunting vessels as well as in mobile containers.

<http://ont.news/2prKlbK>



A black and white photograph of a director's chair with a clapperboard resting on the floor next to it. The clapperboard has the letters 'ON&T' printed on it. The background is dark, and there is a bright light source behind the chair, creating a strong shadow on the floor.

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MONTH IN REVIEW

Phoenix-built ROV Transferred by U.S. Navy to Undersea Rescue Command

Phoenix International Holdings, Inc. was tasked by NAVSEA to design and build an ROV to conduct salvage operations to water depths of 2,000 ft of seawater.

<http://ont.news/2pnq76v>

RJE International Lands Military Contract for New Pinger

RJE International has been awarded a contract from NUWC to supply the next generation End-Of-Run Location Mini-Pingers to support military tracking range.

<http://ont.news/2oC25qX>

General Atomics Lithium-Ion Fault Tolerant Batteries to Support SAHRV

General Atomics Electromagnetic Systems (GA-EMS) will provide its Lithium-ion Fault Tolerant (LiFT) battery system for the SAHRV.

<http://ont.news/2oOpilh>

Lockheed Martin LRASM Conducts Successful Jettison Flight Test

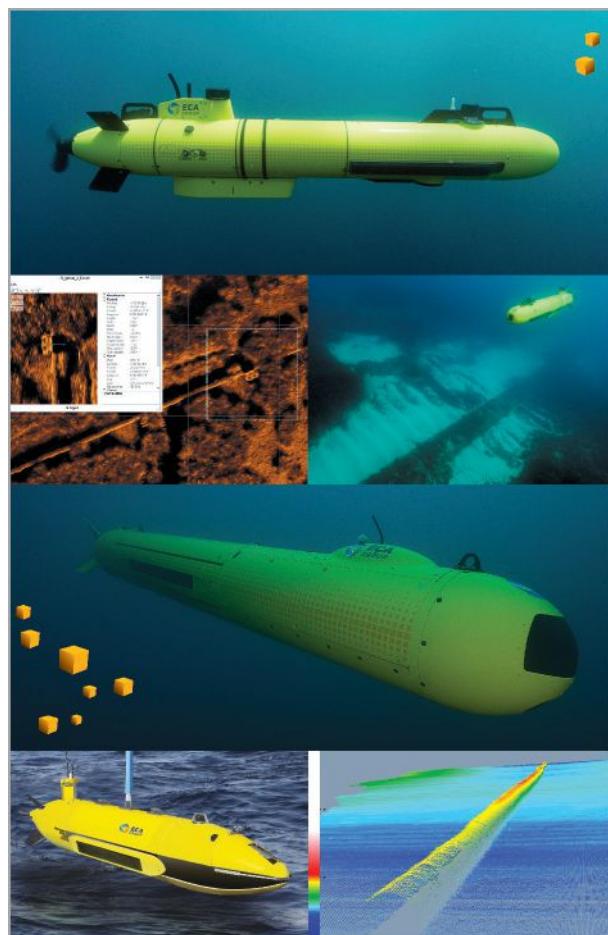
Lockheed Martin's Long Range Anti-Ship Missile (LRASM) was successfully released from a U.S. Navy F/A-18E/F Super Hornet at NAS Patuxent River, Maryland.

<http://ont.news/2qdtkZ1>

SEA Ambient Noise Prediction System Upgrade

Cohort company SEA has been awarded a UK Ministry of Defence contract to upgrade the Ambient Noise Prediction System (ANPS) for the UK Royal Navy.

<http://ont.news/2qdBC2U>



Autonomous inspection and survey by AUV

ECA Group, engaged in underwater robotics for 40 years, has developed a wide range of autonomous vehicles for Navy, Hydrography (IHO S44), Oil & Gas and scientific applications.

In comparison with traditional towed solution, this comprehensive unmanned system including ECA Group AUV range, the post processing data management solution and an Autonomous Underwater Recovery System, reduces expenditures cost while enhancing data quality.

ECA Group modular solutions are air transportable which simplifies the mobilization and enables worldwide operations.

ECA Group AUVs are optimized for various tasks:

- Survey (pre-lay and post-lay)
- Pipeline inspection
- UXO detection
- Hydrography
- Black Box detection



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AUV Solutions



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Falling Crude Oil Prices are Forcing the Hand of OPEC's Leader

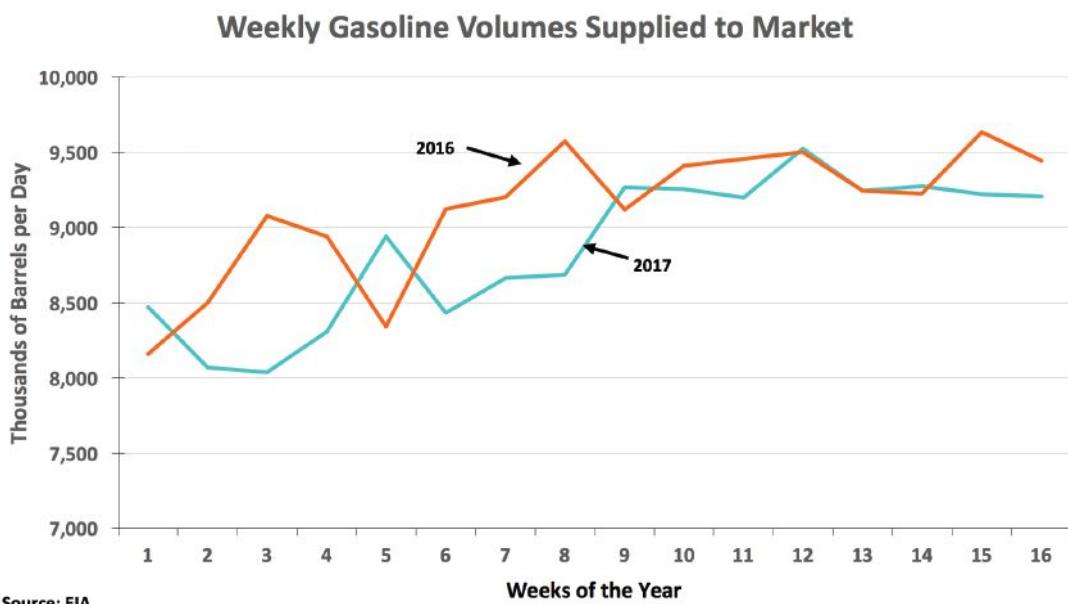
Crude oil prices are falling; April has been a trying month for the commodity. After spending the last half of March in the high \$40s-a-barrel price range, the last days March saw crude oil futures finally push above \$50. Fears that OPEC's production cut agreement was failing were allayed at that time as the organization produced data showing that most of the agreed-to reductions had been implemented and, where members fell short, Saudi Arabia had more than compensated with output cuts. As April progressed, OPEC released more data to substantiate members' output reductions, along with reports hinting that the agreement might be extended for another six months. The PR effort sent crude oil futures up towards the mid-\$50s a barrel as crude oil traders and speculators built their future contract long positions to a new record high.

However, a funny thing was happening in the U.S. as the weekly change in crude oil inventories shifted from small increases to small declines. While most oil traders focus on the weekly crude oil inventory data, sometimes action in refined products will drive oil prices. As seen from the chart showing the weekly changes in crude oil and gasoline inventories as well as the movement in weekly crude oil prices, early April brought smaller weekly declines in gasoline volumes than expected. But as we moved into the last half of April (the April 28 data have not been reported), weekly gasoline inventory changes increased and either matched or exceeded the weekly declines reported for crude oil.

Oil traders and speculators discovered that refinery turn-arounds responsible for the build in weekly crude oil inventories during March were now operating and crude was being purchased. As would be expected, refineries were cranking up their gasoline output to build stockpiles for the upcoming summer driving season. But the gasoline inventory builds seemed to be somewhat larger than analysts expected, which sent them back to review gasoline volumes supplied to the market (an indicator of demand). What they found troubled them as they were considering what was happening within the broader oil market.

As shown in the chart of weekly gasoline supply, for nearly every week to date in 2017 demand has fallen below the same week in 2016. Of some concern was that for March and April gasoline demand had been essentially flat, and, overall for the period, cumulative volumes in 2017 were below those of 2016. That shouldn't be happening if the economy is doing as well as the macroeconomic measures suggest. With the low unemployment rate, a greater number of job openings being advertised, and wages showing improvement, one would expect gasoline consumption to be up as driving should be increasing. On the other hand, with weaker than anticipated new car sales, declines in general retail sales, massive layoffs of retail workers, and the bankruptcy of several retail chains, maybe the U.S. economy isn't doing as well as advertised.

The fallout from growing gasoline inventories has been a weakness in crude oil prices. In a matter of a few



By: G. Allen Brooks
Author of "Musings From the Oil Patch"
www.energymusings.com



weeks, the crude oil futures strip has fallen sharply. We no longer see prices at or above \$60 a barrel in the early 2020s. Now, traders seem to be targeting \$55 a barrel. Crude oil futures are threatening to break the \$47-a-barrel technical support level, which should it not hold would cause future prices to test the next support level of \$44 a barrel. That would prove very unsettling for oil producers and exporters, and it might be sufficient to spur OPEC to quickly agree to a six-month production cut, regardless of whether Russia wants to continue to be supportive. The current oil price action comes at an interesting time as Saudi Arabia is making moves, suggesting it may begin working to boost oil prices. In light of current trends, those efforts now may have to become stronger merely to offset the current oil price weakness.

On 22 April 2017, King Salman announced several senior level personnel moves within his government. While he relieved four officials of their positions, most of the attention was directed to the two new leaders he elevated. First, he appointed his son, Prince Khaled bin Salman, to be the Saudi Ambassador to the United States in a move designed to create closer ties between the Saudi government and the Trump administration. The King also elevated another son, Prince Abdulaziz bin Salman, to Minister of State for Energy, which is telling as the Prince, who was previously a senior energy ministry official, opposed the strategy behind Saudi Arabia's 2014 plan to gain market share by allowing market forces to set the price while stepping up production. This gambit helped precipitate the two-

year energy recession the industry has been dealing with.

King Salman also reversed the 20% cut in minister salaries and reduction in government benefits instituted last fall. He also gave the military a raise, an especially large one for the pilots fighting in Yemen. The cuts were considered temporary when they were made, so restoring them was not a complete surprise. As the government reduced its budget deficit last year to \$79 billion down from the record \$98 billion in 2015, the stronger oil prices seemed to be the proper time to move. The government had been targeting a deficit this year of \$53 billion given higher oil prices, but with the spending reversal and the current oil price weakness, that target is probably out of reach barring a dramatic improvement in oil prices. The compensation moves indicate that Saudi Arabia is willing to fight for higher oil prices or accept a larger deficit in order to protect its social contract with citizens by buying stability in return for the government providing most of their everyday needs. With Saudi Arabia's estimated fiscal breakeven price at \$98 a barrel, almost double current oil prices, the government will need to do some heavy lifting in the oil market to boost prices appreciably.

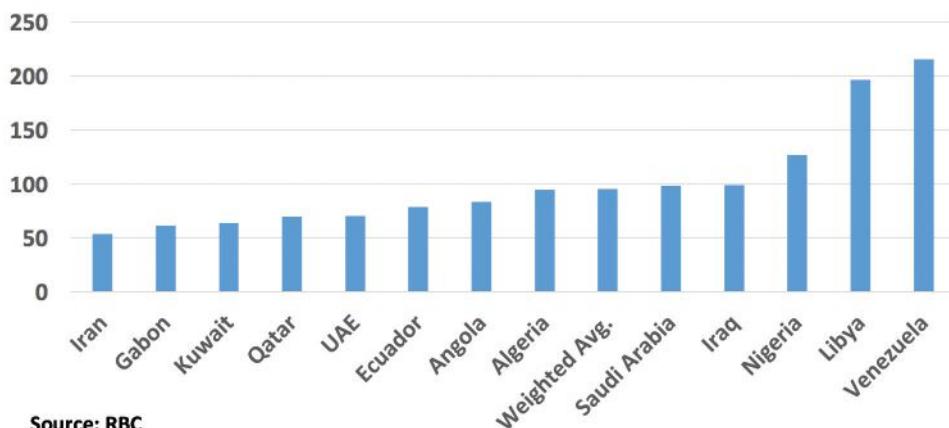
The coming weeks and months will be an interesting period as the slow rebalancing of the global oil market, which is needed to boost oil prices, complicates the internal struggles of Saudi Arabia and OPEC. Higher prices later this year are likely, but the question is—how solid is the foundation for these higher prices?

May 2017

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Estimated Fiscal Breakeven Price (\$/bbl)



Source: RBC

OFFSHORE STATS & DATA

Crude & Natural Gas Spot Prices

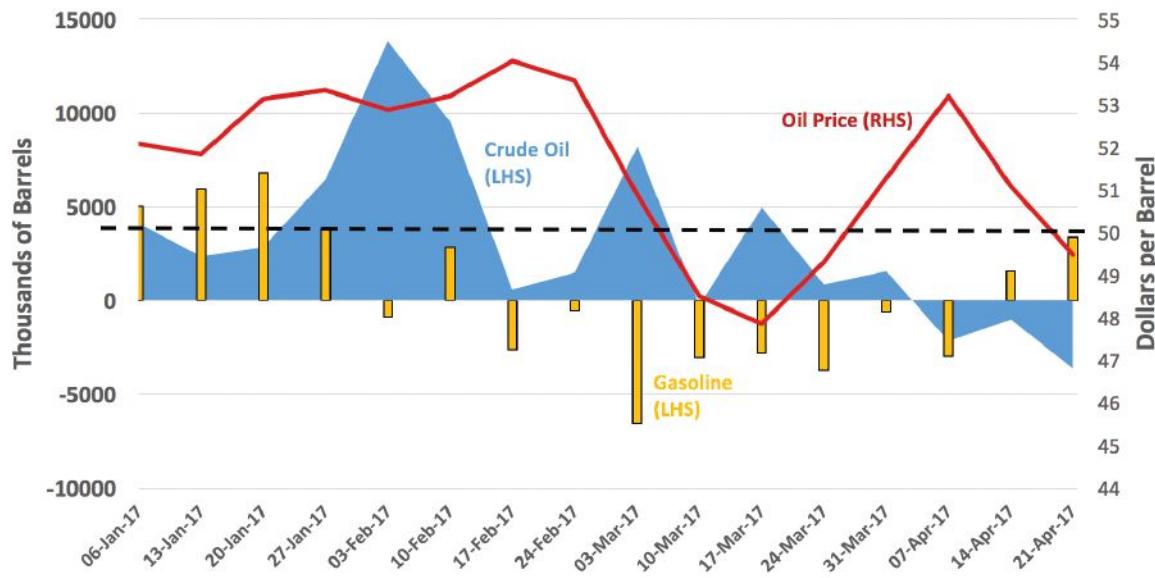
Prices in USD as of April 21, 2017

The month of April has produced mixed results for crude oil and natural gas compared to March; however, compared to the same time a year ago, results are better. For natural gas, which briefly flirted with \$3.25 per thousand cubic feet (Mcf) in April, it looks like the commodity will average in the low \$3/Mcf range for the month. That will be better than gas prices averaged in March (\$2.88/Mcf). But compared to a year ago, natural gas prices are more than \$1/Mcf higher—\$3.12/Mcf versus \$1.92/Mcf. That price differential, coupled with a forward future price curve showing a marginally higher gas price, helps explain the recovery in drilling for natural gas.

On the crude oil front, although prices trended lower as the month of April progressed, by the end of April, crude oil prices were in the low \$49-a-barrel range after having reached prices in excess of \$53 a barrel at mid-month. As upsetting as that may be for oilmen, if they cast their eye back a year, they will see that crude oil prices are \$10 a barrel higher now, an amount that has provided significant additional capital for the industry.

Weekly Crude Oil & Gasoline Inventory Changes and Oil Price

Ocean News & Technology



Source: EIA

\$47.66

\$49.56 previous week



TRENDING DOWN



Cushing, OK
WTI Spot Price

\$3.20

\$3.04 previous week



Henry Hub
Spot Price

Oil & Gas Industry Trends

Key Equity Indexes

Cumulative Percentage Change as of May 2, 2017

Since last month, the equity markets have shown some volatility based on mixed economic data and political uncertainty in the U.S., EU, and Asia. However, they have generally maintained the upward trend we have seen over the last 52 weeks. For that period, the DJIA is up 18% and the S&P 500 is up 16.2%. In contrast, as shown in the chart below, the Philadelphia Oilfield Services Index (OSX) has continued to slip as oil prices pressures have weighed heavily upon that sector.

For the last 52 weeks, the OSX is down 11.8%, continuing the downward trend seen since the beginning of 2017. One interesting factor that we will have to watch going forward is the level of activity to bring lower-cost onshore wells into production without benefitting the offshore market. The market's perception of these offsetting factors will be important in determining the direction of the OSX in the coming months.

Selected Equity Indexes - Cumulative Percentage Change Last 52 Weeks



May 2017

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20.913.46

-27.05 from previous week



TRENDING DOWN

DJIA

2388.33

+4.13 from previous week



TRENDING UP

S&P 500

150.78

-2.64 from previous week



TRENDING DOWN

OSX

ON&T

2017 EVENTS

Teledyne CARIS
Ottawa, Canada
June 19-22
www.caris.com/conferences/caris2017

Telecom Exchange
New York City, NY
June 20-21
<http://thetelecomexchange.com/nyc>

Oceans' 17
Anchorage, AK
September 17-21
www.oceans17mtsieeanchorage.org

AWEA Offshore Wind
New York City, NY
October 24-25
www.awea.org/events/event.aspx?eventid=50111

IOSC
Long Beach, CA
May 15-18
www.iosc2017.org

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Teledyne Marine Technology Workshop
San Diego, CA
October 15-18
www.teledynemarinecom/events/teledyne-marine-technology-workshop-2017

LAGCOE
Lafayette, LA
October 24-26
www.lagcoe.com/events/event-one

WorkBoat
New Orleans, LA
November 29 – December 1
www.workboatshow.com

Deepwater Decommissioning Workshop
Houston, TX
May 23-24
<http://decommissioninggom.offsnetevents.com>

OilComm
Houston, TX
October 3-5
www.oilcomm.com

MTS Dynamic Positioning
Houston, TX
October 9-11
<http://dynamic-positioning.com>

SPE ATCE
San Antonio, TX
October 9-11
www.spe.org/events/en/2017/conference/17atce/home-1.html

Deep Sea Mining Summit

London, UK

May 22-23

www.deepsea-mining-summit.com**Offshore Wind Energy**

London, UK

June 6-8

<http://offshorewind2017.com>**Seawork International**

Southampton, UK

June 13-15

www.seawork.com**Oceans Aberdeen**

Aberdeen, UK

June 19-22

www.oceans17mtsieeaberdeen.org**SPE Offshore Europe**

Aberdeen, UK

September 5-8

www.offshore-europe.co.uk**UTC**

Bergen, Norway

June 20-22

www.utc.no/conference**Offshore Energy**

Amsterdam

October 9-11

<http://offshore-energy.biz>**WindEurope**

Amsterdam

November 28-30

<https://windeurope.org/confex2017>**MAST**

Tokyo, Japan

June 12-14

<https://mastconfex.com>**UASUV**

Athens, Greece

May 17-19

www.unmanned-v.com**UDT**

Bremen, Germany

May 30 - June 1

www.udt-global.com**ADIPEC**

Abu Dhabi, UAE

November 13-16

www.adipec.com**World Congress of Ocean**

Shenzhen, China

November 3-5

www.bitcongress.com/WCo2017/default.asp**Philippines Marine**

Manila, Philippines

July 12-14

<http://philmarine.com>**Submarine Networks World**

Singapore

September 25-27

www.terrapinn.com/conference/submarine-networks-world/index.stm**Asia Pacific Deep Sea Mining**

Singapore

November 9-10

www.asia.deepsea-mining-summit.com

2017 EDITORIAL CALENDAR

ON&T

CALENDAR

JANUARY

Editorial: Underwater Navigation; Manned Submersibles Research & Development Services
Product & Services Focus: Multibeam & Side Scan Sonar; Research & Development Services

FEBRUARY

Editorial: Oceanology & Meteorology; Decom & Abandonment
Product & Services Focus: Buoys & Monitoring Instrumentation; Environmental Monitoring/Testing Services

MARCH

Editorial: Subsea Fiber Optic Networks; Maritime Security
Product & Services Focus: Connectors; Cables & Umbilicals; Diver Detection Systems

APRIL

Editorial: Offshore Technology; Ocean Mapping & Survey
Product & Services Focus: Subsea Tools & Manipulators; Batteries; Training/Safety

MAY

Editorial: Autonomous Unmanned Vehicles; Defense & Naval Systems
Product & Services Focus: Tracking & Positioning Systems; Seismic Monitoring; Equipment Leasing/Rental Services

JUNE

Editorial: UW Imaging & Processing; Marine Salvage/UW Archaeology
Product & Services Focus: Magnetometers; Water Dredges & Airlifts; Diving Services

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JULY – Digital Distribution Only

Editorial: Ocean Engineering; Marine Construction
Product & Services Focus: Navigation, Mapping & Signal Processing; Data Processing Services

AUGUST

Editorial: Workclass ROVs; Deepwater; Pipeline/Repair/Maintenance
Product & Services Focus: Cameras, Lights & Imaging Sonars; Oil Spill Clean-Up Services

SEPTEMBER

Editorial: Ocean Observing Systems; Subsea Telecom; Offshore Wind Installation & Maintenance
Product & Services Focus: Water Sampling Equipment; Cable Installation Services

OCTOBER

Editorial: Offshore Communications; Subsea Inspection, Monitoring, Repair & Maintenance
Product & Services Focus: Acoustic Modems, Releases & Transponders; Marine Communications; Survey & Exploration Services

NOVEMBER – Digital Distribution Only

Editorial: Offshore Support, Supply & Emergency Vessels; Deep Sea Mining
Product & Services Focus: Ship Protection Systems; Cranes, Winches & Control Systems; Vessel Charter/Leasing Services

DECEMBER

Editorial: Light Workclass ROVs; Commercial Diving; Year in Review
Product & Services Focus: Diving Equipment & Services; Buoyancy Materials; Construction & Repair Services

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SHOW DISTRIBUTION

JANUARY

UDT Asia – January 17-18*
Marine Data Infrastructure GCC – January 30-31*
Euromaritime January 31– February 2
GoM Oil Spill & Ecosystems – February 1-9
Oil North America – February 14-16

FEBRUARY

Underwater Intervention – February 21-23
US Hydro – March 20-23*

MARCH

Canadian Underwater Conf & Expo – March 26-28 Ballast Water Management – March 29-30
MCE Deepwater Development – April 3-5
Ocean Business – April 4-6
Telecom Exchange – June 20-21*

APRIL

Int'l Offshore Wind Forum – April 19-21*
OTC – May 1-4
AUVSI XPONENTIAL – May 8-11
IOSC – May 15-18
Deepwater Decomm Workshop – May 23-24*

MAY

UDT – May 30 – June 1
Offshore Wind Energy Europe – June 6-8
Seawork Int'l – June 13-15

JUNE

Teledyne CARIS – June 19-22*

JULY – Digital Distribution Only
TBD

AUGUST

SPE Offshore Europe – September 5-8♦

SEPTEMBER

Oceans 17 – September 17-21
Teledyne Marine Technology Workshop – October 15-18♦
AWEA Offshore Wind – October 24-25♦
WindEurope November 28-30

OCTOBER

Oilcomm – October 3-5
MTS Dynamic Positioning – October 9-11♦
Offshore Energy – October 9-11
Offshore Well Intervention GoM – TBD*♦
Clean Gulf – December 5-7

NOVEMBER – Digital Distribution Only

World's Congress of Ocean – November 3 – 5*
International Workboat – November 29 – December 1*♦

DECEMBER

TBD

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♦ Pending



ADVERTISING

NORTH AMERICA

Lisa Chilik

574-261-4215

lchilik@tscpublishing.com

EDITORIAL

MANAGING EDITOR

Greg Leatherman

772-617-6795

gleatherman@tscpublishing.com

INTERNATIONAL

Mimi Shipman

+44 (0) 777 601 7564

mshipman@tscpublishing.com

EDITOR

Rhonda Moniz

Phone: 506-951-4896

rmoniz@tscpublishing.com

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Crowley Mariners Demonstrate Commitment to Environmental Stewardship

In March, the Crowley Maritime Corp. crew aboard the company-managed USNS Invincible demonstrated their commitment to environmental stewardship by saving a distressed sea turtle, which had become entangled in nets and fishing lines in offshore waters near southwest Asia. The at-sea rescue, which the crew dubbed "Turtle Ops," was performed when the crew had no pending operations and could be executed safely and efficiently. To aid the entangled turtle, the crew used the USNS Invincible's bow thruster to maneuver the ship into position to bring the sea creature alongside and on board. The Crowley crew, along with U.S. military personnel on board, then cut away the nets and fishing lines and released the turtle back into the ocean.

<http://ont.news/2ql6LI4>

Damen Companies to Provide Green Solutions

Bringing together the experience and knowledge of two Damen companies is the close cooperation between Damen Green Solutions and Damen Shiprepair & Conversion (DSC). The two companies combine their specific skill sets to offer ship owners a smoother transition towards compliance with new environmental regulations and cleaner sailing. Regarding the subjects of Ballast Water Management, exhaust after treatment systems, LNG conversions, and other more traditional methods of cleaner shipping, the synergy between Damen Green Solutions and DSC provides ship owners and operators the very realistic benefits of proven project management skills, reduced downtime and informed product selection.

<http://ont.news/2qpYcmo>



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MacArtney Appoints New CEO

The MacArtney Underwater Technology Group has appointed Claus Omann as CEO, effective as of August 2017. Niels Erik Hedeager, the current CEO, will at the same time take over the role as Chairman of the Board of Directors. Omann has a strong technical and commercial background and has previously worked for LEGO, Viking Life-Saving Equipment, and TRIAX in various senior management positions, including Technical Director and most recently CEO. "This is the job I have dreamt about, and I am honored getting this opportunity to join MacArtney and lead the organization on the next journey," says Omann.

<http://ont.news/2pPnWLL>



Valeport Appoints New Financial Director

Leading manufacturer of oceanographic, hydrographic, and hydro-metric instrumentation, Valeport has announced the appointment of Phill Harvey to the new post of financial director. Harvey, who has over 30 years' experience in the financial sector supporting many SME manufacturers and exporters, will join the senior management team to oversee all financial aspects of the business. His strong commercial background, which includes roles at Handelsbanken and Lloyds Bank, means that he is ideally positioned to deliver Valeport's ambitious growth plans, beginning with a review of the businesses' administration functions.

<http://ont.news/2p1v2J4>

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Introducing the New 2017 Ocean Industry Directory

Scheduled for release in January 2017, the updated Ocean Industry Directory provides a dedicated solution for finding product and service providers. Avoid searching multiple, incomplete directories that fail to consolidate ocean industry companies in one place. The comprehensive, easy-to-use Ocean Industry Directory takes the mystery out of corporate listings by distinguishing between manufacturers, sellers, rental agents, and service providers.

Get Listed!

The Ocean Industry Directory is featured in every issue of Ocean News & Technology's print and digital magazines, providing exposure across multiple media channels that is important in a competitive marketplace. In addition, the Ocean Industry Directory is a key component of www.oceannews.com and updated on a monthly basis.

Key Features

If you're interested in becoming a part of the Ocean Industry Directory, consider the benefits of adding your own corporate listing. Key features include:



Company Listing

Offers companies the opportunity to list their company name, address, phone number, and website. All listings submitted through the website will be screened by a moderator to ensure that they align with the mission of the Ocean Industry Directory.



Search by Product or Service

Each listing will be categorized according to the product and or service offered by the company. The directory lists over 200 different oceanographic categories. Users will be able to search the categories listed within the directory to easily find information regarding companies associated with the products and services they are researching.



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The directory offers three tiers of corporate participation. Ranging from free to upgraded, our listings are tailored to fit your company's marketing budget. These directory participation levels include:

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Link to chosen categories for products and services	●	●	●
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Sales contact name and email		●	●
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TSC Representatives

North American Ad Sales:

Lisa Chilik
Tel: 574-261-4215
Fax: 772-221-7715
lchilik@tscpublishing.com

International Ad Sales:

Mimi Shipman
Mob: +44 (0) 777 6017 564
Ph: +44 (0) 1460 242 060
mshipman@tscpublishing.com



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ADCP/DVL

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Nortek excels in the development and manufacture of acoustic Doppler instrumentation. Doppler Velocity Logs (DVL) are used for subsea navigation. Acoustic Doppler Current Profilers (ADCP) are used to understand physical processes in the ocean, rivers, lakes and laboratories. We pride ourselves on being innovative in product development and production processes. Nortek provides solutions to engineers and scientists by offering real-time data collection and support from our responsive technical team.

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Poway, CA 92064
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Rowe Technologies Inc. [RoweTech] specializes in the design and manufacture of underwater acoustic Doppler products and imaging systems for the oceanographic, hydrographic and hydrologic markets. Founded in 2009, Rowe Technologies is a technology-based private company with the main office located in Poway CA, USA. Rowe's ADCP/DVL competitive advantage is single-unit configuration which allows simultaneous current profiling and bottom tracking.

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Unit 15 Romsey Industrial Estate,
Romsey, Hampshire SO51 0HR,
United Kingdom
Tel: +44 (0)1794 830 909
E-mail: ross@a2sea.co.uk
Website: www.a2sea.co.uk
Contact: Ross Taylor



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In 2016, A-2-Sea Solutions was ranked 13th on the UK Sunday Times SME Export Track 100 league table and 21st on the Fast Track 100.

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10333 Richmond Ave
Suite #1000
Houston TX 77042-4128
Tel: +1 (832) 833-8000
Fax: +1 (832) 833-8002
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Website: www.cortlandcompany.com
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Toll Free: 800 848 4257
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Fax: +1 760 471 4970
E-mail: sales@falmat.com
Website: www.falmat.com
Contact: Shawn Amirehsani

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Phone: (951) 659-2183
Fax: (951) 659-3958
E-mail: Sales@southbaycable.com
Website: www.southbaycable.com
Contact: Gary Brown, Sales Manager



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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)
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Website: www.birns.com
Contact: Eric Birns



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E-mail: sales@birnsaquamate.com
Website: www.birnsaquamate.com
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El Cajon, CA 92020 USA
Tel: +1 619 562 7071
Fax: +1 619 562 9706
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The SEACON Group are world leaders in underwater connector technology and provide an extensive and diverse range of electrical, optical and hybrid connector assemblies, submersible switches and cable system solutions for many applications within the Oceanographic, Defense, Oil and Gas and Environmental markets. With locations in California and Texas, USA, Mexico, Brazil, the United Kingdom and Norway and a worldwide network of agencies and representatives, SEACON is able to supply very quick solutions to any requirements across the globe.

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 Pirsenteret
 N-7462 Trondheim, Norway
 Tel: +47 73 54 55 00
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 E-mail: km.seatex@kongsberg.com
 Website: www.km.kongsberg.com/seatex
 Contact: Finn Otto Sanne at finn.otto.sanne@kongsberg.com



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E-mail: gstevens@conshelf.com
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Website: www.km.kongsberg.com/seatex
Contact: Finn Otto Sanne at finn.otto.sanne@kongsberg.com



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Tel: +47 73 54 55 00
Fax: +47 73 51 50 20
E-mail: km.seatex@kongsberg.com
Website: www.km.kongsberg.com/seatex
Contact: Finn Otto Sanne at finn.otto.sanne@kongsberg.com



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Tel: +47 73 54 55 00
Fax: +47 73 51 50 20
E-mail: km.seatex@kongsberg.com
Website: www.km.kongsberg.com/seatex
Contact: Finn Otto Sanne at finn.otto.sanne@kongsberg.com



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rue Gutenberg
56700 Hennebont, France
Tel: +33 2 97 36 41 31
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95 Hines Road
Ottawa, ON K2K 2M5
Tel: +1 613 599 8900
Fax: +1 613 599 8929
E-mail: info@rbr-global.com
Website: www.rbr-global.com



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41 Martha Avenue
Mount Uniacke, NS Canada
B0N 1Z0
Tel: +1 (902) 466-7000
Fax: +1 (902) 466-4880
E-mail: Sales@romor.ca
Website: www.romor.ca
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65 Tuas Avenue 1
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13431 NE 20th St.
Bellevue, WA 98005
Tel: +1 425 643 9866
Fax: +1 425 643 9954
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Skeidaráras 12, 210
Gardabæjar, Iceland
Tel: +354 533 6060
Fax: +354 533 6069
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120 Newsome Dr. Suite H, PO Box 1309
Yorktown VA 23692-1309
Toll Free: +1 800 447 4804
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Strandpromenaden 50
NO-3183 Horten
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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.

SUBSEA TOOLING

SUBSEA AMERICAS

3447 Hwy 182
P.O. Box 185
Berwick, LA 70342
Tel: +1 985 714 1767 or 985 518-0055
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Fax: +1 508 563 3445
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