MARINE TECHNOLOGY REPORTER

November/December 2019

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The Tech Advances

Tech Files
The March to Miniaturization

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Preview
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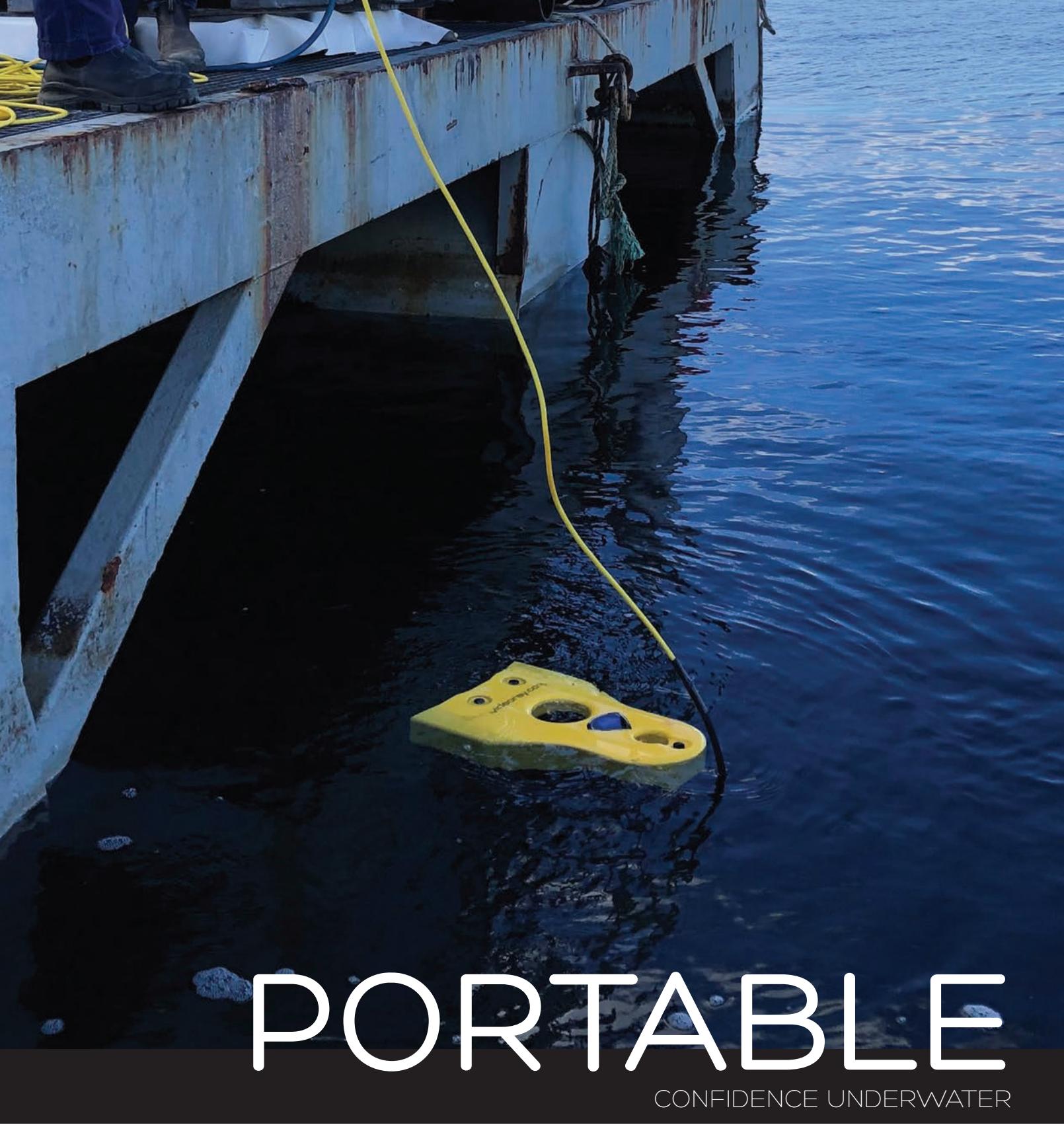

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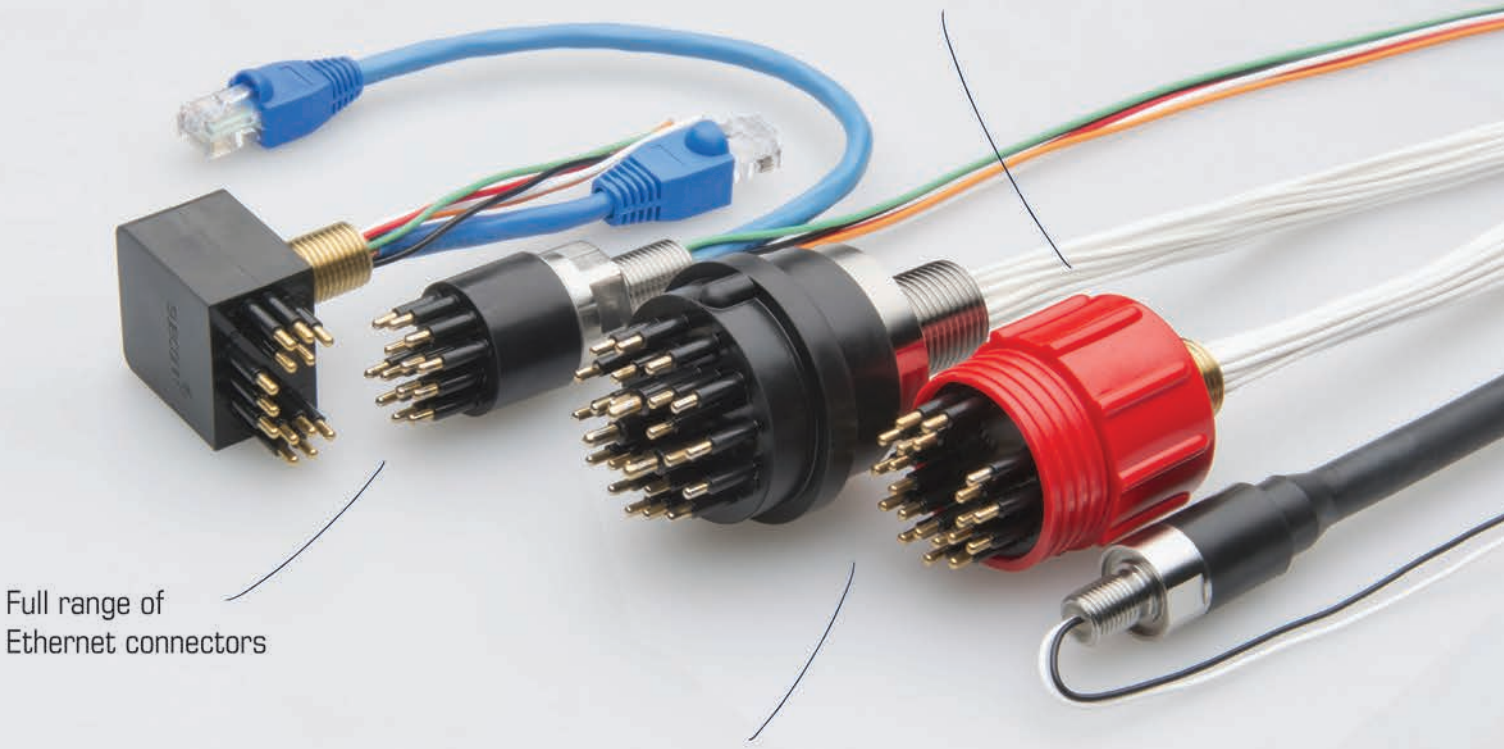

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NEW YORK
118 E. 25th St., New York, NY 10010
Tel: (212) 477-6700; Fax: (212) 254-6271

FLORIDA
215 NW 3rd St., Boynton Beach, FL 33435
Tel: (561) 732-4368; Fax: (561) 732-6984

PUBLISHER
John C. O'Malley
jomalley@marinelink.com

Associate Publisher & Editor
Gregory R. Trauthwein
trauthwein@marinelink.com

Contributing Writers
Justin Manley, U.S.
Elaine Maslin, Aberdeen
Tom Mulligan, Ireland
Claudio Paschoa, Brazil
William Stoichevski, Oslo

Production Manager
Irina Vasilets
vasilets@marinelink.com

Production & Graphic Design
Nicole Ventimiglia
nicole@marinelink.com

Corporate Staff
Manager, Marketing
Mark O'Malley
momalley@marinelink.com

Accounting
Esther Rothenberger
rothenberger@marinelink.com

Manager, Information Technology Services
Vladimir Bibik
bibik@marinelink.com

Circulation
Kathleen Hickey
mtrcirc@marinelink.com

Advertising
Vice President, Sales and Marketing
Rob Howard
howard@marinelink.com
Tel: (561) 732-4368 • Fax: (561) 732-6984

Advertising Sales Manager
Mike Kozlowski
kozlowski@marinelink.com
Tel: (561) 733-2477 • Fax: (561) 732-9670

Editor's Note

2020 Vision

Personally I find it hard to believe that yet another year has flown by and we will soon turn the clock and enter the year 2020. That said, the end of the year is always a suitable time to reflect and to chart the course ahead. With that in mind we present several articles in this edition which help that process. Starting on page 20, Andy Lipman and Alan Yu from ABS ask if 2020 will be the year for subsea mining. Subsea mining has captured the fascination of the subsea crowd since Howard Hughes built the Glomar Explorer in 1972. The cover story for its real mission – recovering a Soviet submarine – was that the rig would be used to mine manganese nodules from the deep ocean floor, a story that was so effective that it had the unintended consequence of stirring interest in ocean mining.

Following this is Elaine Maslin's "March toward Miniaturization." Here she reports on a growing battalion of small, compact systems that are marching in on the subsea world, in some ways making it a bigger space for more to enter. Smaller remotely operated vehicles (ROVs) and smaller autonomous underwater vehicles (AUVs) are growing in number and in turn driving smaller technologies that support them. Her story starts on page 26.

Finally, starting on page 48, *Offshore Engineer* managing editor Eric Haun looks at the offshore energy market. The "new normal" is a phrase tossed around often in offshore energy circles today as those servicing and operating in the sector grapple with the harsh realities of the prolonged industry downturn. Operators, service companies and equipment suppliers have been forced to adjust to oil selling at prices well below the $100+ per barrel mark seen in years past. As of this writing, Brent oil was hovering around $62 per barrel, and analysts expect prices will remain in this range for some time into the future. Haun, who covers the market in earnest via OEDigital.com, shares insights on the direction and pace for offshore oil and gas in 2020 and beyond.

Happy reading and Happy New Year!

Gregory R. Trauthwein
Associate Publisher & Editor

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Reed Exhibitions

From its founding in 1969, Oceanology International has evolved into what is arguably the biggest and best gathering for the global subsea technology community. To help celebrate Oi's 50th, Marine Technology Reporter *visits with* **David Ince**, *Event Director, Oceanology International for his insights on 'what's to come' for visitors and exhibitors at Oceanology International 2020 in London.*

David Ince

Briefly discuss your responsibilities with the venerable Oceanology International brand.

I have responsibility for the management and operational delivery of the Oceanology International portfolio including exhibitions and partnerships, conference/content programme development, audience/visitor delivery and event/portfolio marketing. The portfolio has grown over the last couple of years and we now hold an Oi event every 6 months in different global and regional markets including London, San Diego, Shanghai and the newly launched Oi Middle East event in Abu Dhabi.

I am fortunate enough to have been involved in the management of Oceanology International since 2015, and to be able to help develop Oi throughout its 50th anniversary has been a fantastic experience. There are not many events that can say they have been running for 50 years in any market, and Oceanology International is not only an important event in the business calendar, but also holds a special place in many people's hearts, as they have been involved and had engagement with the show for, in some cases, decades. It is very much an event that has grown with the industry, and therefore with individual careers and many companies development.

To what do you credit the long, successuf run of Oi?

That Oi has been able to develop and grow as an event for 50 years, highlights the affinity people, exhibitors and visitors have had with the show. Oi has been able to develop alongside the companies and sectors its helps represent and is something I take pride in delivering. We are a direct representation of the people, technology and innovations that have driven the industry forward for 5 decades and with that comes a responsibility to continue to deliver the content, contacts and community that our exhibitors and visitors expect.

What can visitors to London expect new for Oi '20?

Bigger and better is the mantra behind all things Oi, as we look forward to the next 50 years of representing the global Ocean Technology community. As always there will be a healthy social element to the event whether it be the OceanSocial Icebreaker, daily happy hours, or individual exhibitor functions being held across the week. We are also trying to focus on the people elements of Oceanology and are currently reaching out to all of the people that have been involved over the years to tell us their best Oi stories and journeys intertwined with the event. I would love to be able to have a live focus, during the exhibi-

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tion focusing on this element, and then reiterated in the special 50th anniversary supplement we are producing in partnership with our friends here at *MTR*.

How about a 'by the numbers' look at Oi '20?

We are also on track to produce the largest Oi exhibition yet, with more than 500 companies represented across 17,000 sq. m. of the Excel Centre, double the amount of companies demonstrating equipment live on the Royal Victoria Dock, a new Future Tech Hub showcasing 18 small companies that are all new to Oi, an extended Technical Conference, Ocean Futures Forum (Blue Economy and Emerging Markets), Catch the Next Wave (the Future of Ocean Technology) and a whole lot more all to an expected audience of over 8,000 people, a great testament to the strength, longevity and delivery of Oceanology International.

From traditional exhibition to conferences, from on-water demos to networking reception, the Oi brand brings together the global subsea community.

The Oi brand does not rest on its laurels, and in fact you have recently expanded, again?

Yes, it is very exciting to be able to announce a new edition of Oceanology International Middle East, which will be taking place in Abu Dhabi from the September 7 to 9, 2020. We have an established office in the UAE and have been running the World Future Energy Summit in Dubai for many years, with existing partnership with different areas of government in the region already established.

As we see at each Oceanology event, science, technology and innovation help drive effective solutions as different industries and governments look to the world's oceans as a solution for sustainable and responsible resource development.

With the Arabian Gulf and Indian Ocean region increasing its footprint across different marine environments Reed Exhibitions and Oceanology International is perfectly aligned to help answer these challenges. At the end of our 50th anniversary, we are excited to bring this event and the connections it can facilitate between the international community and regional stakeholders to the Middle East, alongside established our events in London, San Diego and Shanghai.

So with a global brand, what are the central concepts that tie together the Oi event no matter where it sets up for business?

If we look across the entire portfolio of Oi events it is the technology that binds them together as the requirements for better and more sustainable ways of working in the world's oceans increases. There are different areas of focus in each region when it comes to use of technology however I think you could still say that tall of the events are driven by the Marine Science, Ocean Observation, Offshore Energy and Ocean Resource sectors, even if the proportions that attend at each event differs slightly. We are always looking to develop a unique audience for each event, for example at Oi Americas in San Diego, over 90% of the audience have never visited another Oi event before, a very important distinction to continue to develop in order to deliver value to the companies investing in each event. Oi China in Shanghai is predominantly Chinese although the team are also building audiences from key SE Asian markets including Japan, Malaysia and South Korea. Oi in London is the key global meeting spot, connecting businesses, government and academic institutions together.

Bring on the next 50 years!!

Jonas

Photo Courtesy IHO

Dr. Mathias Jonas

International Hydrographic Organization

By Greg Trauthwein

Briefly discuss your personal and professional history. Specifically, how did you navigate to the top of the IHO.

Prior to this appointment I held the posts of Vice President of the Federal Maritime and Hydrographic Agency and National Hydrographer of Germany with responsibility for sea survey and sea cartography. Being a mariner, I have been involved in integrated navigation matters since the beginning of the nineties. In addition I completed the world's first technical certification of an Electronic Chart Display and Information System ECDIS in 1999 and was continuously contributing to IMO and IHO standardization activities for navigation equipment, survey and cartography since. I was elected as Secretary-General at the IHO Assembly in April 2017.

The Revised Strategic Plan of the IHO

Goal 1: Evolving hydrographic support for safety and efficiency of maritime navigation, undergoing profound transformation

Targets	SPI (measure for success)
1.1 Deliver standards for hydrographic data and specifications of hydrographic products; support their regular production; and coordinate regional and global services for their provision.	1.1.1 Percentage of Member States having operationalized production and distribution of hydrographic data products and services based on IHO Universal Hydrographic Data Model (S-100), under an implementation framework of coordination and agreed timelines (2026: 100%). 1.1.2 By 2026 the revised regulations for International Charts and Chart specifications (S-4) enables production of official paper charts based 100% on the content of ENCs, as provided for in the IHO standards. 1.1.3 Number of hydrographic data products and services based on Universal Hydrographic Data Model cater for the new requirements: autonomous shipping, reduction of emission.
1.2 Develop standards, specifications and guidelines in the areas of data assurance, including cyber security and data quality assessment.	1.2.1 Percentage of hydrographic data products and services based on S-100 model are covered by IHO standards, specifications and guidelines on cyber security (2026: 100%). 1.2.2 Percentage of navigationally significant areas (e.g. charted traffic separation schemes, anchorages, channels) for which the adequacy of the hydrographic knowledge is assessed through the use of appropriate quality indicators (2026:100%).

Goal 2: Increasing the use of hydrographic data for the benefit of society

Targets	SPI (measure for success)
2.1 Build a portal to support and promote regional and international cooperation in marine spatial infrastructures (MSDI).	2.1.1 Number of hits downloading data/information from the portal.
2.2 Promote new tools and methods to accelerate and increase coverage, consistency, quality of surveys in poorly surveyed areas.	2.2.1 Percentage of adequately surveyed area per coastal state. 2.2.2 New Standards for Hydrographic Surveys (S-44), allowing for all hydrographic applications and broader use, is promulgated by 2021 and used by in various fields by 2026.
2.3 Apply UN shared guiding principles for geospatial information management in order to ensure interoperability and extended use of hydrographic data in combination with other marine-related data.	2.3.1 Number of HOs reporting success applying the principles in their national contexts (2026: 70%).

Goal 3: Participating actively in international initiatives related to the knowledge and the sustainable use of the Ocean

Targets	SPI (measure for success)
3.1 Improve existing capacity building strategy and programmes, and collaborate with other bodies who deliver capacity building and training.	3.1.1 Percentage of Coastal States are capable and forward marine safety information (MSI) according to the joint IMO/IHO/WMO manual on MSI (2026 90%).
3.2 Improve knowledge of the world's seafloors.	3.2.1 Amount of data received per year by the IHO Data Centre for Digital Bathymetry (DCDB). 3.2.2 Number of contributors to DCDB who are not hydrographic offices.
3.3 Implement a comprehensive IHO digital communication strategy in order to enhance its visibility and accessibility to its work	3.3.1 Number of visits, likes, re-postings, etc. associated to the IHO social media sites. 3.3.2 Volume downloaded from the IHO website and Geographical Information System (GIS).

IHO is obviously well-known, but for those not in the know, please provide an overview of the organization that you lead.

The International Hydrographic Organization is an intergovernmental consultative and technical organization that was established in 1921 to support safety of navigation and the protection of the marine environment. The object of the Organization is to bring about:

- The coordination of the activities of national hydrographic offices
- The greatest possible uniformity in nautical charts and documents
- The adoption of reliable and efficient methods of carrying out and exploiting hydrographic surveys
- The development of the sciences in the field of hydrography and the techniques employed in descriptive oceanography.

The official representative of each Member Government within the IHO is normally the national Hydrographer, or Director of Hydrography, who, together with their technical staff, meet at 3-yearly intervals in Monaco for an IHO Assembly. The Assembly reviews the progress achieved by the Organization through its committees, sub committees and working groups, and adopts the programmes to be pursued during the ensuing 3-year period. A Secretary General and two Directors are elected to administer the work of the Organization during that time.

The Secretary General and Directors, together with a small international staff of technical experts in hydrography and nautical cartography and locally recruited administrative support staff make up the IHO Secretariat in Monaco. The Secretariat of the IHO, coordinates and promotes the IHO's programmes and provides advice and assistance to Member States and others. Today IHO counts 93 Member States from six continents.

What are the top 3 or 4 initiatives/ issues on the IHO agenda for the coming year? Please be specific.

The revised strategic plan of the IHO addresses three main goals, specifies related targets and defines Strategic Performance Indicators to measure success. *(See Table to the left)*

I think it is generally agreed that these are times of heightened geo-political unrest. If you would like to, please discuss how this impacts the work that IHO conducts.

As pointed out by the revised strategic plan, the Member States face a growing request for maritime geoinformation beyond surface navigation, a rapid development in technology to survey the oceans and charting technologies, the increase in exploitation and exploration of the vulnerable maritime ecosystems, the digitalization of all processes and the compelling need for collaboration across all maritime science, engineering and administration domains. The principle of multilateralism is the basis for the coordinating role of the IHO to maintain internationally harmonized responsiveness to the above challenges.

Under your tenure, what do you count as IHO's greatest accomplishment, and why?

In general, IHO activities are ongoing transformation processes which have started under my predecessors and will not end with my term. These processes are interdependent with other overarching processes like digitalization, improvement of technology and increased relevance of the maritime issues in terms of exploitation, preservation and modelling of natural processes for disaster management. The difference I can make in my role is to control the interrelation of the goals and targets of the IHO with these overarching processes and to propose and conduct ways to intensify our contributions. Notable steps in this context happened within the last two years were:

- The completion of ECDIS carriage requirement in 2018

"The (IHO) Member States face a growing request for maritime geoinformation beyond surface navigation, a rapid development in technology to survey the oceans and charting technologies, the increase in exploitation and exploration of the vulnerable maritime ecosystems, the digitalization of all processes and the compelling need for collaboration across all maritime science, engineering and administration domains."

- IHO´s provision of digital GIS services to create a global image of survey and charting activities of their members
- The further definition modern technical standards for data exchange and installation of technical infrastructure for the next generation of digital nautical charting to enable a fully integrated approach (IMO e-navigation)
- The renewal of IHO´s corporate design, the upgrade of communication means and digital outreach
- The intensified contribution of bathymetric data and geodata standardization competences to overarching processes addressed under the UN Sustainable Development Goals and the UN Decade of Ocean Sciences for sustainable development
- The revival of collaboration with the bodies of the Antarctic Treaty and the Arctic Council to create a more comprehensive image of the physical conditions within polar waters
- The efforts spent for an increase in ocean mapping by means of

the Seabed2030 project to map the entire oceans by 2030.

We have seen quantum leaps in technological advancements in the hydrographic space. What do you see as the most important developments in the past 5 years?

- The final shift in cartographic priority from printed to digital charting by means of a data centric approach for all sorts of hydrographic products
- Improvements in sensor technology for sea survey: multibeam, lidar and satellite derived bathymetry
- The introduction of citizen science – we name it crowd sourced bathymetry – in our domain

What technology or technique do you see as promising in the coming years?

- Hydrography will enable autonomous technology for their own domain in sea survey and sea transportation in general
- Information gained with remote sensing from air and space will be transformed in hydrographic knowledge
- Smart end user devices integrate marine geoinformation in analogy to an "App concept"
- Smart in-situ sensors (low weight, low power consumption, internet of things) as payload for swimming (drifting, sailing) and flying drones
- Preprocessing of in-situ sensor data on the spot
- Artificial intelligence to handle the massive amount of hydroacoustic data
- Position fixing devices with high vertical accuracy in real time
- Payable broadband communication at sea.

Please discuss the importance of these market developments (if not already covered):

- **Increased Maritime Traffic in the Arctic regions:**

"Needs hydrographic support in sparsely surveyed areas and assisting technology like forward looking sonars integrated into the navigational environment."

- **Global climate change and rising sea levels**

"Improvement in global datasets of seabed topography – mapping the oceans in their entirety with reasonable resolution. Improved modelling of sea water level based on dense in-situ sensor grids and correlated with remote sensing input (satellite data) and refined gravity model (geoid)."

- **The push by IMO to cut maritime emissions 50% by 2050**

"Route optimization, under keel clearance management based on improved hydrographic data and water level modelling. Plus, strengthening of local production and local consumption to avoid unnecessary sea transportation."

Specifically, how many coastal states contribute to IHO, and what do you think is a key to get more on board?

Today IHO counts 93 Member States from six continents. The ideal goal is the number of IMO membership – currently 174. Since the IMO has land locked members as well, a realistic maximum

for IHO could be 120, my desire is to reach 100 in 2021 – the year of 100 years anniversary of the IHO.

IHO assists in capacity building to setup national capacity in hydrography. Proven by Member States which joined recently, this is regarded as a measure to gain sovereignty about the wet part of the national territory. Africa is the region of the greatest deficiencies in terms of membership but likewise a continent with great potential in maritime activities. Since nutrition with sea food will be instrumental to feed a fast growing population, fish farming will be key – especially along African costs. Proper survey of domestic waters is a precondition for.

Every business, every leader has challenges. What do you consider your top two or three challenges today?

Keeping track with pace of technological change. Remaining flexible through avoidance of ever increasing bureaucracy. Getting noticed as important contributor to the maritime domain in a multitude of voices and a superficial reflection of complex issues in social media. And, finally, remaining productive as a technical consultative organization under increasing political tensions in some regions.

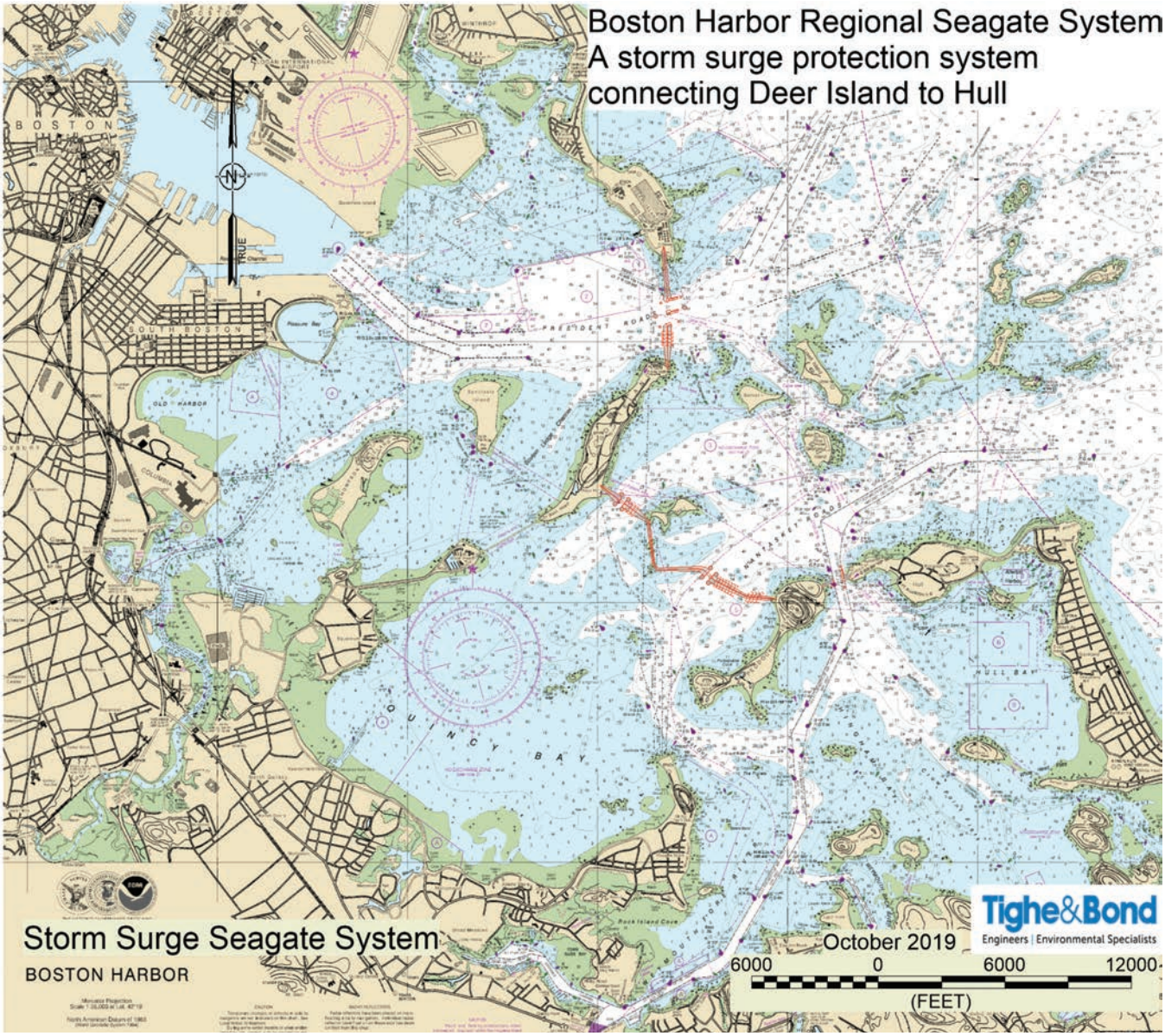
Personally, what do you like to do in your spare time/leisure activities?

The Cote D'Azur offers the perfect mixture of natural beauty, culture history and Mediterranean life style. I enjoy swimming, hiking and skiing, strolling through the historic city of Nice and have lunch in a fish restaurant at Saint Jean Cap Ferrat. I was recently blown away by Cecilia Bartoli´s performance at the Opera Garnier here in Monaco. No need to go elsewhere – sooner or later they all come here, attracted by the magic of the place.

Sea Level Rise

Protecting of Ports from Storm Surge

By Duncan Mellor, P.E., Principal Coastal Engineer, Tighe & Bond



Coastal flooding disasters have occurred periodically through history often followed by construction of flood defenses to help ensure it does not happen again. One of the most well known was the 1953 North Sea Flood in the Netherlands when a storm surge occurred on top of astronomical high tides causing thousands of deaths, property and economic damages. The Dutch and UK reacted and increased construction of sea defenses including storm surge barriers, such as the Delta Works and River Thames barriers. In the US the New Bedford/Fairhaven port was severely flooded by hurricanes in 1938 and 1954 causing $8.3 million in damages, which lead to the construction of the New Bedford Hurricane Barrier in 1962 by the Army Corps of Engineers at a cost of $18.6 million. The Army Corps project summary notes that this barrier has since prevented $24.1 million in flood damages (to 2011), and properties within the protected area are no longer required to purchase FEMA flood insurance. The Port of New Bedford does emphasize they are one of the safest ports of the eastern seaboard with the storm and flood protection provided by the hurricane barrier.

More recently, Hurricane Ike caused storm surge damage to Galveston in 2008 and a feasibility study is underway by the Army Corps of Engineers, with an Ike Dike concept design being advanced by Texas A&M University. Similar concepts for a hurricane surge protection barrier are being progressed for the New York-New Jersey Harbor in the wake of Hurricane Sandy, with the most feasible barrier connecting Long Island to Sandy Hook. Common to the existing and proposed storm surge barriers are three main elements: dike; tidal flow gates and navigation gates. The dike and tidal flow gates are existing traditional engineering technology, aided in the modern age with computer modelling of the harbor to size and locate the tidal flow gates to maintain water quality and to minimize current velocity at the navigation gates. The navigation gates hold the largest engineering challenge, balancing demands for the widest possible gate opening, against cost and engineering to develop an economically viable barrier design.

The largest storm surge navigation gate is Maeslant Barrier in the Netherlands at 1,200 ft wide as a single sector gate comprised of two rotating floating sector leaves. St. Petersburg has a similar floating sector gate 650 ft wide. New Bedford also has a sector gate 150 ft wide, but the gate leaves are on wheels. The Bubba Dove floodgate in Louisiana uses a floating barge gate 250 ft wide and is reported to have been one one-third the cost of a sector gate. A similar floating barge gate has been proposed for the Galveston navigation gate, 787 ft wide. Some of the existing navigation gates in exposed waters are around 40% wider that the ship beam, while lock type gates in protected waters with alignment fendering may only be 6% wider that the ship beam. A recent concept for a storm surge barrier across the outer harbor islands in Boston uses redundant multiple navigation gates, with some separation, and PIANC guidelines suggest 380 ft wide navigation openings for 140 ft beam vessels (170% wider than the ship beam).

With the heightened concerns about sea level rise, perhaps more frequent severe storm surges and the severe economic damages caused by coastal flooding, there does appear to be increasing interest in and demand for storm surge barriers. The possibility of a large, once in a lifetime, infrastructure funding bill by the federal government has also primed the pumps to have these storm surge barriers advanced to at least feasibility level. This can be a significant benefit for ports, with the opportunity to market enhanced cargo safety that may not be offered by competing ports. However, these structures will need to be well designed, with adequate clearances and approach fendering for safe vessel passage, with allowances for future ship size increases (width and depth), and unknown future sea level rise.

Subsea Mining

Will 2020 be the Year?

Photo Courtesy Nautilus Minerals

By Andy Lipman & Alan Yu, ABS

Anyone who has been around the Offshore Oil and Gas or the Marine industries for long has heard of plans for mining various minerals located on or just below the seafloor. In fact, when Howard Hughes built the Glomar Explorer in 1972, the cover story for its true mission – recovering a Soviet submarine - was that the rig would be used to mine manganese nodules from the deep ocean floor. This cover story was so effective that it had the unintended consequence of stirring great interest in ocean mining among offshore companies and the general public.

In the years since, there has been a great deal of research and exploration in this field. However, except for shallow water diamond mining off the coast of Southern Africa, no commercial deep-sea mining operation has yet been started. Now it seems that 2020 may actually be the year that commercial deep-sea

TOOLS OF THE TRADE: Solwara 1 project seabed mining tools.

ocean mining starts in earnest.

Types of ocean minerals.

There are three types of deep-sea ocean minerals of commercial interest; polymetallic nodules, seafloor massive sulfides and polymetallic crusts.

Polymetallic Nodules were the first of the seafloor minerals to be discovered. These nodules are of commercial interest for their high manganese content. In one area of the North Pacific Ocean seabed known as the Clarion Clipper Zone, the International Seabed Authority (ISA) estimates there are over 20 billion tons of these nodules. Generally, these nodules lie atop ocean sediment at depths greater than 3000 meters.

Seafloor Massive Sulfides (SMS) are formed by undersea volcanos and generally lie in shallower water than manganese nodules. The deposits of copper, zinc, gold and silver are what is of commercial interest in these ar-

eas. Many, if not most of these potential fields are located in the Pacific Ring of Fire and are found within a Coastal States' Exclusive Economic Zone (EEZ) or outer Continental Shelf.

Finally, Polymetallic crusts are also found in relatively shallow water within coastal states' EEZs. These crusts form a hard pavement on the seabed up to 25cm thick. The minerals of commercial interest are cobalt, titanium, platinum and some rare-earth minerals (REM).

Each of these types of deposits present their own unique challenges for effective and environmentally sound mining. As a rule, equipment designed for one type of mining is only suitable for that type.

Challenges: *Legal*

Although the technical challenges are daunting for any type of deep-sea mining, the legal and environmental challenges presented to any mining operation are potentially even more so. Any commercial subsea activity which falls within the EEZ generally 200nmi (and for the purposes of subsea mineral rights, extends out to 350nmi to the continental shelf) is governed by an individual coastal state's regulations.

Some of the Pacific Island nations which early on had significant offshore

SOLWARA1 Mining Support Vessel in FUJIAN province PRC.

Photo Courtesy FUJIAN MAWEI SHIPBUILDING

mineral discoveries have enacted their own legislation to govern mining. For the many areas of commercial interest which fall outside these coastal state boundaries; the United Nations Convention on the Law of the Sea, which established the International Seabed Authority (ISA) came into force in 1994. The ISA has since then met with stakeholders to further its main goals of regulating deep-sea mining and protecting the ocean environment from any harmful effects of mining operations. In the ensuing years, the ISA has promulgated prospecting and exploration regulations for all types of seabed minerals. Starting in 2016, the ISA began drafting Regulations on the Exploitation of Mineral Resources, which must be in place before any commercial mining operations can commence. There is a good chance now that the

Regulations could be promulgated in 2020. A link to the draft version of the Regulations can be found here https://ran-s3.s3.amazonaws.com/isa.org.jm/s3fs-public/files/documents/isba24_ltc-wp1rev1-en_0.pdf

Challenges: *Technical*

When transitioning from the prospecting phase to the commercial exploitation phase, there are four main challenges to be faced:

1. Designing and building a suitable mining support vessel or installation.
2. Designing and building proper subsea mining tools – that is, the machines actually perform the mineral extraction on the seafloor.
3. Designing and building the riser and lift system for transporting the mineral slurry to the surface.
4. Once on the surface, dewatering and cargo handling.

However, the most daunting technical challenge of all is incorporating all these new technologies into an integrated system that will work reliably, effectively, and seamlessly for the entire mining field life.

It must be remembered always with the design of each of these systems that, in addition to being capable of meeting the technical design specifications, they also must meet the environmental rules established with respect to biodiversity, plume density and extent, and sedimentation rates, rules either of the ISA in International Areas, or of the Coastal State within the EEZs.

Mining Support Vessel

The first necessity in any subsea mining plan is a suitable floating installation. In addition to the most basic maritime design consideration of stability, structural integrity, station keeping, and safety, special design considerations for support of subsea mining must be taken into account. These include handing of seafloor mining tools, handling of riser and lift systems, cargo dewatering and handling systems. As with oil and gas installations, abandonment and recovery operations due to weather or other circumstances must be properly planned and designed into the vessel or rig.

For many, the Solwara 1 Production Support Vessel which was built and launched at Fujian Mawei Shipyard is an example that includes all of the key elements.

Seafloor Mining Tools

Except for the nodular type of minerals that can be directly collected and lifted to the production vessel, many different varieties of seafloor mining tools will be required to prepare the seafloor mined material to the sizes that can be effectively lifted to the production vessels. For SMS mines, the mining tool prototypes have been built and to some degree successfully demonstrated. Other seafloor mining tool prototypes have been tested successfully. Most designs involve a crawler of some type with either a cutter or a suction head depending on the target materials.

Risers and lift systems.

The difficulty of moving many tons per day of dense slurry from depths of 1000 meters or more cannot be underestimated. For SMS projects where the depths may not exceed 2000 meters, steel risers of the vertical top tension design are mainly contemplated. For mining nodules in depths greater than 3000 meters, the weight of steel risers is a huge problem, so alternative materials are being considered. Pumping systems involving centrifugal pumps are also quite problematic for these lifting distances. A positive displacement design subsea pump was built by GE Subsea Systems for the Solwara 1 project. An air lift system test loop and small-scale air lift systems have been constructed and tested so far but have not been scaled to deep-water for testing. Others have proposed truly innovative designs which do not involve pumps or air lifts, such as a continuous conveyor system or even magnetic induction systems.

Dewatering and Cargo Handling.

Although not as eye-catching as the seafloor mining tools or subsea pump design, it must be considered that once the slurry reaches the mining support vessel or rig at the surface, the water must be removed and returned to the approximately the same depth from where it was extracted. Meanwhile the remaining ores must be dried and stored until they can be sent ashore. Much thought has gone into how to design environmentally sustainable dewatering and cargo handling systems, with most designs contemplating some combination of settling, cyclone separation, and heat drying.

Produced water, because of microbial content and temperature differential cannot be discharged at the surface. Therefore, a system of pumps and downcomers to the near seabed must also be designed. In order to be successful, the amount of production from a single Mining Support floater would entail producing at least 1000-6000 tons of dried ore per day; so the economics would seem to dictate the need for a ship to ship transfer to a shuttle type of cargo handling vessel while the mining vessel remains on station. In this area, the dredging industry may offer a guide to similar technical solutions.

Stakeholders

It is important to identify what role each stakeholder plays in full-scale subsea mining.

First and foremost is the Owner, or in the ISA terminology the Contractor. This is the organization which is most directly responsible for implementation of the design and operation of any undertaking. In many cases, national organizations are contemplated for this role, as commercial entities are considered too risk averse, or underfunded. In the case of China, there are State Owned Enterprises (SOE) which are well funded, and deeply involved in several different mining projects. Worldwide, there are many other state and commercial actors who are at various stages of readiness in their mining plans.

Regulators – The regulators are the International Seabed Authority in International Areas, the Coastal State authori-

ties in the EEZs and also the Flag State authority of the Mining support vessel. All of these will enforce specific safety and environmental protection regulations.

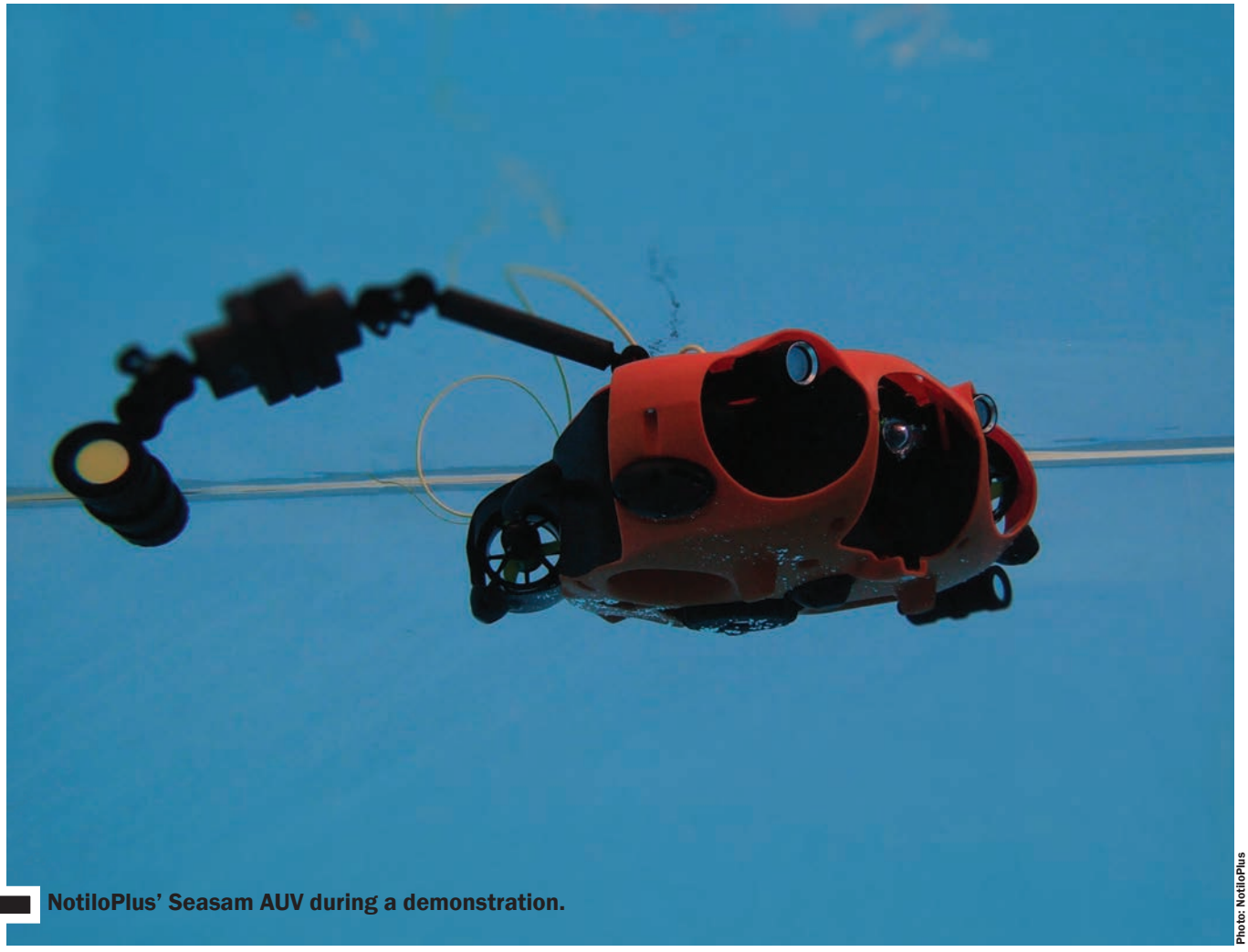
International Classification Societies – Much like the established conventions for Safety of Life at Sea (SOLAS) and Prevention of Pollution from Ships(MARPOL), International Classification Societies are recognized by the signatory states of these conventions and by Coastal State authorities as competent to monitor compliance with the conventions. These societies have established themselves as well positioned to verify compliance as third parties between the Owners and the Regulators. Additionally, proper design, construction, installation, and survey after construction of subsea mining systems are vital to ensure the health and safety of operators as well as protection of the marine environment. To this end, ABS has Rules and Guides which aid not only Owners and Regulators, but also financial institutions and insurance underwriters with evaluating whether standards are met and maintained in accordance with ABS Rules and other conventions during the operational life cycle of the project.

The General Public

Since the Oceans are designated as the common heritage of mankind, it must be considered that the entire population of the earth is a stakeholder in any subsea mining operation. Therefore, it is the duty of all other stakeholders, the Owner, the Regulators, and the Class Societies to ensure that subsea mining is conducted in a way that meets safety standards and in an environmentally sustainable manner.

The goal of sustainable mining of the mineral resources from the deep ocean floor has always seemed just out of reach. Now, for a confluence of reasons, establishment of a proper regulatory environment, advances in materials and engineering, and an increasing worldwide demand for metals, it is more than likely that 2020 will be remembered as the year that the world's first full scale subsea mining venture begins. It is now up to the stakeholders in this new industry to coordinate and implement well thought-out and well executed plans that are not only economically viable, but also meet or exceed environmental protection regulations. As the leading offshore Classification Society, ABS stands ready to play an important role, ensuring safety and environmental protections are in the forefront. If executed responsibly by all stakeholders, there is no reason why this new industry will not have a bright future.

The March of M



NotiloPlus' Seasam AUV during a demonstration.

Photo: NotiloPlus

By Elaine Maslin

A growing battalion of small, compact systems is marching in on the subsea world, in some ways making it a bigger space for more to enter. Smaller remotely operated vehicles (ROVs) and smaller autonomous underwater vehicles (AUVs) are growing in number and in turn driving smaller technologies that support them. The result is a few new kids on the block and what you could call a rising march of miniaturisation.

They span from vehicle manufacturers to acoustic and optical sensor system makers. A number of these attended a demonstration event focused on unmanned systems in the offshore space, held by Norway's Equinor, in Tau, near Stavanger, in October 2019.

NotiloPlus

Starting with the vehicle manufacturers, one was NotiloPlus, a French start-up, founded in 2016, that's producing a

Miniaturization

Photo: Elaine Maslin

small but smart ROV.

The Seasam weighs in at 9kg and is the missing link between a small and compact but piloted ROV and bigger ROVs packed with kit that cost a lot. Nicolas Gambini, the Marseille-based company's co-founder and CEO, says NotiloPlus is enabling a small vehicle with a lot of smarts through computing power. "Machine learning and software allows you to do positioning and sensing," he says. "For positioning, you need to use lots of hardware, but we wanted this to be as cheap as possible. So, for less than the price of one high-end positioning sensor we have a system that uses cheaper sensors but then fuses them and uses algorithms to magnify the data so that it's close to most perfect sensors.

"This means [with the Seasam] we can use simple acoustic sensors for positioning and a camera for computer vision. The computer vision means that in the frame of what the drone sees it can identify a point of interest and touch it, if that's what's needed." The vehicle can either be tethered, if you want live feedback, and untethered. "Also, it can provide fully autonomous diver following or dam or ship hull inspection. For a small ship, say 10m long, it doesn't even need a map, it can by itself identify a rudder etc. For a long hull, you can tell it the shape and length and then it choses its own pattern for an inspection."

The firm, which does its testing in

NotiloPlus' Seasam AUV has been operating around the world.

Photo: NotiloPlus

Photo: Birger Haraldseid

Lyon, has been shipping Seasam systems since March this year and 300 are now "out there", from France to Korea, working in the leisure market, eg. diver centres, as well as industrial, inspecting infrastructure, and science. Gambini says it can carry other pay load or tools and can be adapted. The firm also has a partnership with TechnipFMC, which including working on things like industrial production of the drone how provides a global offering. Looking into the future, Gambini says interconnected drones are likely where the industry will go.

Birdview

Not all subsea operations have to be done by subsea vehicles. Another start-up, Birdview, is designing an aerial drone that can drop sensors into the water to gather data – or whatever you might want a subsea sensor to do. The Oslo-based company has already been working with Norway's Institute of Marine Research (IMR) in Bergen to provide a remote sensor for offshore fisheries – i.e. a drone that is launched from a fishing vessel and dips a sonar into the water to see if there are shoals of fish, which can then inform the vessel where it should go.

Mohibb Malik, a Project engineer at Birdview, says the company has been using commercially available aerial drones, but is now developing its own modular system. "The drones available today are great for land based flight, but not for offshore marine environments," says Malik. "We're making a design that's watertight and can float (in case of a ditching)." Where flights it's been doing currently are at about 15-20 minutes, the target for its own drone is three hours – within a 50km range in order to maintain control/communication with it.

While the company was founded in 2014, it's only been really active for

During a drone demonstration event in Tau, near Stavanger, Norway, Bird View demonstrated its ideas.

about a year, says Malik, mostly focused towards the fishing sector. This has involved using a DJ1 6-blade drone that it's been launched from the IMR's fishing vessels offshore, learning and honing take-off and landing. Here, it's been using a Simrad echo sounder, that's dropped into the water on a small winch from the drone, to find fish. The echo sounder gathers data that's then processed to show where fish are. And the results have been good, says Malik, avoiding issues fishing vessels can have with vessel noise in the water because it's able to dip the sonar further away from the vessel. The next step is edge analytics – i.e. data processing on the drone so fisherman know faster where fish are.

But, Birdview see other opportunities, including dipping a modem to gather data from underwater sensors or even to provide a communications link to remote control ROVs or mobile underwater platforms, so they don't have to stay within range of a communications hub.

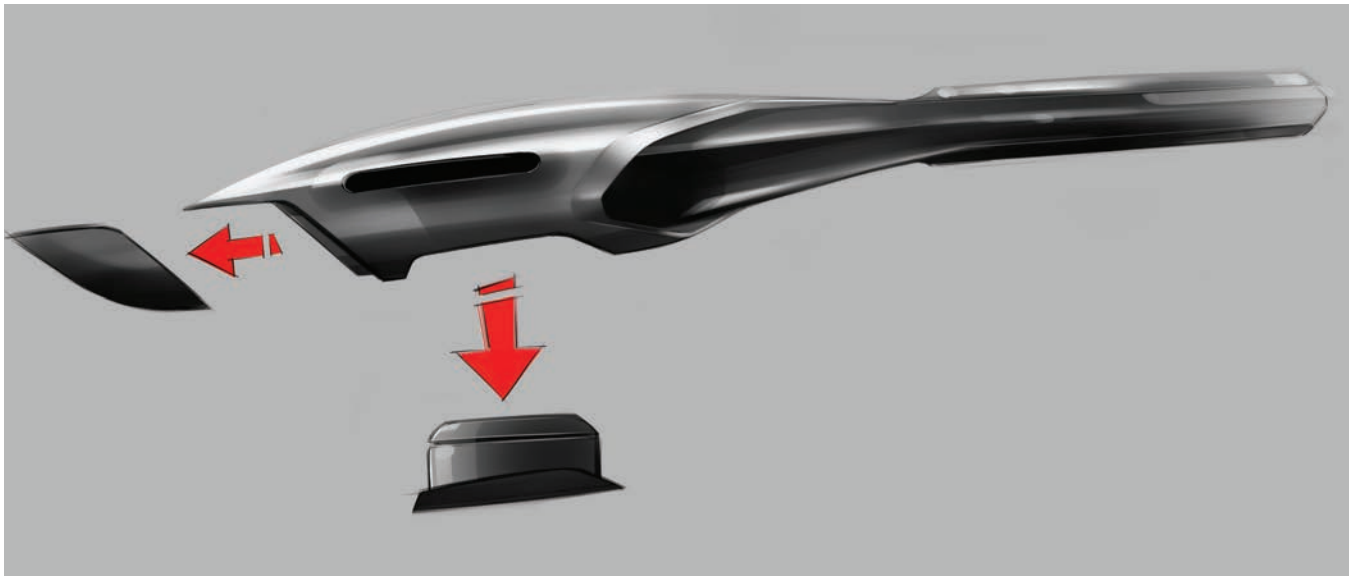
It's now working on a system with a 50km single range with semi and fully automated missions. A challenge is data transfer – when away from the host vessel or communications networks, less data can be sent, so the drone's communications systems have to be able to reduce the amount of telemetry, but still have the bandwidth to receive new missions, without direct control.

The firm aims to start testing its homegrown drone in about a year and take it to market in about 18 months to two years. Birdview is also working with TechnipFMC.

Water Linked

These systems need sensors and new kid on the block is offering some of those. Over the past seven years, Water Linked, based in Trondheim, Norway, has developed ultra-small subsea positioning and underwater modems. The subsea positioning system is based on an inverted short baseline system, using

Birdview's drone concept.



Artist Illustration: Birdview

four receivers and a locator on a mobile object, such as a vehicle. It's been integrated with Blue Robotics mini ROVs since 2017.

It's small because Water Linked's focus has been on the computing that can number crunch lower power (i.e. smaller) sensors to come up with the same results are bigger (i.e. more costly) sensors. The company has also designed its own transducers and, to remain lean, it outsources manufacturing within Norway.

"We are doing number crunching to increase the chance of out-putting a correct position," says Oliver Skisland, CEO at Water Linked. "It's not taking the first and easiest answer as the truth, it's doing a lot of computing to increase the possibility of giving a correct position." Water Linked is doing this using high-performance field programmable gate arrays (FPGAs). "FPGAs are a fantastic tool because you can programme them to be optimised for a specific task, compared with a generic PC," explains Skisland. "We're using ultra-modern technology to create small, power-efficient and cost-effective products. We take a very integrated approach where even the tiniest components are discussed in detail before it is allowed onto our boards."

Power is a trade-off. Water Linked's positioning system works out to 100m, with an extension to 200m coming in 2020. Its modems work out to 1km, says Skisland. Further would mean more power, which would mean bigger vehicles. But, this is the optimum for the market the firm is targeting – mini ROVs. More and more people are using mini ROVs because they've become cheap enough. With sensors on them, they can do more with them such as advanced navigation and providing documentation (position data) for survey or inspection work or accurately position divers, says Skisland. So, just like NotiloPlus, Water Linked says it can offer a whole system for the same price as a single sensor. "We're opening a new market, giving mini-ROVs new tool to do advanced navigation that's not been done before," says Skisland.

At the Tau event, Water Linked's positioning system was used as an "underwater GPS" on Oceaneering's Freedom 60% scale Freedom AUV test vehicle. There, with four what the company calls receivers on the docking station and a "locator" on the vehicle, it provided 1cm-accuracy for the AUV to dock into a subsea docking station. An optimal scenario would see the vehicle and the docking station each with four receivers and a locator. "Then, the docking station would know about all nearby AUVs and all AUVs would know where to find all docking stations. The docking station could easily implement a kind of 'landing system' as you find in airports where it could tell which AUV was in que to dock and which AUVs had to wait," says Skisland. With Water Linked modems, images could be transferred at 10m range to give vehicle pilots a view of what's going on, he says.

Next on the company's hit list is a super small Doppler velocity log (DVL) to help small ROVs or AUVs hold posi-

A Water Linked locator.

Photo: Water Linked

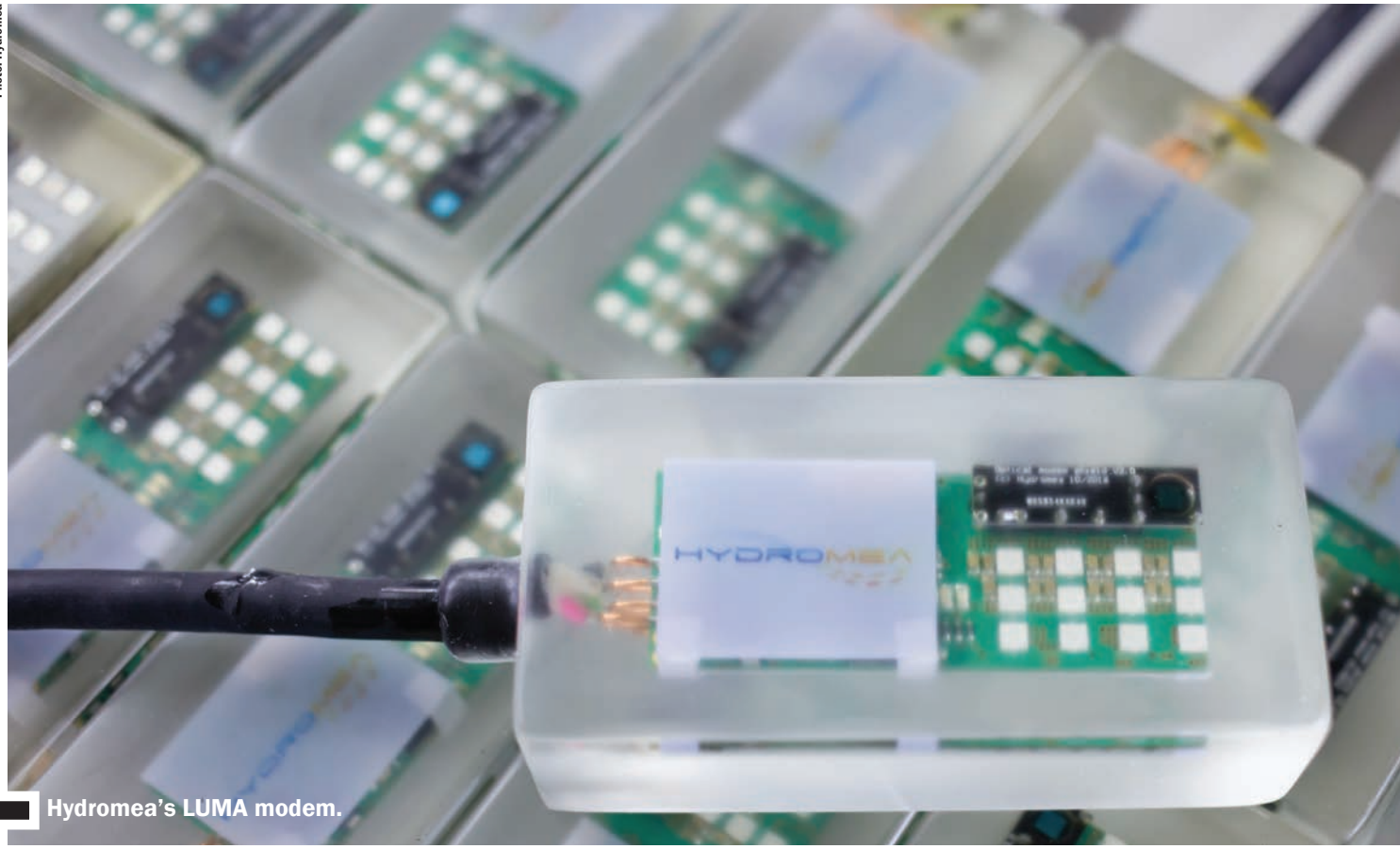
tion for inspection or intervention work. It's due to be launched early 2020. Depth rated to 300m, it is set to have a minimum altitude of 0.15 m, 50 m maximum altitude from its 25mm high and 55mm diminutive form factor.

Hydromea

Providing a communications link between vehicles or assets is another new kid on the block – Hydromea. The firm's founders, Felix Schill (CTO) and Alexander Bahr (COO), had started out designing a swarm of miniature AUVs back in 2003. After going their separate ways – one to do a PhD at MIT in underwater navigation and the other one to do a PhD in underwater mesh network communication at the Australian National University in Canberra, Australia, they came together at the Ecole Polytechnique Fédérale de Lausanne (EPFL) in Switzerland where they started working together again on miniature AUVs.

But, while trying to build them, they realized that they couldn't find small

Photo: Hydromea



Hydromea's LUMA modem.

enough thrusters, batteries for endurance, and small acoustic modems. In addition, they were asked by Germany's Alfred Wegener Institute (AWI) to expand their work on optical communication and develop a standalone unit. Their LUMA 500ER now offers 500kbs (thousand bits per second) data rate at up to 70m range over a 120 degree cone, says Igor Martin, the firm's CEO. But he says they think that can be expanded to multi megabits per second at greater distances.

"Now we see that as you miniaturize stuff, it becomes more affordable," says Martin. "It gives you the flexibility to retrofit. It's portable and scalable. Instead of costing tens of thousands, it's thousands and it opens up different opportunities. With small portable systems from companies like Water Linked and Hydromea, you enable an environment where having inexpensive modems or tools or sensor-systems - allows you to scale up."

The firm has been on the Oil & Gas Technology Centre's TechX accelerator program and has seen its optical communication technology used by Rever Offshore, Ocean Installer and i-Tech 7 for tasks like transmitting roll/pitch/yaw data from gyro boxes to observing ROVs during subsea construction projects to give on-deck crane operators, for example, faster information about what's happening subsea.

A LUMA modem was deployed by Rever Offshore at a wellhead site as part of an Ashtead Technology Autonomous Monitoring System (AMS+) during a drilling project for Total in the North Sea early in 2019. An ROV could then get data from the AMS+, using LUMA, 8m from the wellhead.

Later in 2019, an Alfred Wegener Institute and Max Planck Institute for Marine Microbiology scientific cruise on the research vessel Sonne used LUMA modems on Geomar's ROV KIEL6000 to directly communicate with subsea instruments, also with LUMA modems, in 4000m water depth, to ensure that their sensors were working and reconfigure them if necessary.

With the technologies it's built over the last 10 years, including LUMA, Hydromea is now turning its attention to building a miniature, tether-less semi-autonomous underwater drone, called the ExRay. It's being designed to be able to operate inside confined spaces filled with water, such as ballast water tanks on vessels. The goal is for it to be able to use simultaneous localization and mapping (SLAM) to navigate tanks and to use mosaicing software to produce 3D heat maps of areas needing maintenance. The first ExRay is due to launch in 2021.

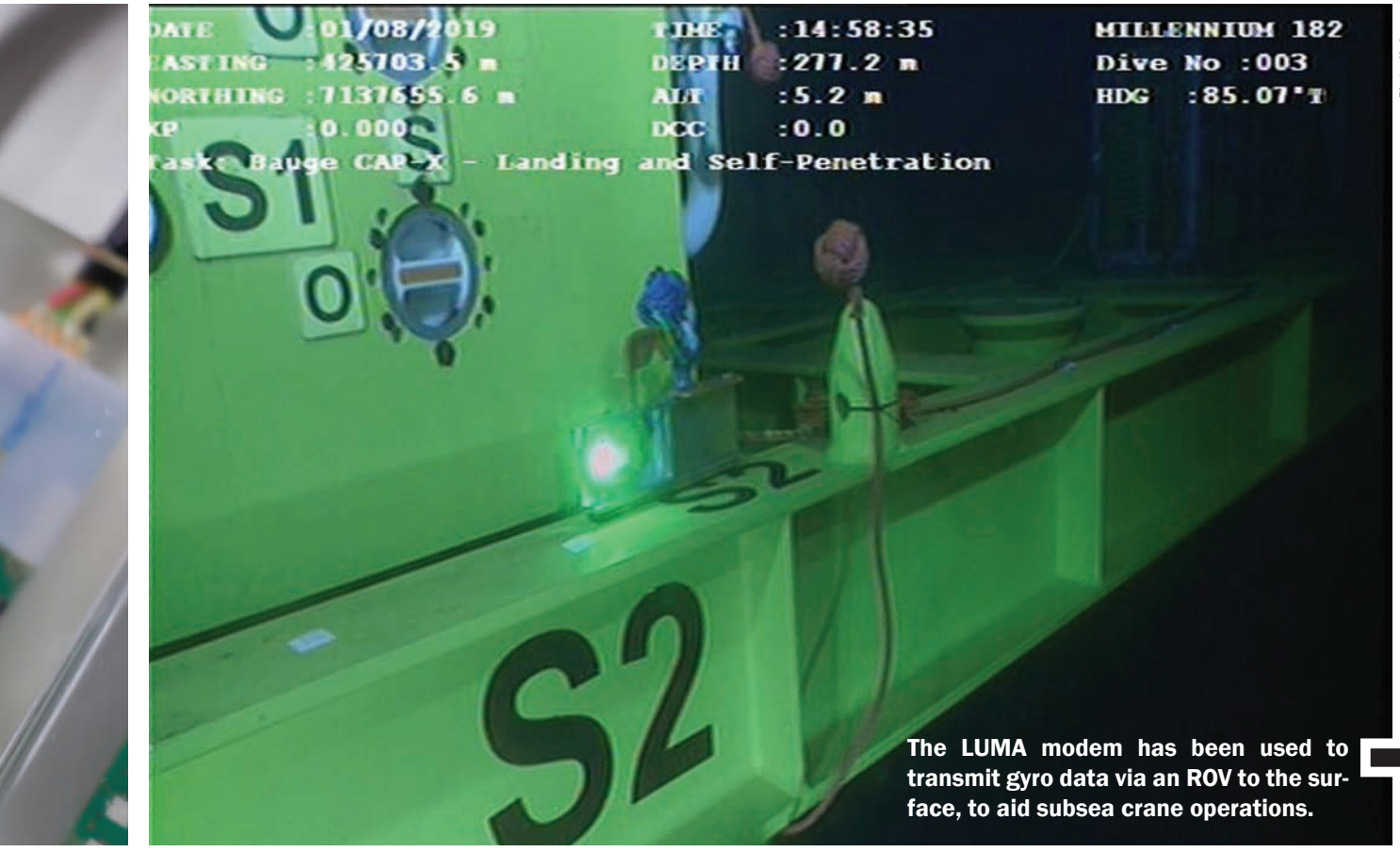
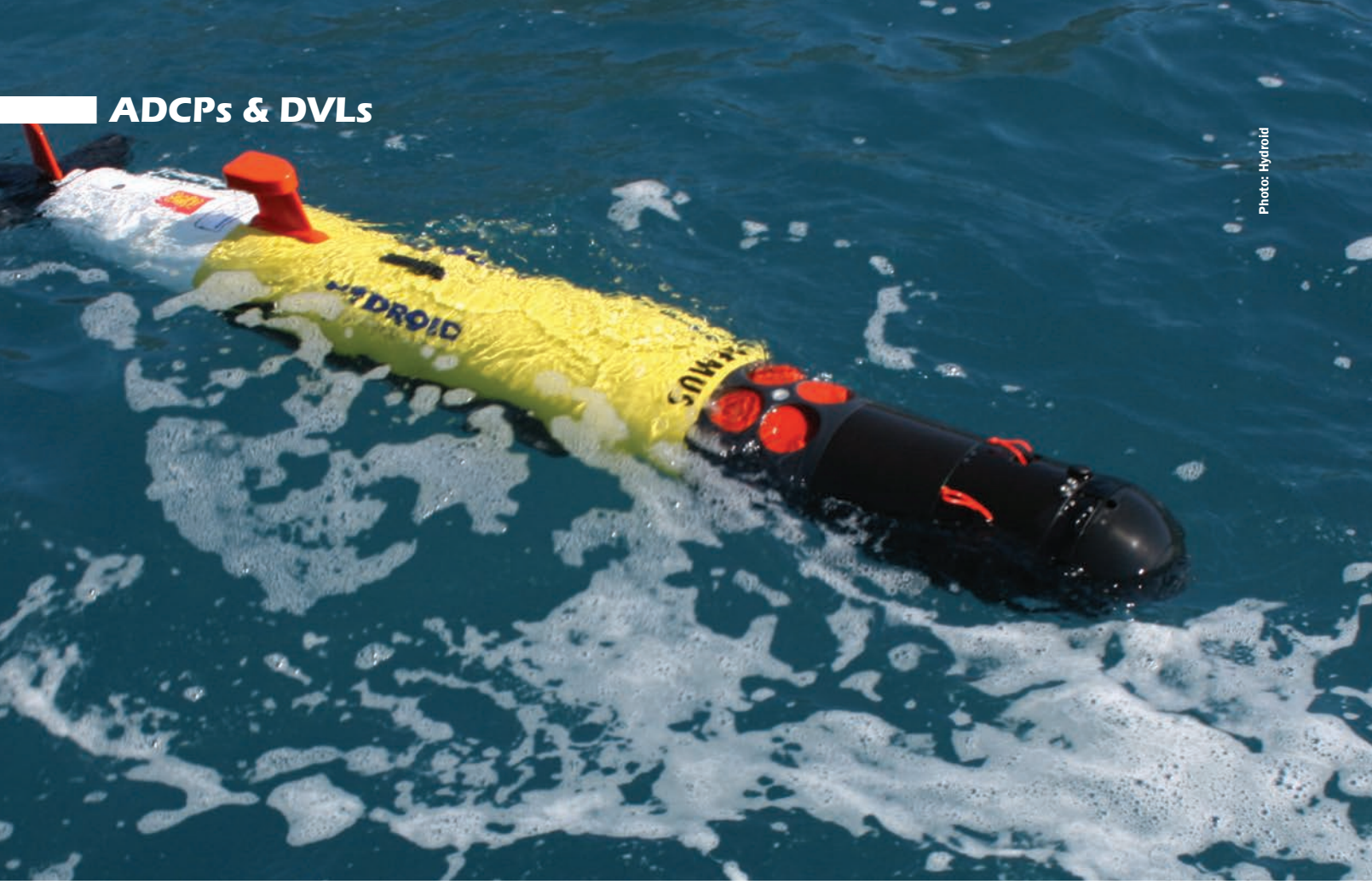


Photo: Hydromea

The LUMA modem has been used to transmit gyro data via an ROV to the surface, to aid subsea crane operations.

Hydromea's LUMA modem was used to transmit data from Ashtead's AMS+ system.

Photo: Hydromea



ADCPs & DVLs

Advancing ADCPs & Disrupting DVLs, Recent Technical Developments

By Justin Manley

All seagoers know the ocean moves. Some thrive on riding the wind and waves while some hang on and look for a rail downwind with a bit of green in their face. But measuring the movement of the water, or of objects through the water, is a key aspect of many ocean technologies and applications. It is possible to use a principle of sound waves called the Doppler effect to measure motion in water. A sound wave has a higher frequency, or pitch, when it moves to you than when it moves away. You hear the Doppler effect in action when a police car siren speeds past with a characteristic increasing intensity of sound that fades when the car passes.

The Doppler effect enables a key ocean instrument known as an acoustic Doppler current profiler (ADCP). This

LEFT: A REMUS vehicle shows the traditional four-element DVL array.

device measures the motion of water flowing past it. When mounted in a stationary buoy, or on the seafloor, it provides a measure of the water current. Alternatively, when mounted in a moving platform such as an undersea vehicle the instrument can measure motion relative to the water, or the seafloor. This is known as a Doppler velocity log (DVL). The first patents on the most capable broadband ADCPs were issued in 1997. This capability unleashed the modern era of current measurement. In the decades since, oceanographers and ocean engineers have employed these tools in a variety of configurations and thousands have been delivered. But what have the last few years brought to the field?

As the ADCP/DVL ecosystem has matured there have been many innovations. Recently, leading manufacturers

BELOW: The compact ECO ADCP.

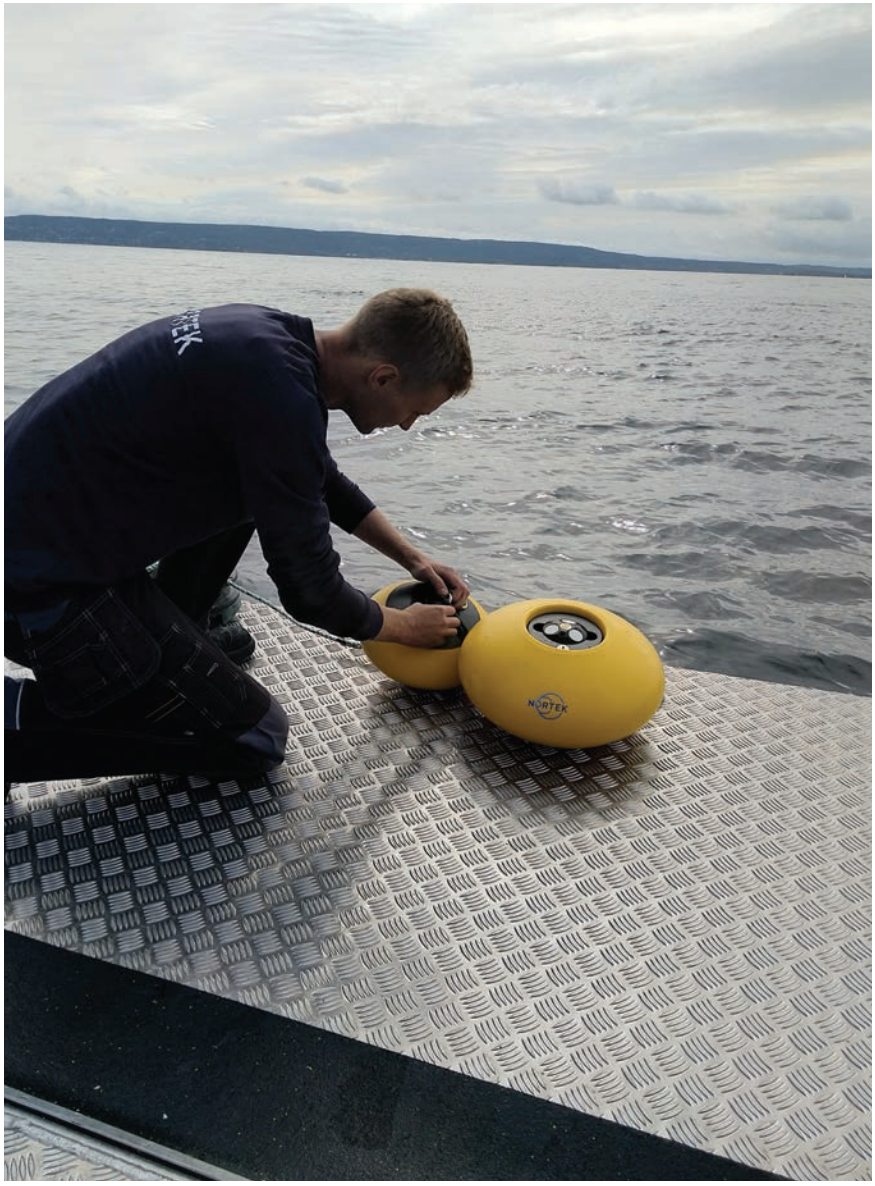


Photo: Nortek

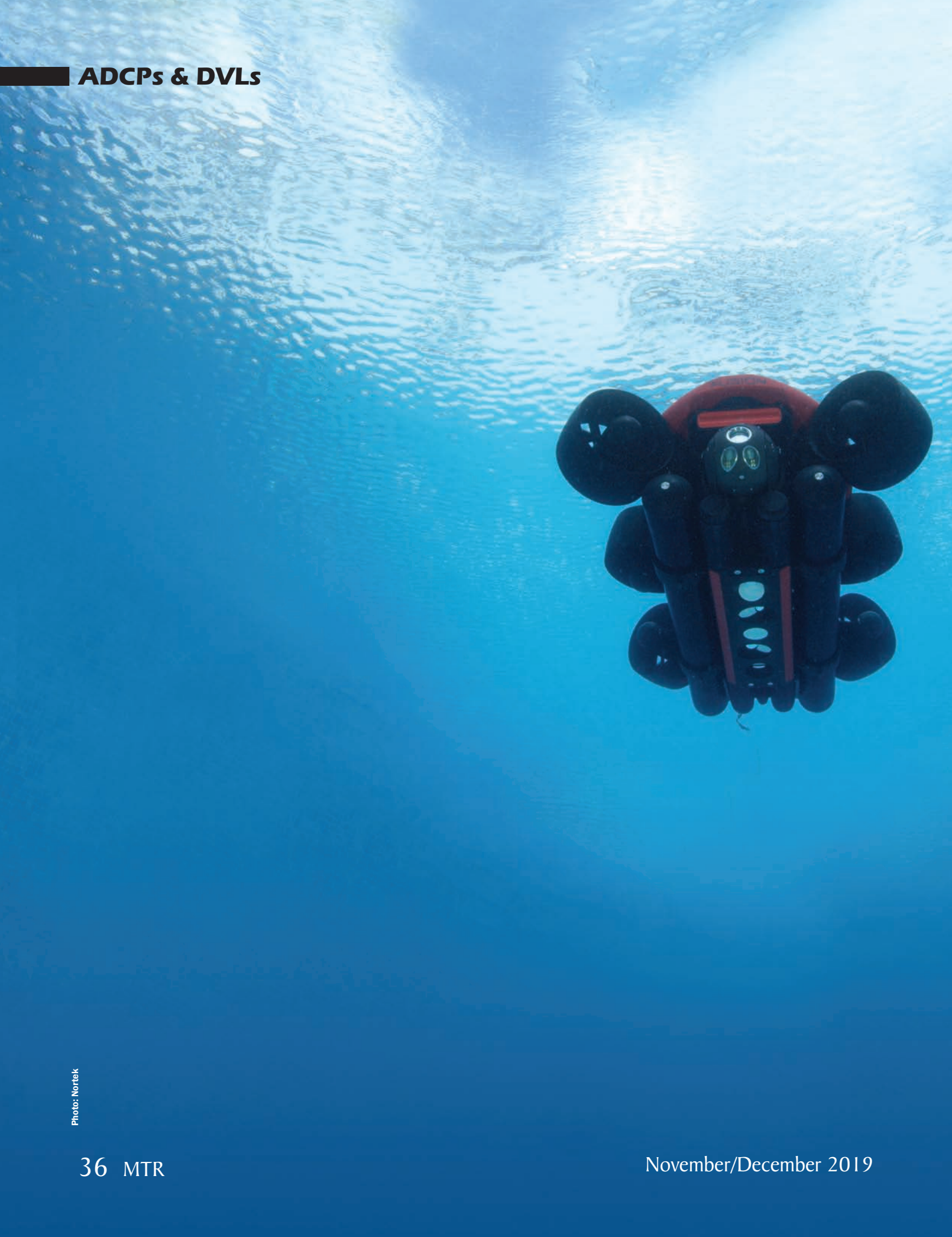


Photo: Nortek

LEFT: An inline DVL on the Fusion vehicle

have brought creative developments to the field. Teledyne RDI, the successor to the first company to commercialize the ADCP, continues to deliver key technologies, especially DVLs, for undersea vehicles. One of the most common unmanned undersea vehicles in service is Hydroid's REMUS. This vehicle typically employs Teledyne's compact DVL in the original configuration of four transducers mounted in a ring. The DVLs in these vehicles augment the GPS positions, recorded at the surface, and often inertial motion measurements to assist the vehicle in tracking its position for improved "dead reckoning."

The four transducer array is not the only configuration for a DVL, nor UUVs the only beneficiary. Another configuration is a phased array. This looks like a single transducer face but it is actually an electronically computer-controlled array of transducer elements which creates a series of acoustic "beams" pointing in different directions. Recently, Teledyne introduced the first phased Array DVL rated to 6000 meters, the pioneer 300. For a given size and performance, phased array technology provides greater bottom tracking range than traditional DVLs in this case up to 275 metres from the seabed. The Pioneer DVL was employed on board Vulcan Inc's deep rated ROV, supported by the R/V Petrel, as it made numerous WWII shipwreck discoveries in the Pacific. This same configuration is now used in Teledyne's latest DVL, the Tasman. Introduced in April 2019. The field-replaceable phased-array transducer design enhances position accuracy, eliminates the need for speed of sound correction and reduces the drag on an undersea vehicle. This in-

BELOW: The Tasman DVL employs a single, phased array.

Photo: Teledyne Marine

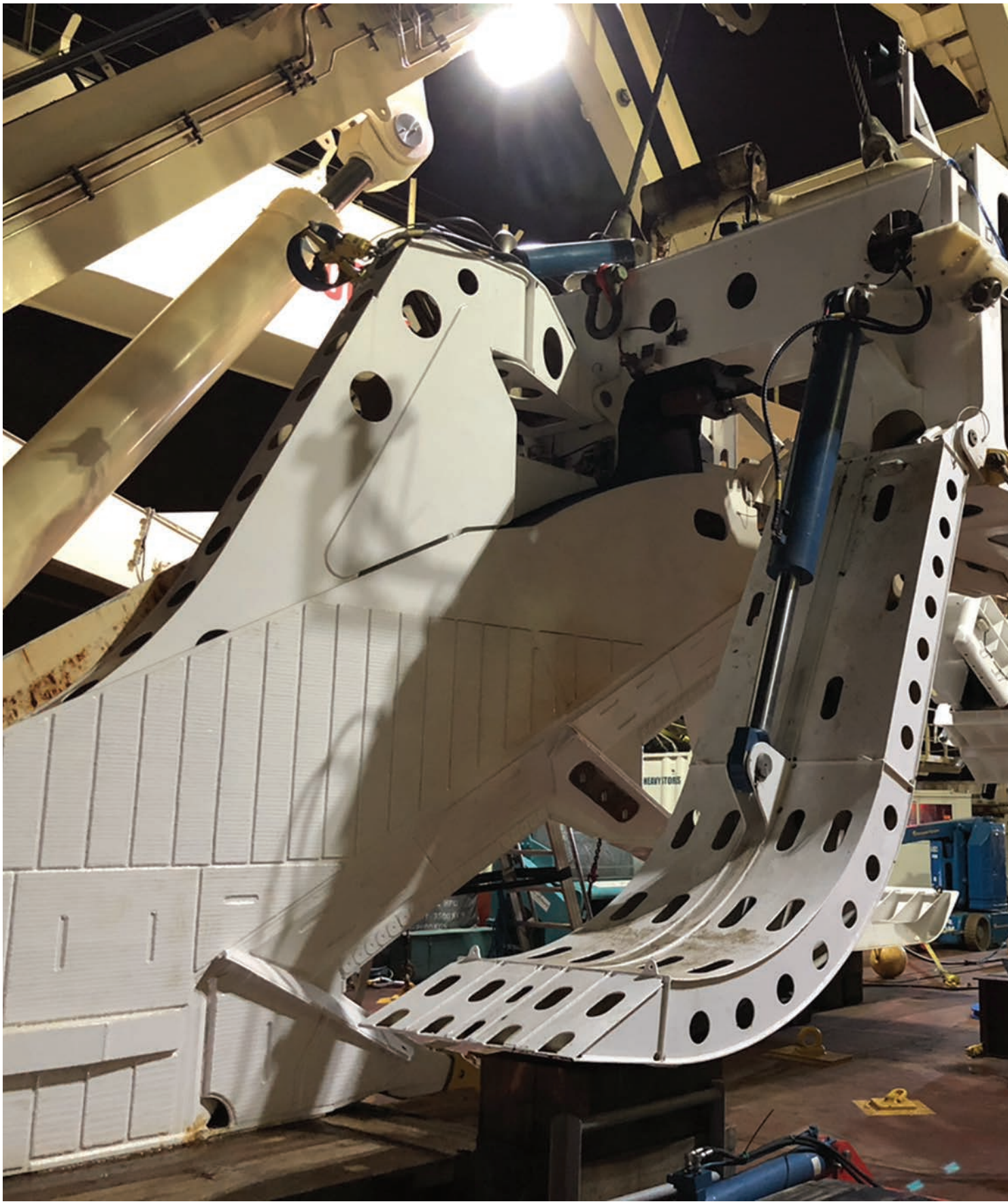
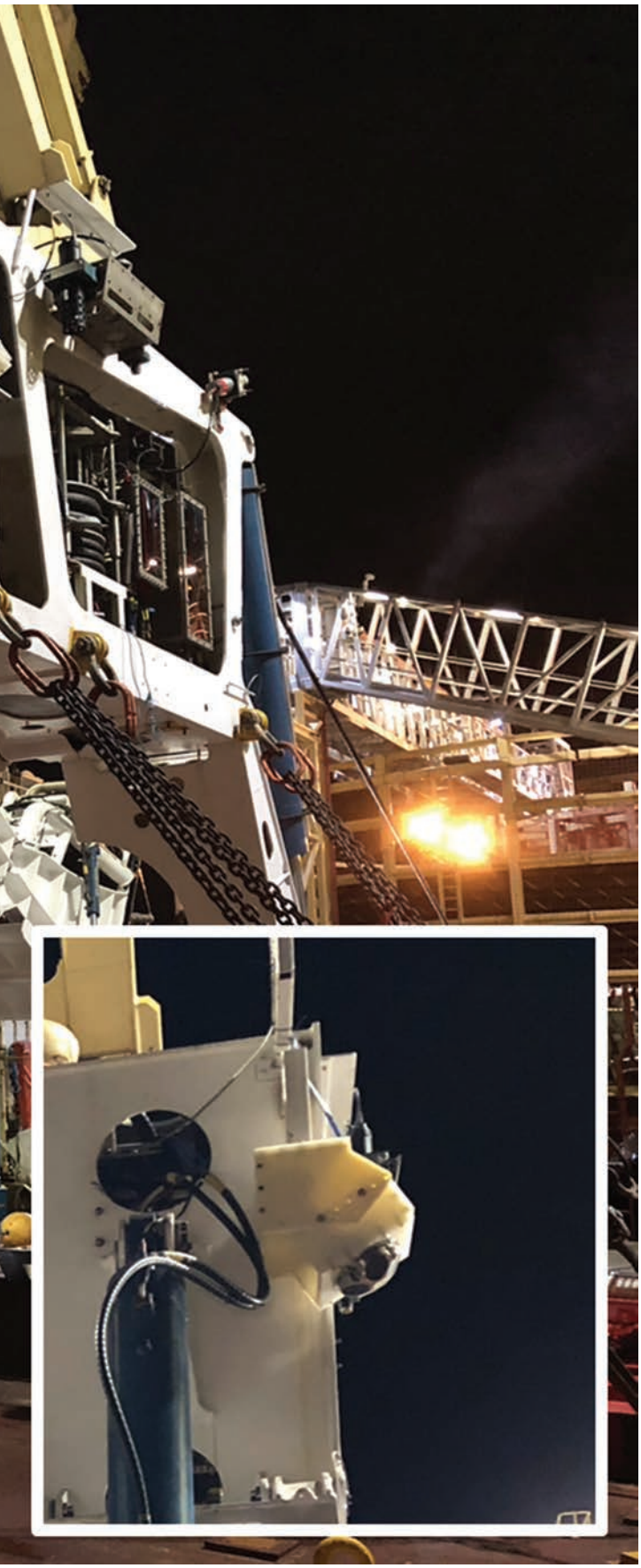


Photo: Sonardyne



strument also provides ethernet connectivity, helpful in today's ever more sophisticated undersea vehicles.

Meanwhile at Sonardyne, the Syrinx DVL has been incorporated in an innovative solution - the hybrid acoustic-inertial navigator SPRINT-Nav. Here, the DVL transducers, the inertial motion unit and the depth sensor are housed together, offering a number of advantages. For instance, the individual DVL beams are used to update the INS solution while also computing a DVL velocity vector. The result is a more accurate and robust acoustic-inertial solution where the INS can discard individual beam measurements and persist even when some DVL beams lose bottom lock. Alignment offsets between the different sensors are calculated at the factory so the system can be rapidly mobilized, and GPS alignment runs are unnecessary. The deployment is so flexible the system can be mounted even at extreme angles.

Another manufacturer innovating in the space is Nortek. While most DVLs employ a cylindrical form factor this is not always suitable for some applications. In one case a new undersea vehicle, the Fusion from SRS, demanded a different shape. Fusion is a hybrid underwater vehicle that combines AUV and ROV capabilities with diver navigation and propulsion in one system. Nortek delivered smaller transducers and electronics for this vehicle as well as a unique in-line transducer arrangement. In addition, the instrument suite added a dedicated altimeter for more accurate altitude measurement directly below the vehicle. Evolution in DVLs is enabling further innovation in undersea vehicles that depend upon them for navigation.

While DVLs are evolving rapidly together with undersea vehicles their ADCP cousins are evolving as well. Nortek provides another example here. Seeking to improve the efficiency of operations and decrease the cost of current measurements they recently introduced the ECO platform. ECO, Nortek's mini-ADCP for shallow water profiling was announced for sale in late 2019. It features a handheld, wirelessly charged 1MHz ADCP, programmed with a smartphone app. Data processing and quality assurance is provided through an automatic cloud-based service. In addition to these adaptations for the instrument itself Nortek took the development one step further and designed a compact buoy and timed-release system to simplify deployment in shallow waters.

ADCPs and DVLs are arguably one of the foremost enablers of both oceanography and undersea robotics. While they are not a new technology, their evolution has been rapid in recent years. New array designs, ever increasing diversity in frequency range, and novel configurations have come on scene quickly. Innovations inspired by current consumer tech, including apps and cloud computing are exciting developments not often seen in ocean instrumentation. But the demand for measurement of water's motion is significant and drives equally significant innovation. The next decade of movement will be exciting.

LEFT: SPRINT-NAV functions well, even at extreme angles.

Remote Sensing

Innovations Enhance Riverine Exploration

By Michael Shillenn, Vice President and Certified Photogrammetrist, Quantum Spatial Inc.

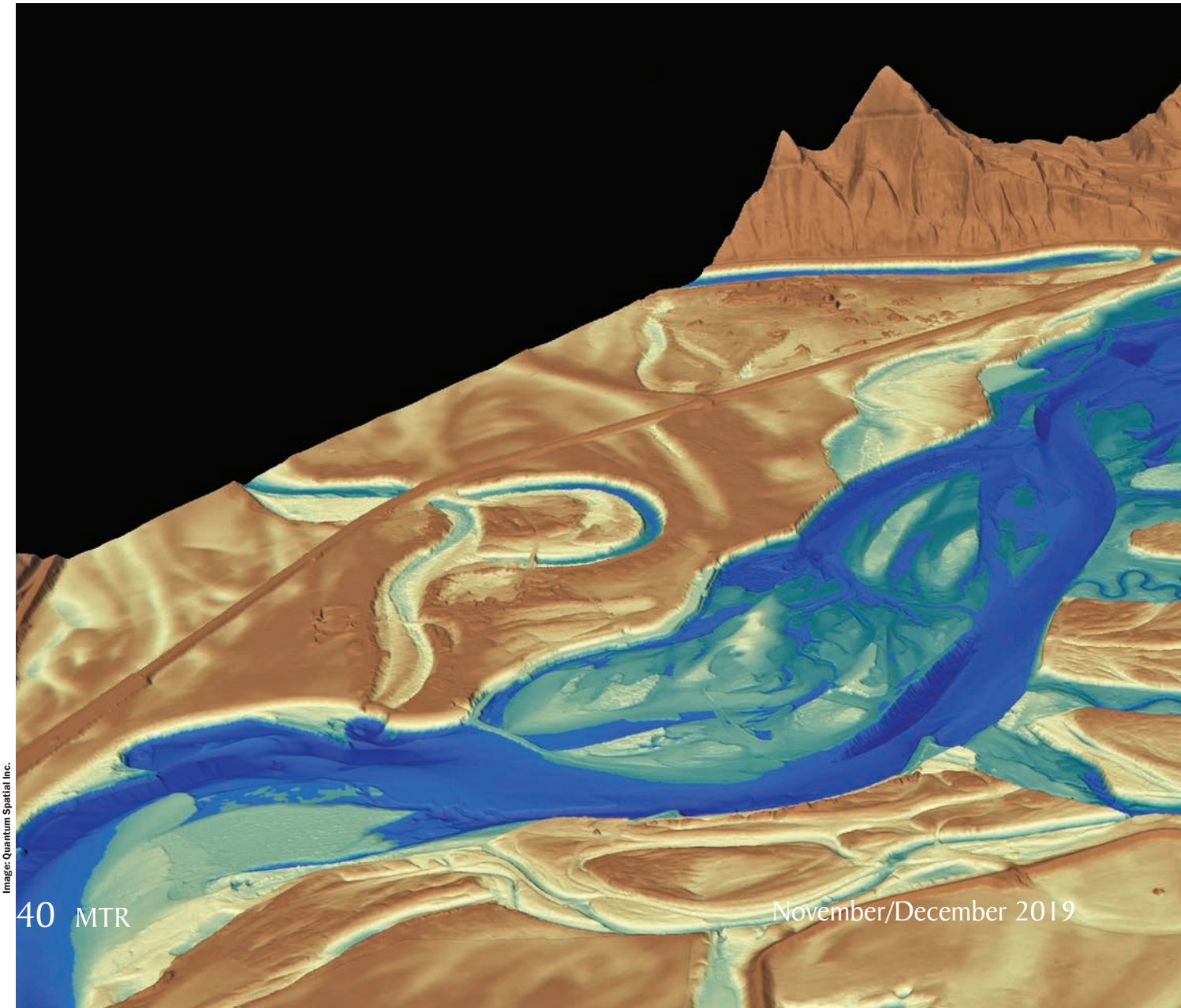


Image: Quantum Spatial Inc.

Boat-mounted sonar has long been the technology of choice for gathering bathymetry data for inland waterways, but it isn't ideal for riverine environments. As a result, the GIS community has faced significant hurdles when they try to model submerged terrain with the same accuracy and resolution that they can achieve in deeper water or using remote sensing for terrestrial landscapes.

Advancements in remote sensing – including use of topo-bathymetric lidar combined with hyperspectral imaging – are showing great potential in addressing these historical challenges. And, in the process, the first applications of these technologies are changing the ways rivers and inland waterways are modeled, and delivering valuable new insights into water resource management and aquatic habitats.

Exploring the Kootenai River

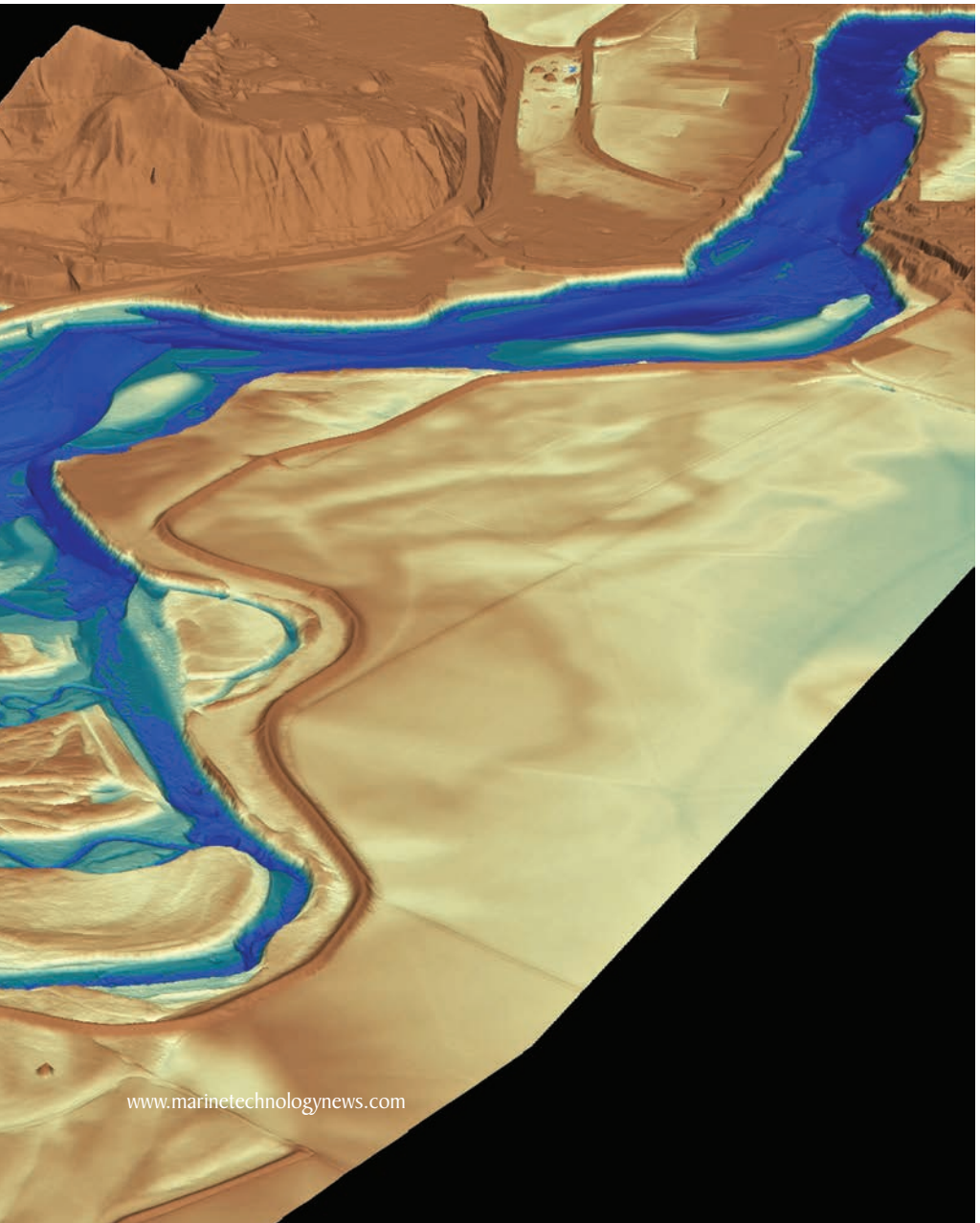
The Kootenai River flows from its headwaters through a rugged region of southwestern Canada, Montana and Idaho, before meeting the Columbia River 500 miles later. The watershed drains a 19,000-square-mile area, spanning six different biomes that provide drinking water and agricultural irrigation, and support a rich variety of flora and fauna. Given that fish, wildlife and humans all rely on the Kootenai River, it has become a hotbed of research on fluvial processes, species protection, habitat enhancement, restoration and flood dynamics for a collection of scientists, environmental groups, tribes and local communities.

In 2017, as part of the Inland Bathymetry Research Project (IBRP), the U.S. Geological Survey (USGS) contracted Quantum Spatial Inc. (QSI) to do a collaborative study examining applications of remote sensing for more effective analysis of shallow water floodplains and riverine environments. With research and restoration activities underway along the Kootenai River, USGS identified this area as a perfect pilot site for evaluation of topo-bathymetric lidar to characterize fluvial patterns and processes, identify optimal conditions, and standardize collection and processing techniques.

Creating a New Remote Sensing Platform

QSI was tasked to collect and process lidar for bathymetric data, co-acquired natural color imagery for ancillary information, and hyperspectral imagery for depth and flow modeling across a 54-mile stretch of the Kootenai River in Northern Idaho. With this pilot program, the USGS hoped to gain better insights into the river and evaluate the potential large-scale commercial value of new techniques for mapping inland bathymetry.

They hoped to increase efficiency and significantly reduce cost by combining all three remote sensing technologies into one aircraft for a single deployment. But doing so created challenges

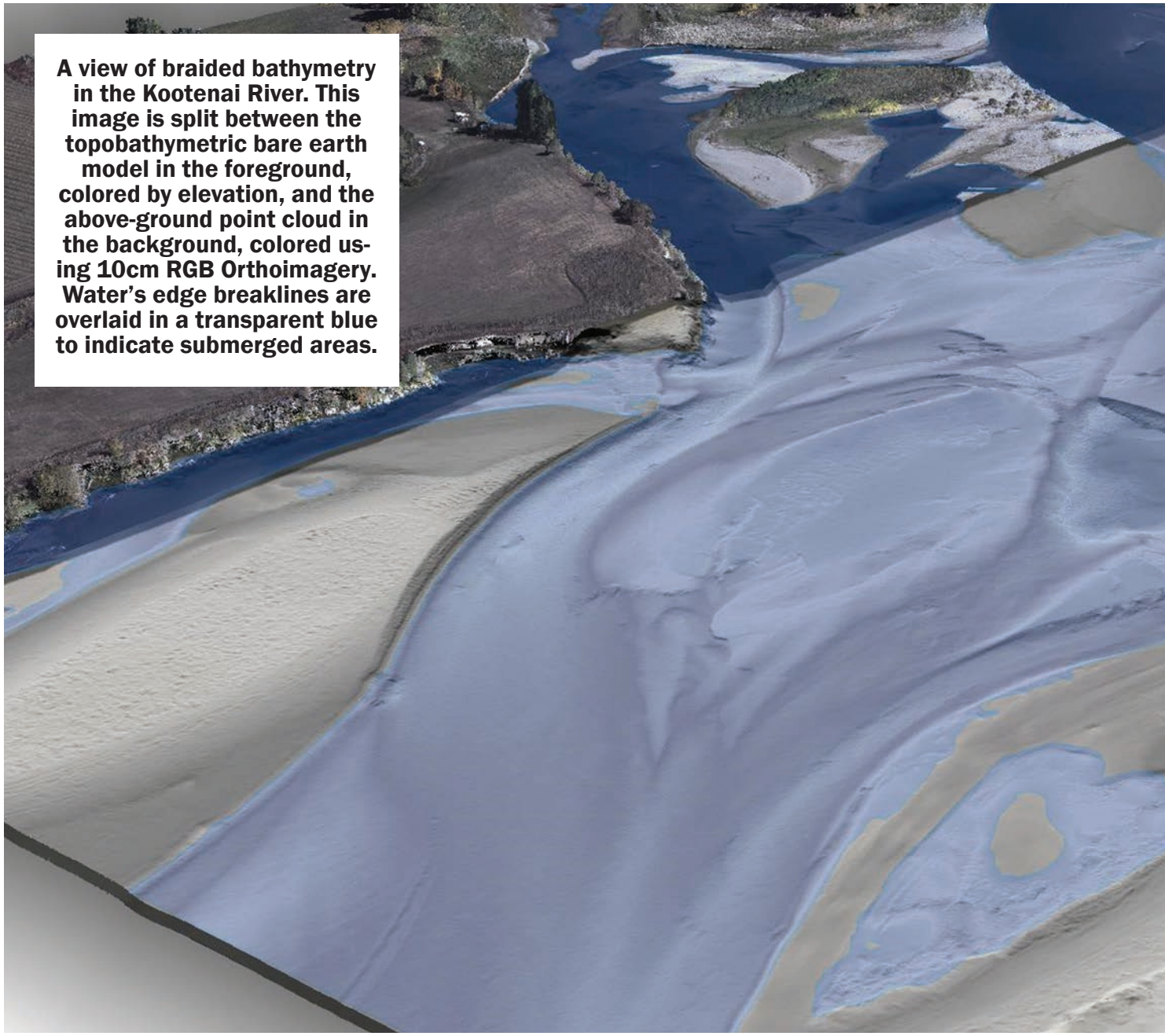


An integrated LiDAR-derived topobathymetric model showing the extensive river braiding depicting both bare earth (brown) and subsurface bottom (blue) terrain.

for the flight team because they needed to collect three disparate types of data within the same timeframe.

The deployment required outfitting and installing the hyperspectral sensor with the topo-bathy lidar (and camera) sensor into a single two-hole aircraft. To create this single airborne platform, QSI relied on the Riegl VQ-880-G topo-bathymetric lidar sensor with an integrated 29MPixel Prosilica GT6600 digital camera, and an ITRES CASI 1500H hyperspectral imagery sensor provided by USGS. The project was among the first riverine area of interest to test the then new 1.5 Secchi Depth Riegl VQ-880-G system settings and performance for modeling Pacific Northwest rivers. The lidar sensor was set to collect data at QL1 pulse density of 8 pulses/m2 for topographic surfaces, and at least 2 pulses/m2 for bathymetric surfaces. The natural color imagery was co-acquired with the lidar at 10 cm GSD, and the hyperspectral imagery was collected at 50 cm pixel resolution.

With sensors installed on the aircraft, QSI then had to evaluate and optimize flight plans for the altitude, field of view and swath width required to meet speci-



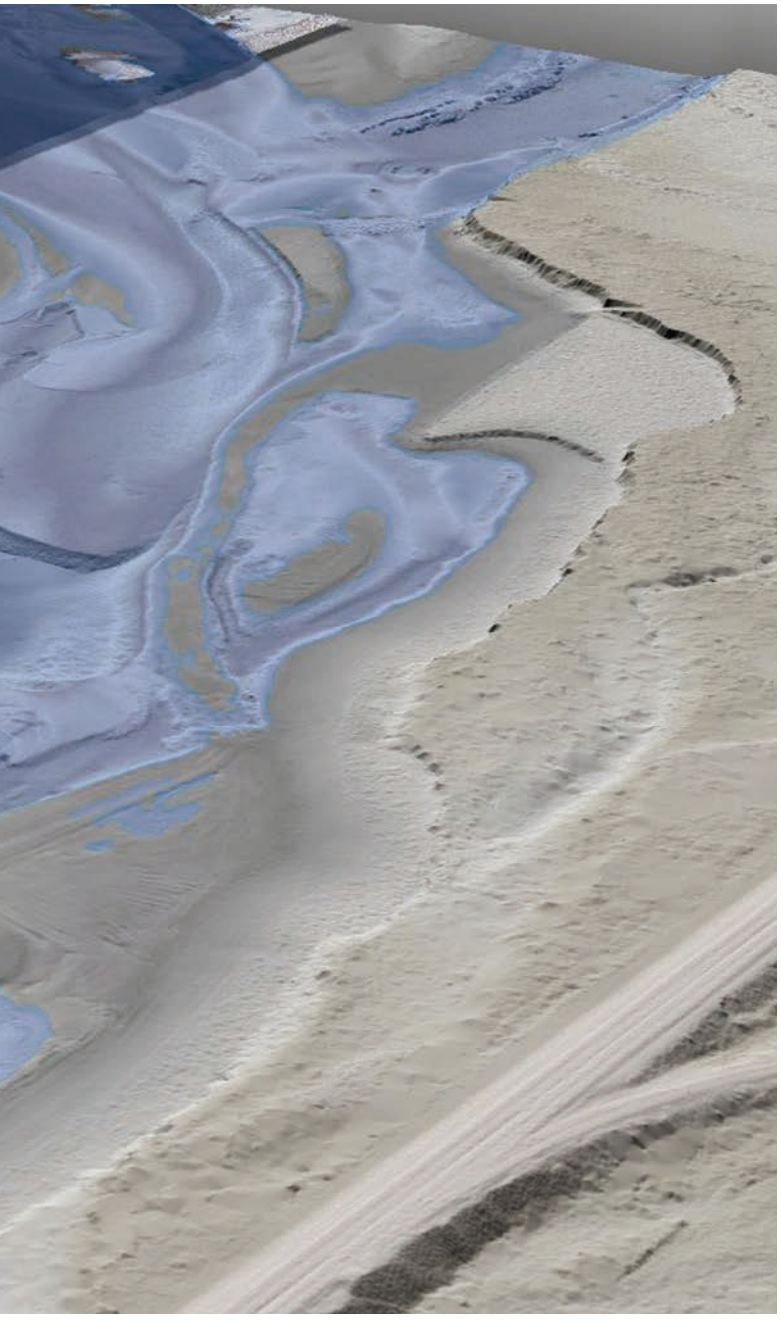
A view of braided bathymetry in the Kootenai River. This image is split between the topobathymetric bare earth model in the foreground, colored by elevation, and the above-ground point cloud in the background, colored using 10cm RGB Orthoimagery. Water's edge breaklines are overlaid in a transparent blue to indicate submerged areas.

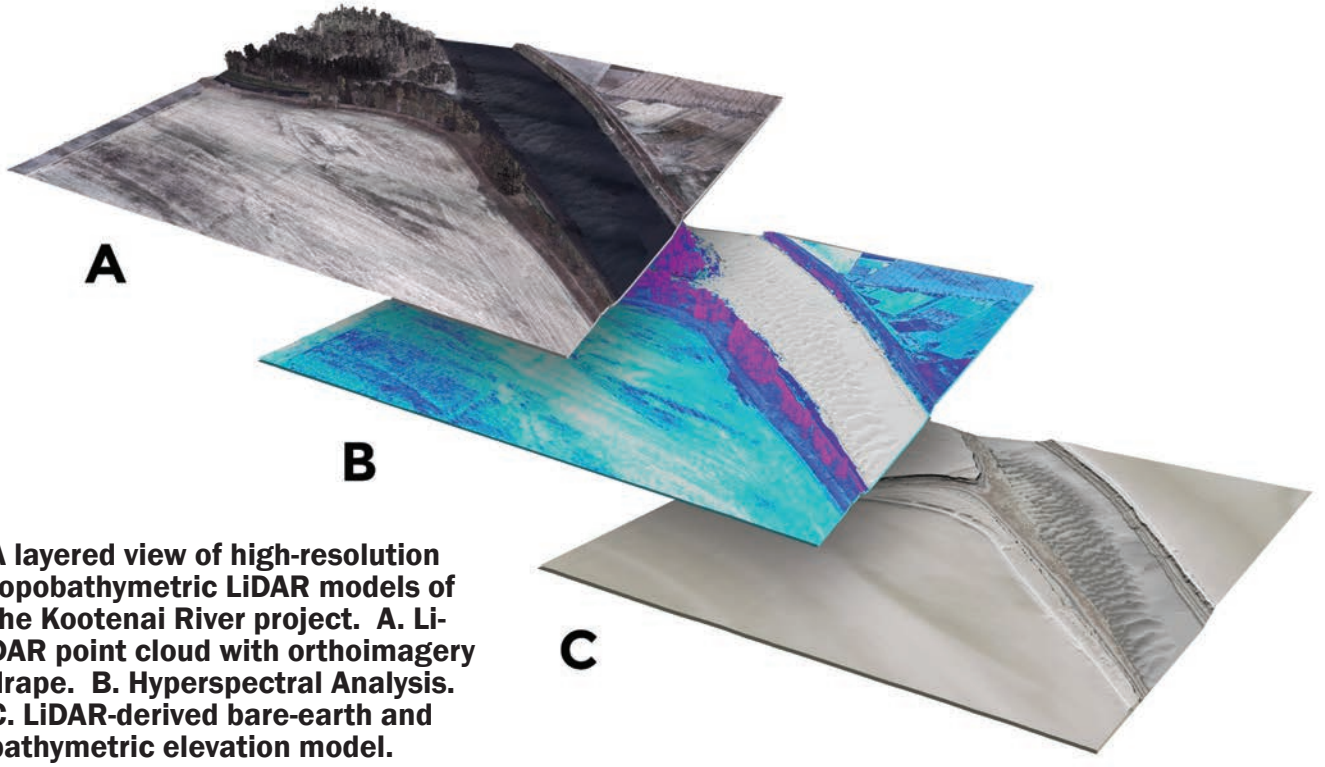
Image: Quantum Spatial Inc.

fications for terrain resolution.

Collaborating on Bathymetry Data Collection

The Kootenai project had only a seven-day acquisition window in late September, and required close collaboration among a variety of stakeholders, including USGS scientists, University of Wyoming (UW) fluvial geomorphologists, River Design Group (RDG) restoration engineers, and QSI's team of project managers, acquisition managers, flight team, ground crew and lidar technical experts. During this short





A layered view of high-resolution topobathymetric LiDAR models of the Kootenai River project. A. LiDAR point cloud with orthoimagery drape. B. Hyperspectral Analysis. C. LiDAR-derived bare-earth and bathymetric elevation model.

Image: Quantum Spatial Inc.

time, the multiple partners needed to coordinate and collect all ground and airborne data in the proper order, while also navigating potential weather concerns.

Hyperspectral imagery was going to be collected after release of a red tracer dye into the river, which would help researchers understand drift patterns and larval fish dispersal. However, since the dye would likely impact water clarity, QSI had to collect lidar first. In addition, all ground operations – measurements for turbidity, setting hyperspectral targets for ground control, release of the dye, setting lidar terrestrial and submerged quality assurance (QA) points and waveform targets, and collecting verification depth profile and cross section data – had to be carefully timed and orchestrated with respect to each other and to the airborne flights.

Another issue impacting the survey was RDG's channel bed dredging operation upstream of the Kootenai project site. RDG had to halt its work there for 48 hours before and during the lidar collection to ensure there was no impact on turbidity from sediment disturbance.

With ideal weather conditions and all partners coordinated, the QSI acquisition team collected more than 20,000 acres of topo-bathymetric lidar data and orthoimagery within a two-day window, then 12,851 acres of hyperspectral imagery two days later.

Remote Sensing Results

This pilot program advanced the understanding of how topo-bathymetric lidar can be leveraged for more widespread use. It also furthered the understanding of Kootenai River ecology and showed how these technologies could be applied in other riverine environments.

Key takeaways from the project included:

- **Flood risk and management strategies –** Local natural resource and planning managers of the Kootenai River watershed were able to gain a valuable understanding of flood risk, erosion and sedimentation patterns. High-resolution flood maps from bathymetric data improved insights into the impact of floods, flood risk and inundation patterns to improve community preparedness and resiliency for the Kootenai River watershed, a USGS Water Mission Area priority area under the Flood Inundation Mapping Program.

- **Restoration projects –** The work supports existing Kootenai Tribe habitat restoration projects and is expected to be useful for future restoration project design, implementation and biological assessment.

- **Dam-related impacts –** Results from the survey can be used to foster a better understanding of sedimentation, instream and dam-related sediment movement patterns, erosion, slope fail-

ure, geophysical impacts on water quality and fish habitat, and stream bed evolution.

• **Fish habitat and local ecology –** The project supported work being done by the Kootenai River Habitat Restoration Program and other ongoing fishery research studies in the region. The lidar and hyperspectral data also provided invaluable insight into the ecology of the Kootenai River, including aspects of flow dynamics, connectivity and channel characteristics that define habitats for recreational, threatened and endangered fish species, such as sturgeon and burbot. Moreover, the hyperspectral imagery and dye dispersion patterns revealed drift and flow dynamics that were helpful in understanding thermal dynamics, tracking pollutants, tracing nutrient drift patterns and following the passive migration of larval fish. Armed with new data, biologists and natural resource managers could better understand the speed and distribution of fish as they move downstream from Kootenay Lake in British Columbia. And, with new insights into the river's geomorphology, fisheries biologists and restoration professionals can now take more targeted efforts toward helping restore in-stream habitat for fish.

• **Predictive modeling –** The project has contributed accurate channel-geometry data as input to flow, sediment transport, and river-bed evolution models developed by the USGS, U.S. Army Corps of Engineers and U.S. Bureau of Reclamation.

The Kootenai River topo-bathymetric lidar project provided almost complete bank-to-bank coverage of braided and shallow bathymetry areas at a high-spatial density that will help fill critical data gaps in 2D and 3D hydrological modeling applications. The success has led the USGS to determine that when collected under optimal water clarity, topo-bathymetric lidar can be a cost-effective and more accurate method for surveying riverine study areas compared to traditional methods. And with this accuracy and detail comes a variety of new insights water, environmental and aquatic habitat management never before possible.

The 'New Normal'

By Eric Haun, Managing Editor, *Offshore Engineer*

The "new normal" is a phrase tossed around often in offshore energy circles as those servicing and operating in the sector grapple with the harsh realities of the prolonged industry downturn. Operators, service companies and equipment suppliers have been forced to adjust to oil selling at prices well below the $100+ per barrel mark seen in years past. As of this writing, Brent oil was hovering around $62 per barrel, and analysts expect prices will remain in this range for some time into the future.

On top of this, there's another new reality for oil and gas companies to come to grips with: the so-called "energy transition". Increasingly, more environmentally conscious governments, societies and investors are piling pressure on the industry and calling for emissions reductions and a shift toward renewable energy.

The industry has taken notice – and action. Oil and gas giants Shell and Equinor, for example, are taking part in developing renewables projects such as offshore wind farms. Claudio Descalzi, the CEO of Italian oil major Eni, said in October that he sees no future for firms focused solely on hydrocarbons.

In fact, many of the sector's biggest names – from the supermajors all the way through the supply chain – have committed to the energy transition. This is good for the environment, but it's also good business.

In the offshore wind sector, many, if not most, of the firms servicing the burgeoning market today have roots in oil and gas. Offshore services companies still hurting from oil's downturn possess the expertise, skillset and technological capabilities aligned with those needed for offshore renewables work, opening the door toward new revenue streams that come with building a greener future. Offshore players such as Saipem, McDermott, Subsea7 and the soon-to-be demerged TechnipFMC, among others, while still heavily involved in oil and gas, have been winning renewables work for years. And their prospects are growing larger.

Europe, the offshore wind leader from the industry's inception, continues to build capacity with a raft of new projects in various stages of development, while Asia and the U.S. are now developing huge markets of their own. The International Energy Agency (IEA) said in an October report that the offshore wind capacity may increase 15-fold and attract around $1 trillion of cumulative investment by 2040, spurred by falling costs, supportive government policies and technological advances such as larger turbines (e.g. GE's 12MW Haliade-X turbine) and innovative floating foundations that are deployable in greater water depths where fixed turbines cannot be installed. And IEA believes the potential for growth is even larger with increased policy-maker support.

Changing of the Guard

While the prospects for renewables are bright, oil and gas still has a major role to play, both at present and into the future. Most analysts agree that demand for hydrocarbons will continue to grow over the next decade or two. This offers a great opportunity for oil and gas players to implement new technologies and low- or no-carbon solutions to be implemented in upstream operations. Importantly, the energy transition encompasses new methods and technologies that will increase efficiency and reduce or even eliminate emissions from hydrocarbon exploration and production. Oilfield services company Baker Hughes, for example, has committed to reducing CO2 equivalent emissions by 50% by 2030 and achieving net zero by 2050. As another example, the Seadrill-operated drilling rig West Mira has been equipped to run on batter power. The list goes on and on.

The shift is undoubtedly a global one, but nowhere is it better showcased than in the North Sea. While those working in the region are already among the most experienced and technologically advanced in the world, a recent report from PwC and Oil & Gas UK finds that innovation and technology, collaboration between operators and the supply chain, and partnership models are crucial to the changing of the guard presently underway, especially as a number of new low carbon solutions continue to gain traction.

The report, *Turning the Tide – the Transformation of the North Sea*, published in November, says that fresh thinking and innovative solutions for driving performance are needed, especially after years focused on cutting costs. A supply chain that cannot sustain further tightening should focus instead on

Image: Equinor)

Equinor's Hywind Tampen project will use floating wind turbines to provide power to the Snorre and Gullfaks oil and gas production facilities.

value over cost, the report suggests, though this will require operators and services firms to adjust their mindset.

Companies now believe it is critically important share their experiences of the deployment of new technologies, collaborate on developments and piloting, and engage more closely with the supply chain to reduce risk and the length of project timelines, the report found.

The PwC and Oil & Gas UK report also predicts an increased focus on technological and business model innovation to drive the next wave of competitiveness given operators and service companies have perhaps cut costs as far as is sustainably possible. New ideas, such as Equinor's Hywind Tampen project, for instance, will help deliver the energy transition. In the Norwegian sector of the North Sea, the Hywind Tampen project will see 11 floating wind turbines deployed as to replace gas turbine power for the Snorre and Gullfaks oil and gas production facilities.

Other emissions cutting solutions such as electrification of production assets and unmanned platforms are also high on the agenda, including that of Norway's largest oilfield services company Aker Solutions, who announced in October that it aims to generate half of its revenue from renewable energy and low-carbon technologies (such as carbon capture and storage, subsea gas compression, floating wind farms, electrification, etc) by 2030.

A lot of hydrocarbons

In October 2019, the mega Johan Sverdrup field began production more than two months ahead of schedule and NOK 40 billion ($4.4 billion) below original estimates, thanks in part to innovative technologies and collaborative methods led by operator Equinor alongside partners Lundin, Total, Aker BP and Petoro.

The largest development in Norway for three decades, the field is expected to produce for more than 50 years, tapping expected recoverable reserves of 2.7 billion barrels of oil equivalent. Once full field production is underway, Johan Sevrdrup will be able to produce up to 660,000 barrels of oil per day at peak. Simply put, that's a lot of hydrocarbons. But, leveraging electricity power from shore, the field has record-low CO2 emissions below 1 kilogram per barrel – demonstrating the importance of technological innovation toward the energy transition, and how the oil industry still has work to do and an important role to play.

Meet the Sea Ox

An amphibious crawling vehicle is designed to prevent people from having to work in the dangers of the surf zone and allow operations to continue in hours of darkness and in more inclement weather conditions.

The Sea Ox and the smaller Sea Otter, both developed by C-2 Innovations, have a maximum depth of 100m and can operate autonomously or under remote control. The rugged Sea Ox, which recently survived 6ft surf and 2kn tidal stream in Californian user trials, has a wet range of 10NM, a dry range of 24NM and can conduct station keeping to collect longer term static environmental observations, or observations at discrete points.

The crawler has a low center of gravity and its large working deck has access to vehicle power and data, allowing a large variety of sensors to be integrated or carried as independent sensors. Past payloads have included cameras, forward looking sonar, CTD, sidescan, penetrometers, vibracores, and turbidity sensors, as well as EM technologies towed behind on a non-metallic sled.

This summer, C-2 Innovations hosed a Sea Ox demonstration in Jacksonville, Fla. attended by MTR and representatives from USACE Jacksonville and various survey, environmental and dredging companies. Attendees were given an opportunity to pilot the vehicle in and out of the water using the handheld controller. Three beach profiles were run using GPS autonomy, and later a state profile line was run. The Sea Ox, which can pressure sensor based bathymetric data, was also-equipped with a Nortek ADCP and AML turbidity and sound speed sensors.

The vehicle can be used in autonomous mode using inertial systems or GPS, and can be driven using RF antenna, RF buoy or using a tether. Trialed this summer at ANTX, the inertial system achieved a misclosure of 3.38m after a 2,813m mission with 44 turns.

C-2 Innovations said Scripps Institution of Oceanography has had one of its vehicles in use for four years, and USACE North Carolina FRF has a contract to purchase one.

Nick Townley, business development, C-2 Innovations, with the Sea Ox.

Photo: Rob Howard, MTR

Robotic Hull Cleaning

The robotic hull cleaning system recently received a big boost to its business when the Dutch national regulatory body Rijkswaterstaat gave the Norwegian company the green light to start offering hull cleaning services to vessels at all Dutch Ports including Europe's biggest port, the Port of Rotterdam. The move is helping the firm solidify its position in Europe following similar permissions in Antwerp, Zeebrugge, Ghent and Southampton.

"Ports want evidence that our system works," said ECOsubsea CEO Tor Østervold. "We can now give it to them. They also want evidence that vessels have active hull biofouling plans, and we are helping operators and ports with the digital implementation of that too," he added.

ECOsubsea's system works by having a robotic cleaning system, move over a ship's hull, gently removing the fouling off the hull without damaging the vessel's hull coating. This is an important factor for ports that are increasingly concerned that heavy metals and microplastics, which are often found in hull coatings, may contaminate their waters when hulls are cleaned.

The cleaning and suction system then draws the fouling detritus ashore or onto a barge, where it is filtered out of the water and sent ashore for processing. Tests by ECOsubsea and seen by the ports that are keen to see the system used, show that virtually all of the detritus taken off the hull will be sent ashore.

"At the end of last year we were only in Southampton," adds Østervold. "Now we are in a growing number of ports including Amsterdam and Rotterdam."

For Østervold, a giant port such as Rotterdam, with a strong environmental benchmark, is an important step in the evolution of the company.

The port of Rotterdam's Breakbulk Business Manager Irene Bennett points to the role the Authority plays in generating a healthier environment, primarily concerning air quality, noise and the natural environment and biodiversity and water quality.

"We recognize that efficient cleaning of ship hulls is better for the water quality in the port and reduces CO2 emissions and fuel costs," she ado. "The advantages of initiatives like ECOsubsea will enhance the sustainability of the entire transport chain. The Port of Rotterdam is therefore happy to promote initiatives that fit in well with our corporate social responsibility goals."

To help owners and operators ECOsubsea urges owners to be proactive and have a system in place to help operators determine the best time to undergo a cleaning. "While onboard performance systems can detect drops in performance due to hull and propeller fouling, it is often at a point when there is already a visible build up of biofouling on parts of the hull," says Østervold. "Visual inspections of a hull are still an important part of hull husbandry."

Photo: EcoSubsea

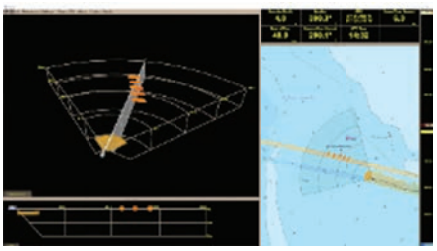


Photo: Farsounder

FarSounder: New 3D Forward-Looking Sonar

FarSounder is proud to debut a new sonar and a new name for its series of 3D forward-looking navigation sonars. With the company's continued growth and focus on research and development, it was time to give the series a name and offer more alternatives. The new name is the Argos series and are now 3 models in the series. The latest model the Argos 350 was revealed for the first time at Ft. Lauderdale International Boat Show.

This new sonar option has all the same applications and quality found in its other navigational sonars. It has been designed with a smaller and lighter transducer and will have a 350 meter range of detection. It is well-suited for mid-sized yachts from 18 - 40+ meters. As in its other two models the Argos 1000 and Argos 500, the design allows for an easy, fixed installation. The Argos 350 however offers another alternative as well. It can be connected to a hoist in a 10-inch diameter sea chest.

"The creative FarSounder team has worked tirelessly to provide a smaller and lower-cost solution for mid-sized vessels. This was a goal of ours for many years," FarSounder's CEO, Cheryl M. Zimmerman, explains. "Ultimately, we are elated to bring our forward-looking sonar to a wider market without compromising on the quality our customers have come to expect from our innovative Forward Looking Sonar systems."

As the leader in 3D Forward Looking Sonar technology, FarSounder has kept the yachting community safe from shallows and in-water obstacles since 2005. In introducing the Argos 350 to this new market, these smaller vessels can now enjoy FarSounder's 3D real-time software and navigate with confidence.

New Tech: Automatic Calibration of Sea State Data

Availability of reliable, real-time ocean surface data can improve the safety, efficiency and performance of offshore and marine operations, as well as coastal monitoring, but the quality of the data is dependent on accurate calibration.

Calibration of wave spectra and integrated wave parameters from radar-based measurement systems has historically depended upon external reference sensors, such as wave buoys, which can present a number of challenges.

Miros' ocean surface monitoring systems support fully automatic calibration, providing the user with high-quality wave and current parameters for a broad range of radar types and measurement conditions, without the need for manual calibration, helping to reduce installation and operational costs.

"Imagine having purchased a leading wave measurement system, only to be told that you need access to an additional system to calibrate the one you just bought," says Miros COO Jonas Røstad. "The calibration process involves considerable logistics, additional costs, and can take weeks if not months to complete, impacting your timeline and your budget." Miros' algorithms automatically calibrate for accurate measurement of ocean state parameters. In fact, all of Miros' radar-based sensors are able to calibrate automatically. Local, real-time ocean surface measurements can improve vessel and structure fatigue assessments, provide input to bridge and decision-support systems, as well as to marine, crane and loading operations, and help to optimize fuel consumption, route planning, cargo safety, passenger comfort, and coastal monitoring too.

WASSP: Launching a new Multibeam Sounder

WASSP Multibeam launched a new rapid deployment multibeam sounder – the W3 Rapid Deployment System (RDS), designed for Navy's, Maritime Police and Search & Rescue organizations.

When a fixed transducer installation in a small vessel such as a tender isn't always practical, the W3 RDS has been designed around a portable Carbon fiber Mast that includes a transducer, motion sensor and satellite compass. This lets operators deploy the unit over the side or the transom of the vessel into the water quickly and easily often in just minutes.

Once deployed, W3 RDS can quickly and effectively profile the seafloor and water column in search of sunken vessels, aircraft or vehicles. Or it can be utilized in events like cyclones, hurricanes, volcanic eruptions, earthquakes or war disasters which can alter the seafloor in such a way as to make navigation unsafe for support vessels.

When in operation, W3 RDS uses a wireless link or a naval secure communication system to send real-time seafloor map data back to the mothership bridge system and display via a WASSP CDX display software or MaxSea navigation plotting platform - all in real-time.

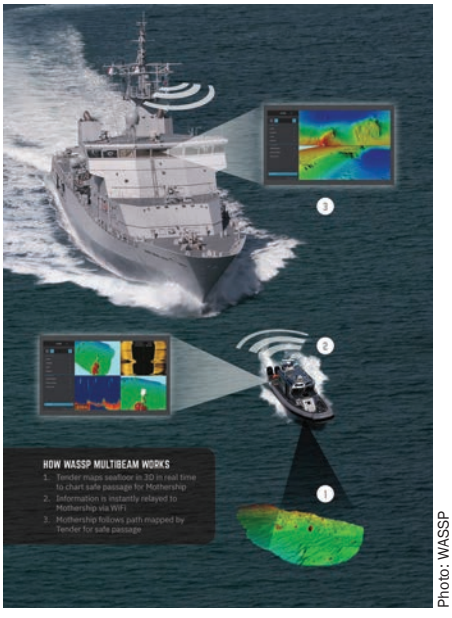


Photo: WASSP

AUMD: *Autonomous Dredging*

As autonomy gains a foothold in the maritime world, dredging appears next in line to transition to operations without direct human control. A new design concept unveiled by C-Job Naval Architects aims to deliver power savings and a larger working window for port maintenance dredging operations.

The Autonomous Underwater Maintenance Dredger (AUMD) design is a completely submerged dredging vessel specifically created for maintenance in port environments. According to C-Job, the fully electric design presents a more sustainable option when compared to conventional dredgers as it requires significantly less power. Equipped with a zero-emissions 16MWh battery pack, the dredger packs enough power for up to 12 hours of maintenance dredging in shallow waters. The design features fully redundant propulsion both in power supply as well as azimuthing- and bowthrusters.

A power/speed prediction comparison study with a conventional trailing suction hopper dredger showed that the AUMD requires 55% less propulsion power, said Rolph Hijdra, Autonomous Vessels Research Lead at C-Job. “And by submersing the vessel we could reduce the suction head cutting the dredge pump power demand by 80%.”

C-Job attributes the propulsion efficiency gains to mitigated wave-making and -breaking resistance, while improved dredging power demand is the result of the reduced suction head of the dredge pump (which is reduced from nearly 35 to six meters).

Submersion also increases operability as it mitigates wave motions as the vessel’s able to remain submerged throughout the dredging cycle. The AUMD only needs to surface for repair, maintenance and charging its batteries. The hull shape allows for operations near the seabed with the flat bottom cross section, and the depth of the vessel is limited to only 8.5 meters which enables it to operate in shallow waters.

The AUMD features the same hopper volume as the traditional dredger even though the overall length of C-Job’s design has been reduced by 20%. And due to the fully buoyant hull, a higher payload over main dimension ratio is obtained.

Power efficiency and operability gains ultimately lead to greater profits, Hijdra said. “Autonomous shipping provides enormous potential for ship owners, with both technical design and economic benefits. According to our research, even with a conservative approach, we found that with the AUMD ship owners can expect nearly twice as much profit after 15 years.”

Hijdra said initial investment is higher, but lower operational costs make AUMD worth considering.

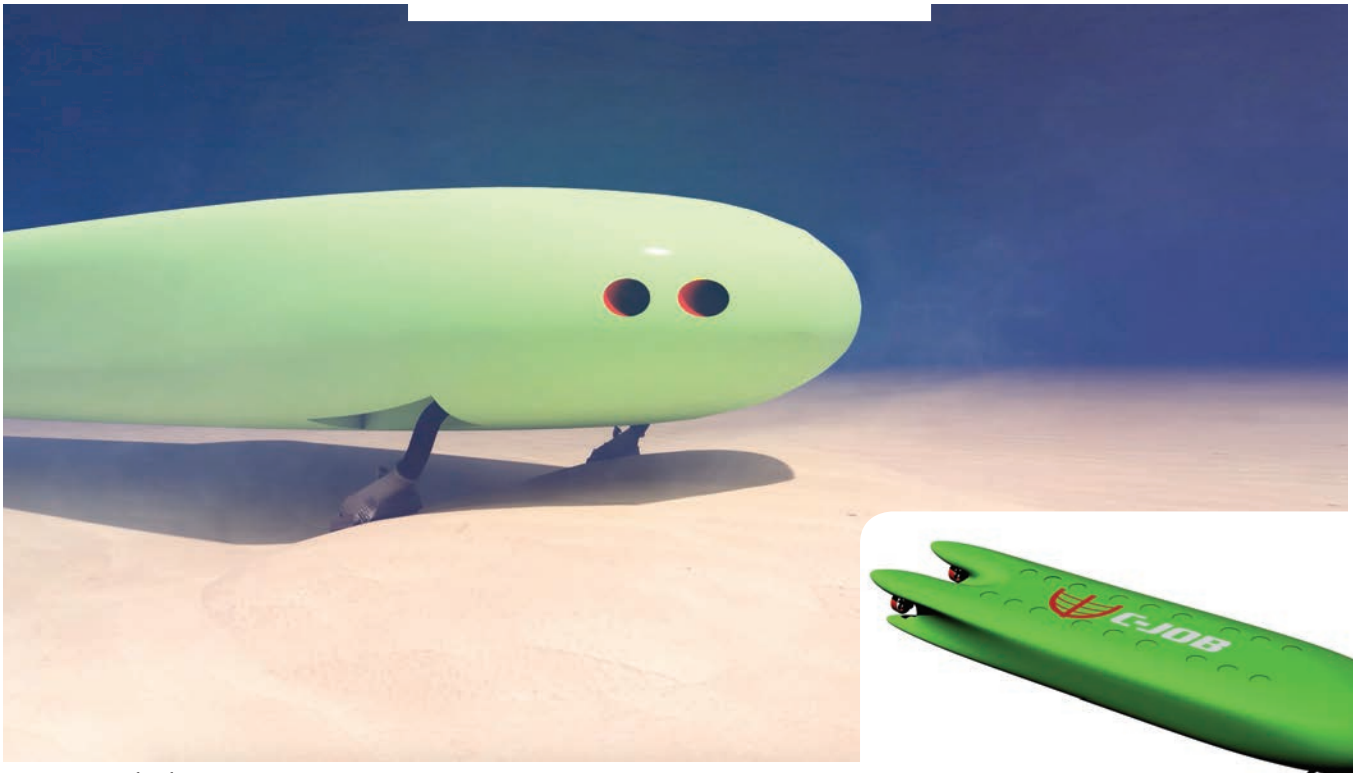


Photo: C-Job Naval Architechs

Prolonging Wellhead Fatigue Life

By Jennifer Pallanich

When oil and gas operators need to carry out workovers or plug and abandon a deepwater well, a primary concern is how much fatigue life remains in the wellhead.

Wells from two decades ago were drilled and completed with rigs that may have been decommissioned, and the newer rigs with their heavier blowout preventers (BOPs) place more load on the wellhead than it was designed to bear.

"This would be using up the fatigue life of the equipment much faster than it was designed for," says Kevin Chell, vice president of Trendsetter Vulcan Offshore (TVO).

In fact, it can be challenging to estimate the remaining fatigue life, he says. It involves creating a model of the well and tracking the weather during operations to determine how much the BOP moved. "It's hard to reconstruct a well history and convert it into fatigue life," Chell says.

There are a couple of ways to solve the problem – one is strengthened wellheads, but that only applies to prevent future problems on new wellheads, and the other is to find a way to stop the BOP from moving as much, he says.

He says changing the frequency of the BOP motions, achieved by tethering the BOP, can reduce fatigue significantly.

"You'll still accumulate fatigue damage. You can't get away from it," he says, but data reflect up to 1,000 times reduction.

The tethering technology was developed in 2012 by TVO for an operator with wellhead fatigue issues that needed to be resolved.

The tensioner component of the wellhead fatigue mitigation system placed on the seabed.

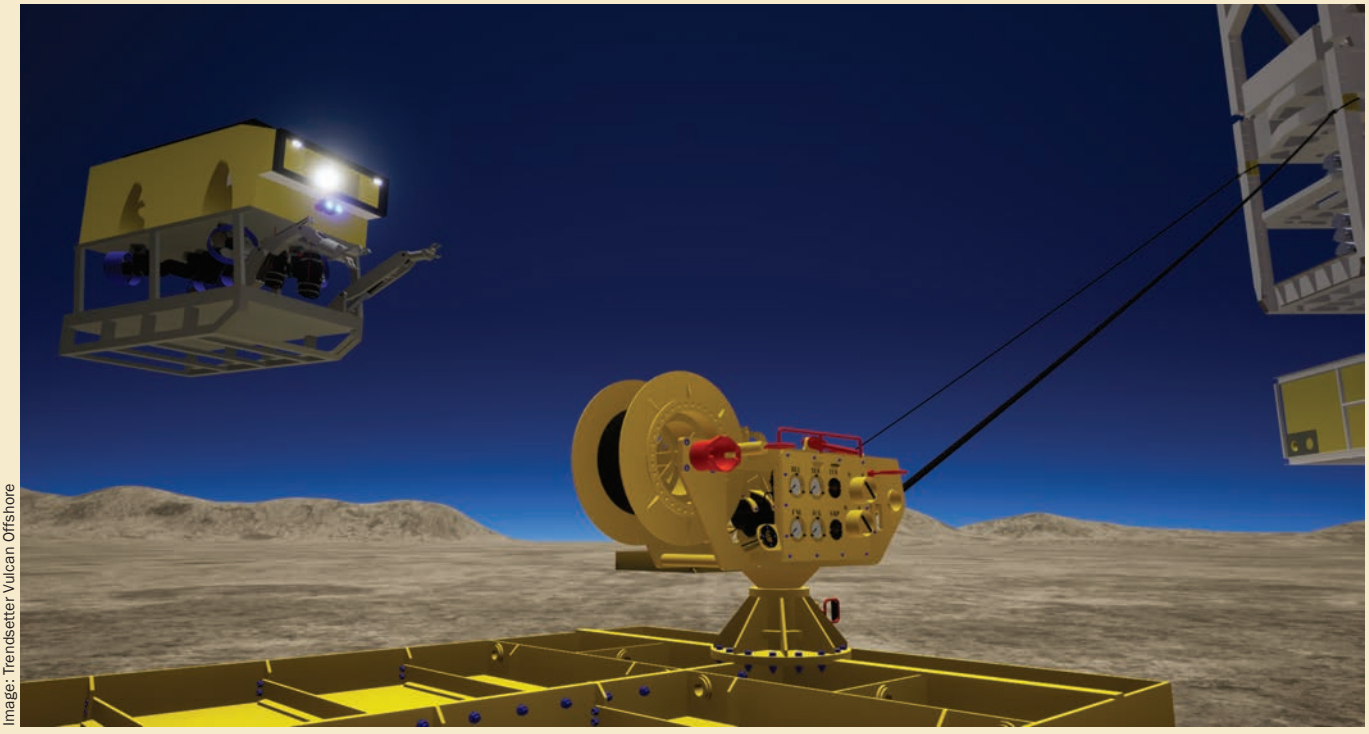


Image: Trendsetter Vulcan Offshore

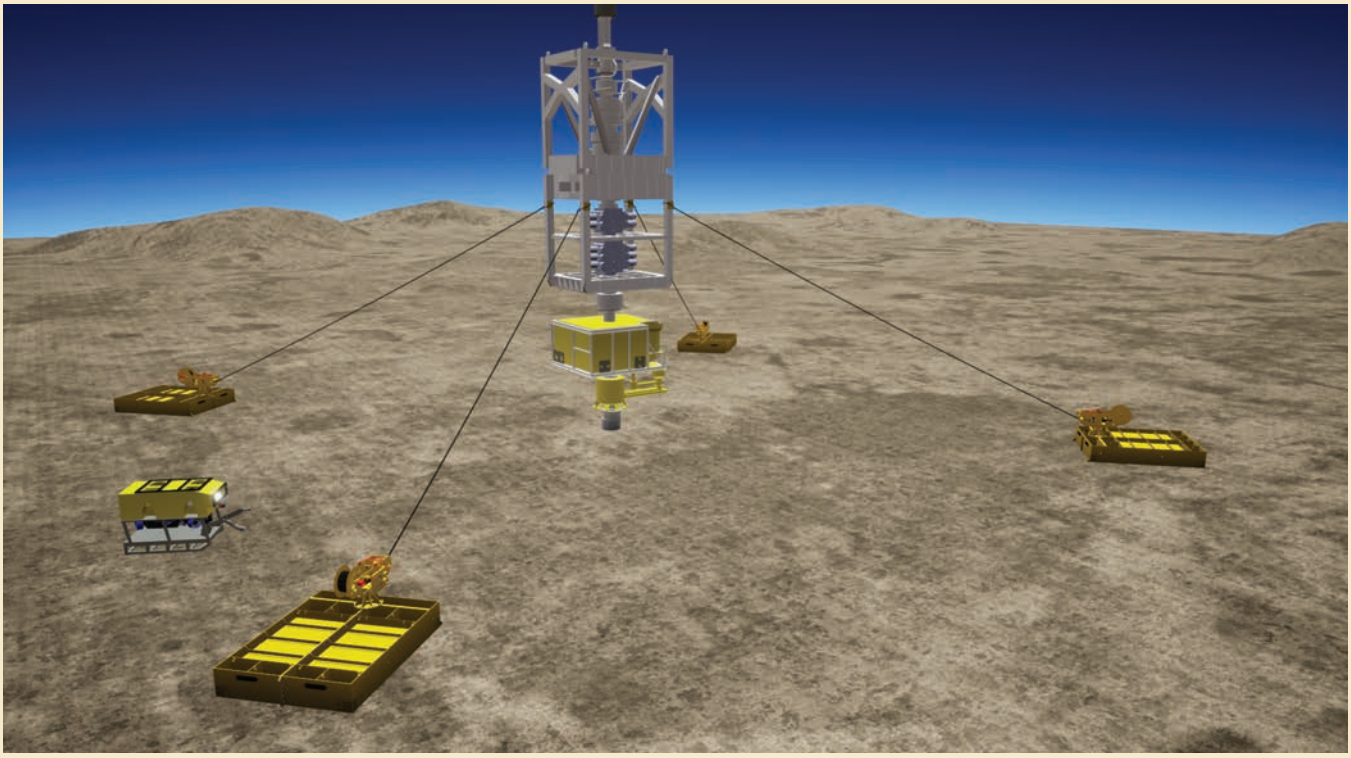


Image: Trendsetter Vulcan Offshore

An artist's rendering shows a typical tethered BOP installation.

The Wellhead Fatigue Mitigation System uses four anchors to provide foundations for the tensioner units, tensioners that mount onto the anchors, connection points on the BOP, and a BOP/riser monitoring system. The monitoring system comprises SMART unit sensors mounted onto the BOP and lower riser, which measure acceleration and angular velocity and transmit the data to a hydro-acoustic dunker deployed from the surface. The dunker is connected to a topside computer that uploads data to a cloud-based portal. The software provides analysis of the motions and translates it into accumulated fatigue for the well system.

Chell says the tethering technology also has the potential to mitigate the effects of dynamic positioning (DP) drive-off/drift-off, and so is applicable for operators with a deepwater semi or drillship on contract but also want to work in much shallower water. Tethering will reduce the bending associated with a DP drive-off event and extend the operability of DP vessels into shallower water. The tethering system will also increase the watch circle and allow operators to work in more severe weather conditions, he adds.

"Some operators are also thinking about using this technology for tethering, starting during the exploration phase," he says. "If they monitor and tether from day one and every subsequent time work is done on the well and then translate that to fatigue damage, they'll know exactly how they're using up the fatigue life."

The system has been used on multiple projects by a major operator since 2016, and Tamarind Resources recently contracted TVO to provide its Wellhead Fatigue Mitigation Systems offshore New Zealand.

TVO is a team of engineers with deep experience in floating systems. Jim Maher, who was a spar product manager at Technip for many years and was president at Horton Deepwater, founded TVO.

"If you know what you want to do, anybody can help you. If you have no idea what you want to do, we can usually help you figure that out," Maher says. "For problems that have no apparent solutions, we develop the concept and then deliver."

Brownfield needs are an interesting part of the Gulf of Mexico due to the aging of the floating systems, he says. As tieback technology improves, he expects operators to opt for subsea tiebacks when they can.

"What we're getting involved in is field development planning and component delivery for the riser systems to come onboard existing facilities to provide some secondary recovery," Maher says.

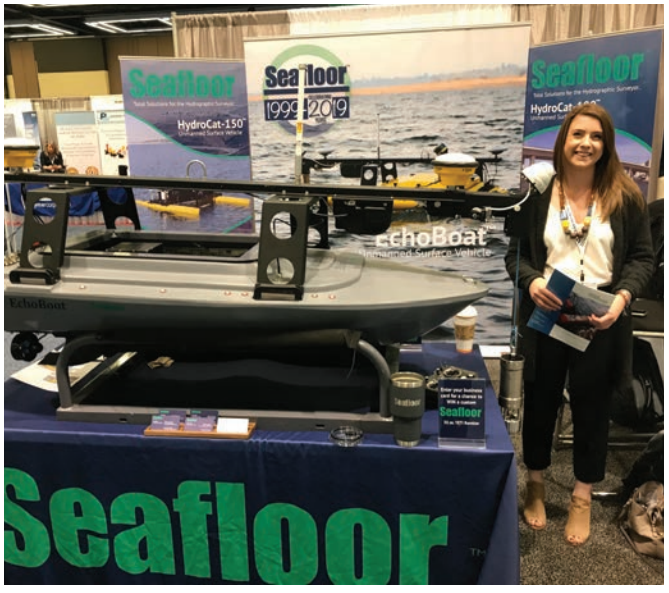
Oceans 2019 in Seattle

Oceans 2019 was recently held in Seattle, Washington, and the event attracted a predictable, high-quality attendance for three days of conference, exhibition and networking. Rob Howard, Mike Kozlowski and Greg Trauthwein were in Seattle for *Marine Technology Reporter,* and on the following pages are a select set of images from the show floor.

All photos *Marine Technology Reporter*.

Aaron Beach & Craig Glover of Chasing Underwater Drones.

Robin Gang Li, President, Seamor Marine and Mike Kozlowski of MTR.



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Bronson Lamb, Marketing Manager, All American Marine

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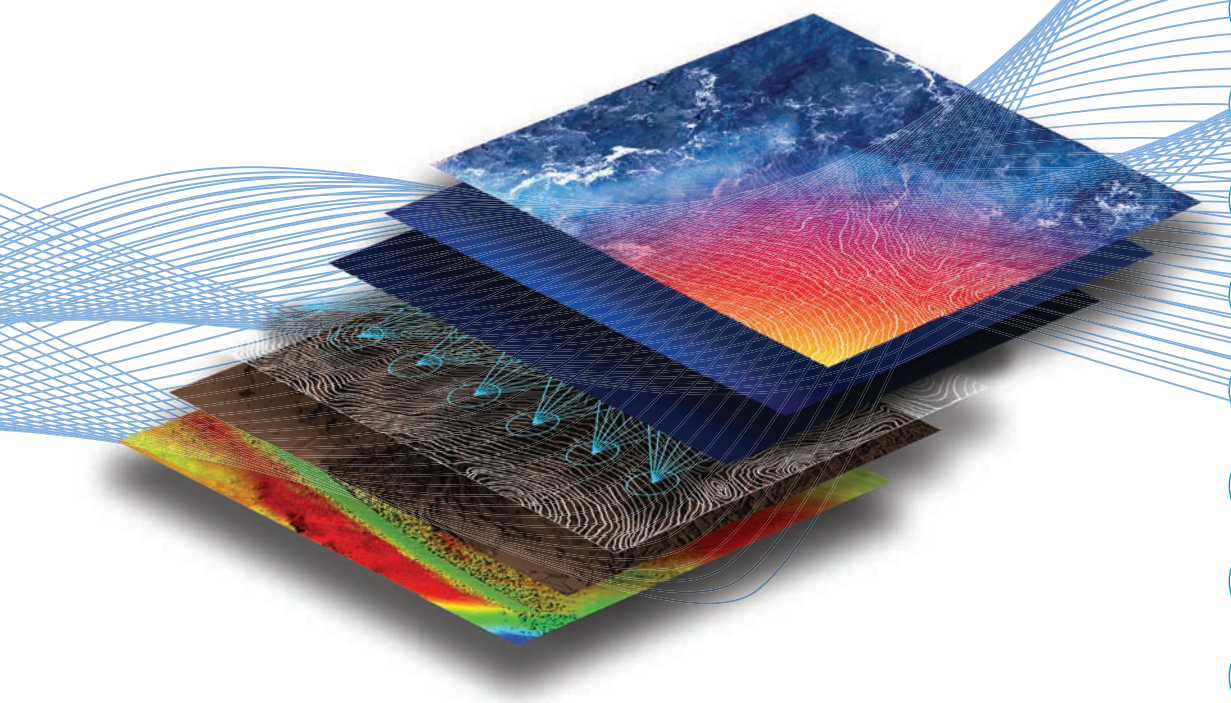

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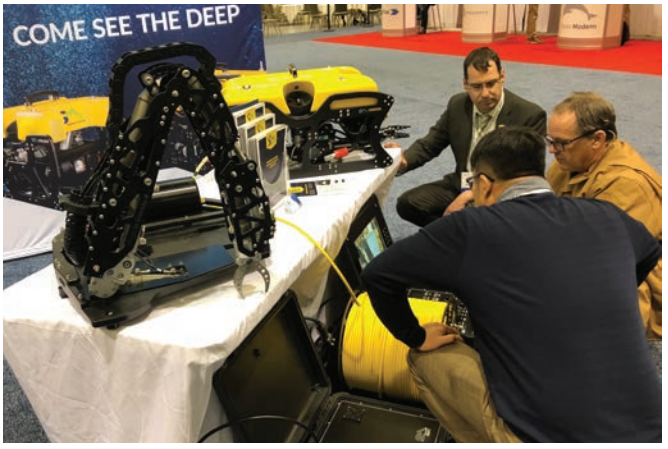
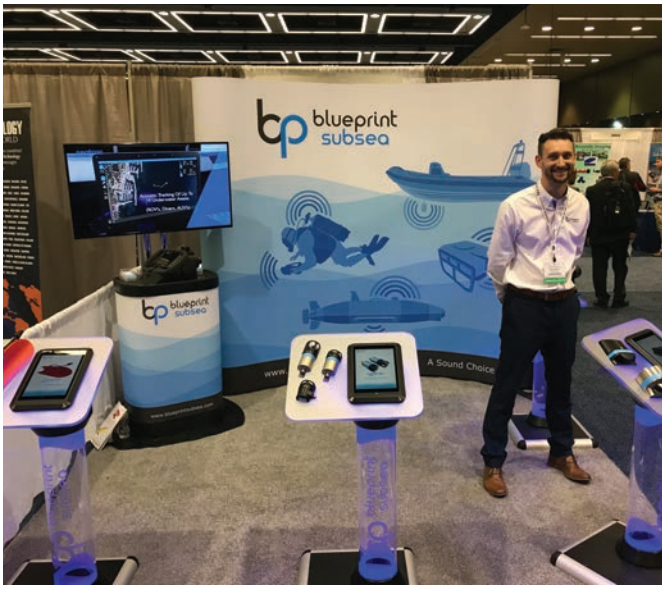


HUA LI, PH. D., GM & Kiyoshi Nikolai Delp, Overseas Sales Dept Ocean & River Instruments, JFE Advantech Co., Ltd.



James Colebourn, Technical Sales Engineer, Blue Print Subsea.

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Marine Technology Reporter is the industry's largest circulating magazine dedicated to the underwater technology and ocean science markets. From the surface to the sub-seafloor, *MTR* provides unbiased news and information on equipment, systems and platforms for use in everything from hydrographic and oceanographic research to defense and renewable energy.

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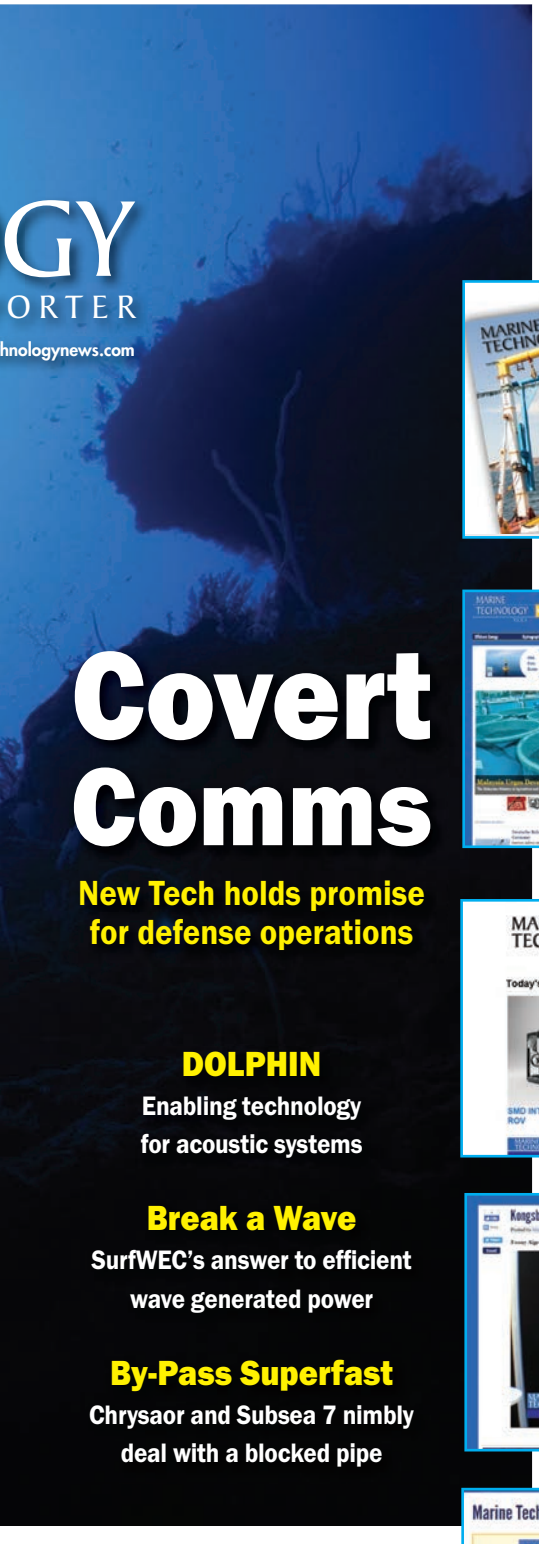

Marine Technology Reporter

The Industry's Leading Publication

MTR provides unbiased news and information from around the world and delivers it to a powerful and highly responsive audience of more than 25,000 recipients. With 100% requested BPA verified subscribers, *Marine Technology Reporter* is the best place for advertising and marketing your company to the global marine science and technology market.

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2020 Editorial Calendar

JAN/FEB

Ad Close: Dec 21

Underwater Vehicle Annual

Subsea Defense Tech

Manipulator Arms and Tools

Autonomous Navigation GNSS MEMS

Unmanned Vehicle Propulsion

Event Distribution

Subsea Expo 2020- Feb 11- 13, Aberdeen
Underwater Defense & Security - Mar 3-5, Southampton
Canadian Hydrograpic Conference- Feb 24-27, Quebec City
Oceans 2020 Singapore - Apr 6-9 Singapore

FEBRUARY

Ad Close: Jan 22

MTR White Papers: Oceanographic

White Paper Electronic Edition Publication Date: February 2020

MARCH

Ad Close: Feb 21

Oceanographic Instrumentation: Measurement, Process & Analysis

Oceanology International New Tech Gallery

Fiber Optic Cables, Connectors & Slip Rings

Marine Drones

Hydrographic Sonar & Software

Event Distribution

Oceanology International - Mar 17-19, London
Sea-Air-Space- Apr 6-8, Baltimore, MD

APRIL

Ad Close: Mar 21

Offshore Energy: Oil & Gas, Wind & Tide

Subsea Electrification

Lights, Cameras, Lasers, Multibeam Sonar

Buoyancy Technology

Scientific Deck Machinery / LARS

Event Distribution

Offshore Technology Conference- May 4-7, Houston, TX
AUVSI XPONENTIAL- May 4-7, Boston, MA

MAY

Ad Close: Apr 21

Underwater Defense Technology

Comms, Telemetry & Data Processing

Hydrophones

Magnetometers & Streamers

Beacons, Flashers & Tracking Systems

Event Distribution

UDT- May 12-14, Rotterdam
Underwater Technology Conference- Jun 16-18, Bergen

JUNE

Ad Close: May 21

Hydrographic Survey: Single & Multibeam Sonar

Research Institutions

USV Platforms

GPS, Gyro Compasses & MEMS Motion Tracking

Interconnect: Underwater Cables and Connectors

JULY

Ad Close: Jun 22

MTR White Papers: Hydrographic

White Paper Electronic Edition Publication Date: July 2020

JULY/AUGUST

Ad Close: Jul 21

MTR 100 - Edition

The 15th Annual Listing of 100 Leading Subsea Companies

MTR looks at 100 leading companies and executives in all subsea disciplines, defense, offshore energy and science.

Event Distribution

Offshore Northern Seas- Aug 31-Sep 1, Stavanger

SEPTEMBER

Ad Close: Aug 21

Autonomous Vehicle Operations

Subsea Residency

ROV Technology: Work Class to Micro Systems

Thruster Tech: Underwater Propulsion

Underwater Tools & Manipulators

Event Distribution

SNAME Sep 29- Oct 3,Houston, TX
Offshore Energy Europe- Oct 7- 10, Amsterdam

OCTOBER

Ad Close: Sep 21

Ocean Observation: Gliders, Buoys & Sub-Surface Networks

Instrumentation: Profilers, Samplers & Sediment Corers

Seafloor Mapping

Harsh Environment Systems for Arctic Ops

Geospatial Software Systems for Hydrography

Event Distribution

Oceans 2020- Oct 19- 22, Biloxi, MS
Blue Tech Week, San Diego, CA
MAST Japan Defense- Nov 2-4, Tokyo

NOVEMBER

Ad Close: Oct 22

MTR White Papers: Subsea Vehicles

White Paper Electronic Edition Publication Date: November 2020

NOVEMBER/DECEMBER

Ad Close: Nov 21

Acoustic Doppler Sonar Technologies ADCPs and DVLs

Fresh Water Monitoring & Sensors

Offshore Inspection, Maintenance & Repair (IMR)

Underwater Imaging: Lights, Cameras, Lasers & Multibeam Sonars

The 2021 Subsea Market Planner

Event Distribution

Underwater Intervention 2021

information may be subject to change

UNITED STATES POSTAL SERVICE®

Statement of Ownership, Management, and Circulation (Requester Publications Only)

1. Publication Title	2. Publication Number	3. Filing Date
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Nine issues per year	9	None

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15. Extent and Nature of Circulation: Requester			Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies *(Net press run)*			15,048	13,382
b. Legitimate Paid and/or Requested Distribution *(By mail and outside the mail)*	(1)	Outside County Paid/Requested Mail Subscriptions stated on PS Form 3541. *(Include direct written request from recipient, telemarketing, and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)*	12,155	12,382
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f. Total Distribution *(Sum of 15c and e)* ▶			13,422	13,082
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17. Publication of Statement of Ownership for a Requester Publication is required and will be printed in the November/December 2019 issue of this publication.

18. Signature and Title of Editor, Publisher, Business Manager, or Owner: *Kathleen Hickey* Circulation Manager — Date: September 18, 2019

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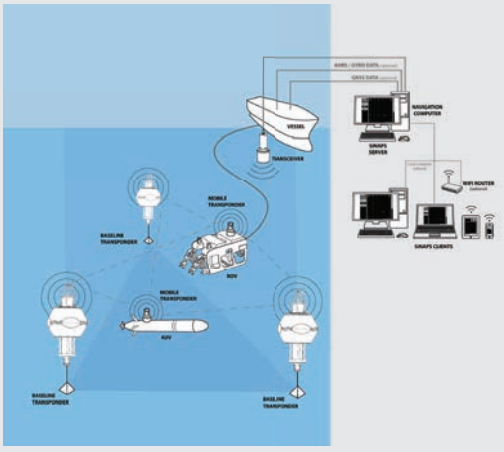

EvoLogics GmbH
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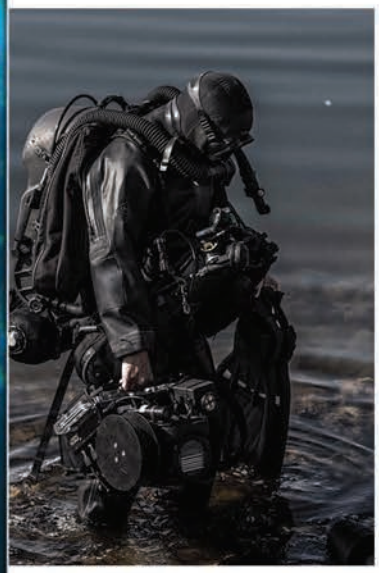

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