MARINE TECHNOLOGY REPORTER

April 2018

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South America Record Setter

A Journey Down to the Atacama Trench

Offshore Geophysical

One-on-One with Fugro's David Millar

Ocean Autonomy

Norway & NTNU in the Pole Position

Offshore Wind

The Five Trends to Watch

X-Prize

The Field is Cut to Nine

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Volume 61 Number 3

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Editorial

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Just back from London and the Oceanology International exhibition put on at Excel London, and without hesitation it is clear to see that Reed Exhibitions retains the honor of putting together the largest, best and most influential subsea business and technology conference and exhibition in the world. By the numbers show management reports 7,400 unique attendees, representing 90 countries, with many revisiting through the week for a total attendance of 13,789.

But the real story was not simply the standard booth and conference fare: the real eye-opener in London was a palpable feel of optimism that I have not seen in a couple of years. As the price of energy stabilizes, it's clear that projects long dorment from the oil majors are gearing back up. Make no mistake, the business of discvoering and recovering energy in the offshore sector is changed forever, the 'new norm' if you will, as companies seek innovative solutions to install, maintain and manage a complex industrial operation under water. But visiting OI, and my recent interviews with many industry leaders – particularly **Gael Bodénès, CEO, Bourbon Corporation**, who sees signs and is banking on an offshore recovery in 2019 – there are clear signs that collectively we emerge from the abyss. Bourbon is an interesting company to watch as it literally is reinventing itselft under the **#BourbonInMotion** flag. #BourbonInMotion is about developing integrated services with performance based on data. It's about capitalizing on digital revolution to connect the fleet, a Smart Shipping program to reduce crew, costs and increase performance. It's about building partnerships with industry partners, locally and globally. Finally, it's about changing culture and communication.

Last, but certainly not least, I am thrilled to welcome **Elaine Maslin** to the *MTR* editorial fold. Elaine needs no introduction in these pages, as many of you have followed her work in other titles for many years. She is a strong addition to our global editorial team with keen insights on the upstream offshore and renewables markets.

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… and then there were 9 …

Field pared in the quest to win $7m Shell Ocean Discovery XPrize

"We have been mapping what lies beneath the seas for hundreds of years, but we have a very long way to go," said Dr. Jyotika Virmani, Ph.D., prize lead and senior director of Planet and Environment at XPRIZE in a recent interview with *Marine Technology Reporter*. "We only have 10 to 15% of the seafloor mapped to any decent resolution, and the ocean covers 70% of the planet."

And so proceeds the latest Shell Ocean Discovery XPrize, a race to deliver a disruptive solution to a traditional maritime space in a three-year global competition challenging teams to advance ocean technologies for rapid, unmanned and high-resolution ocean exploration.

"We should be able to use these new and emerging technologies to tackle the problem of mapping our own planet," said Dr. Virmani. "There is a need for disruption, and we are in the midst of a technology revolution. We really need to pull these (new technologies) into the maritime realm to better understand and better work in the ocean, the last big frontier of our planet. It is in fact it like discovering a new planet with alien creatures."

A Rough Start

The fact that the field has been winnowed to nine teams from seven countries is a feat in and of itself, as the very force of nature that is under study conspired to thwart the first round of testing.

"For this round of testing we had to take a different approach than originally planned because of the hurricanes (Irma and Maria) that hit Puerto Rico," said Dr. Virmani. The original plan was to have the teams arrive in Puerto Rico in early October 2017 to put their tech to the test in mapping an area "where a great map already exists," said Dr. Virmani. But the historic Hurricane Irma struck Puerto Rico in late September 2017, severely damaging the island, its infrastructure and population. "Once the hurricanes hit Puerto Rico we had to change plan."

"We devised eleven criteria to test the technology readiness level," said Dr. Virmani. The nine teams left standing were those that passed the technology readiness criteria test.

Big Prize, Big Picture

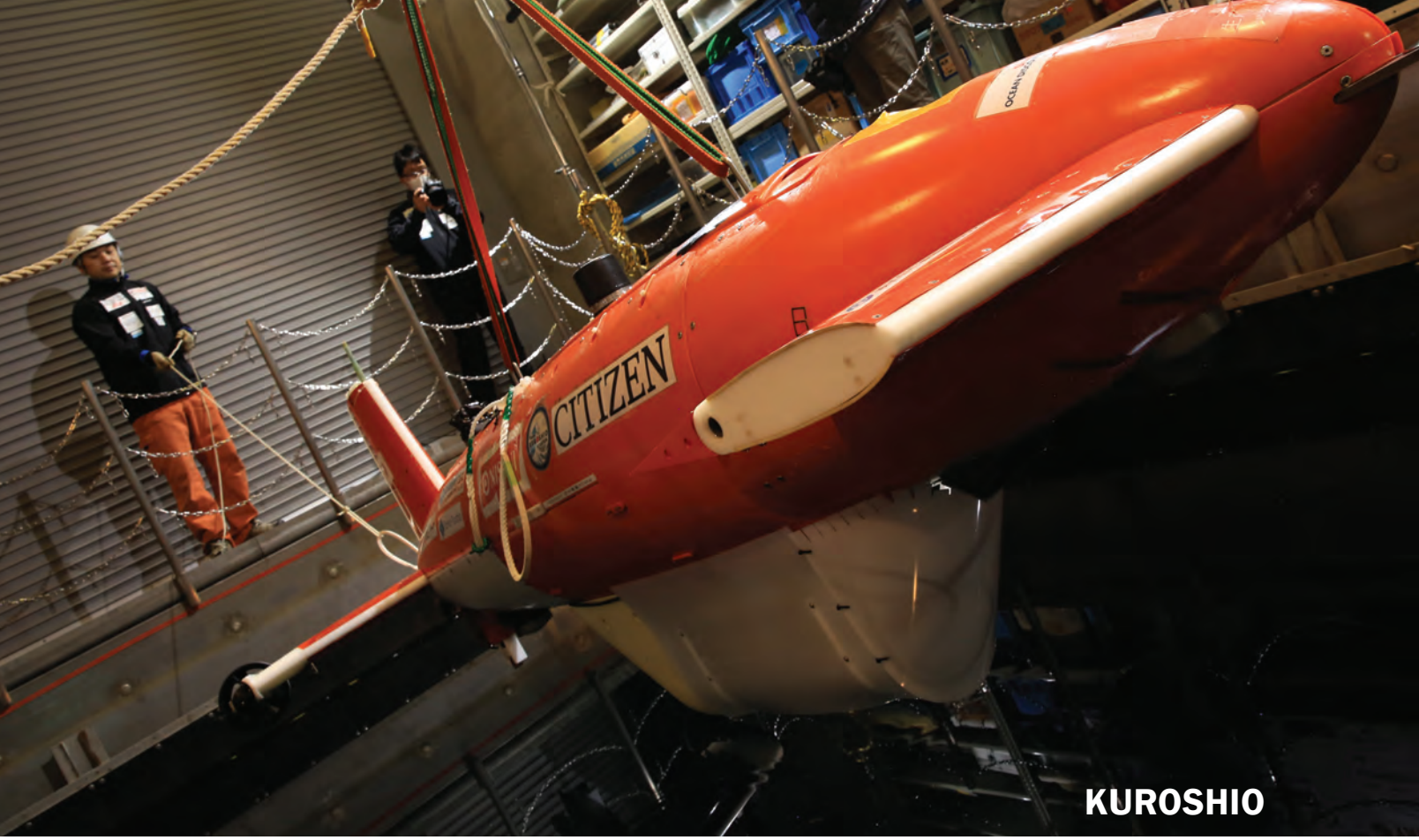
"We are looking to pull in exponential technology shifts into the marine realm," said Dr. Virmani. "There are huge shifts in technology that we're seeing in other areas that we want to bring into the marine realm," such as the use of 3D printing to effectively cut costs, and the use of drone technology to make operations more cost effective.

"I am very excited at what is coming out of this so far, and I think you will see some technologies emerge that truly revolutionize the way in which we access the deep sea and map the deep sea."

While Dr. Virmani is remiss for obvious reasons to tout one tech over the other, she said that teams are trying different approaches to mapping the deep sea; for example one system uses a mapping device that moves vertically in the water column, and then takes a circular map reading (and these circular readings are simply overlapped and melded together.) "The advantage of this approach is you can add other instrumentation so that you can collect additional water column data. It's a completely unique approach to mapping, as well

PISCES

Texas A&M Ocean Engineering (USA)



KUROSHIO

as the new technology … and it is very exciting."

… and then there were 9 …

The nine finalist teams were formally recognized and awarded at Oceanology International in London.

"As we dive into Round 2, we are looking forward to testing the finalists' technologies in a rigorous real-world world situation that will demonstrate their ability to rapidly map the ocean floor at 4,000 meter depths," said Dr. Virmani.

The final nine teams include:

ARGGONAUTS (Germany)

Led by Gunnar Brink, the team is creating two swarms: one swarm in the deep-sea and one on the ocean surface. Five or more intelligent deep-sea robot drones will be accompanied and supported by the same number of autonomous catamarans for geo-referencing, retrieval and transport.

Blue Devil Ocean Engineering (USA)

Led by Martin Brooke, the Duke University team is work-

CFIS

Virginia

Gebco

ARGGONAUTS

Blue Devils

ing with heavy lift aerial drones that drop retrievable diving SONAR pods.

CFIS (Switzerland)

Led by Toby Jackson, the team is building a fleet of AUVs to map and image the ocean floor using lasers.

GEBCO-NF Alumni (USA)

Led by GEBCO-Nippon Foundation alumni, the 12-nation team is integrating existing technologies and ocean-mapping experience with an innovative unmanned surface vessel to contribute towards comprehensive mapping of the ocean floor by 2030.

KUROSHIO (Japan)

Led by Takeshi Nakatani, the team is integrating technologies owned by Japanese universities, institutes and companies for a unique collaborative approach centered around AUVs.

PISCES (Portugal)

Led by Nuno Cruz, the team is aggregating Portuguese technologies developed at INESC TEC (Porto) and CINTAL (Algarve) to create the PISCES system that leverages cooperative robotics.

Team Tao (UK)

Led by Dale Wakeham, the team is developing an autonomous swarm system for rapid surface to deep ocean exploration.

Texas A&M Ocean Engineering (USA)

Led by students and working in partnership with Industry and successful alumni of Texas A&M; the University team is using drone ships and AUVs to explore remote ocean habitats.

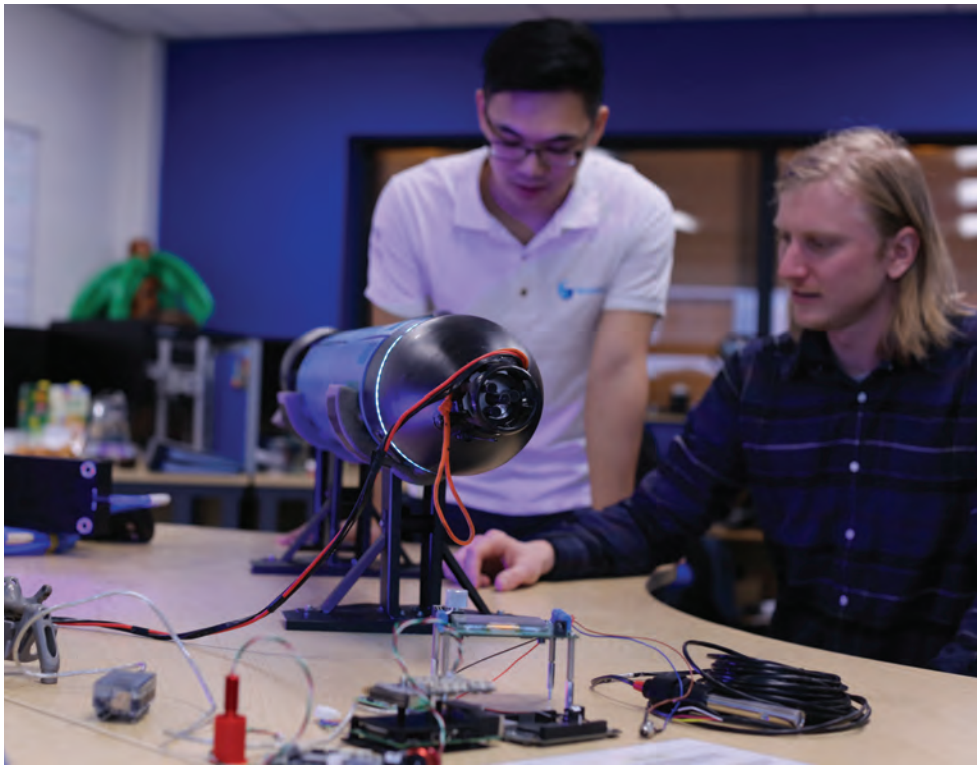
Virginia DEEP-X (USA)

Led by Dan Stilwell, the team is developing small and low-cost underwater vehicles that operate in coordinated teams.

The final Round 2 testing will take place during October and November of 2018. Finalists will have an opportunity to demonstrate their technologies in a real-world deep-sea environment, where they will have to map the sea floor at 4,000m depth and bring back 10 images from the ocean. Fugro, an industry leader in ocean mapping and another partner to the Ocean Discovery XPRIZE, will assist XPRIZE in acquiring the competition's high-resolution baseline bathymetry data that are needed in judging team mapping results.

www.oceandiscovery.xprize.org

Tao



SaabSeaeye

ROV Innovations

Recent tech advances in the global ROV sector

SaabSeaeye: It's Electric

Operators, from the Gulf of Mexico to offshore Australia, report multi-million-dollar savings as they switch to the new generation of electric work vehicles, and the Saab Seaeye Leopard it touted as the most powerful electric robotic work vehicle of its size in the world.

Compared to a 66-ton hydraulic equivalent, its 25-ton complete package brings considerable savings in footprint, mobilization, maintenance and staff.

Operators report the Leopard reducing costs by up to 40 percent in comparison with traditional systems in terms of equipment and personnel costs. With its 0.5 ton forward thrust and its iCON intelligent control system, the 2,000m-rated 11 thruster Leopard can power ahead at over four knots, while providing a stable work platform for handling significant work tasks in strong currents.

Advances in electric underwater technology are creating more reliable systems for a wider variety of complex tasks at the lowest possible cost.

Miniaturization and technological advances are creating electric robotic systems that are smaller, smarter, more agile and more powerful, with a smaller footprint and bigger payload possibilities.

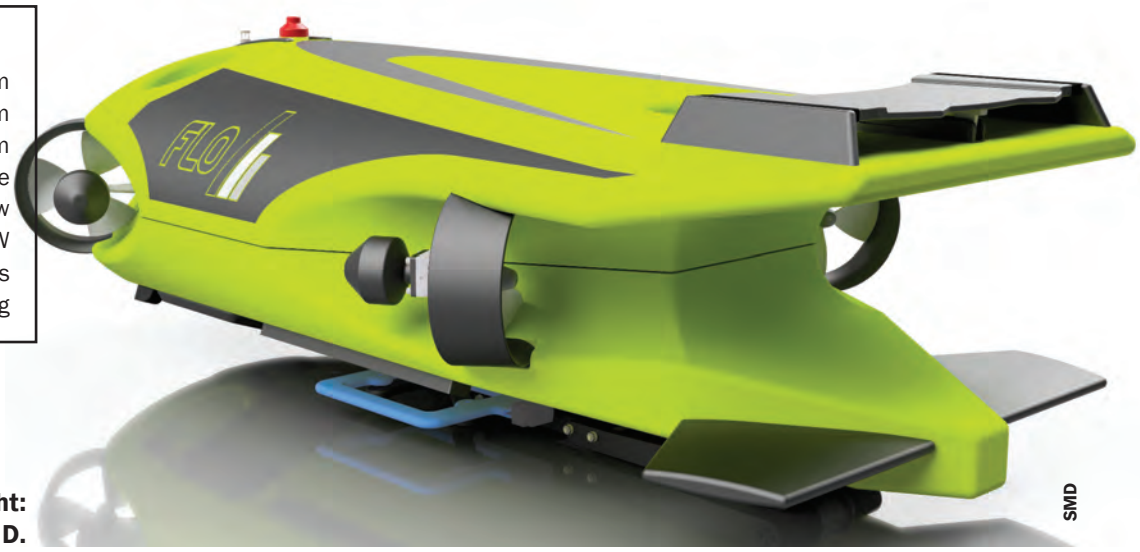
Intelligent control behavior-based architecture such as Saab Seaeye's iCON is key to the evolution of electric underwater technology. The Leopard's iCON control system effectively allows the vehicle to think for itself and provides the operator with far more information about the status of the vehicle and its environment than ever before. It also automates characteristics such as keeping a vehicle on station in strong currents, thereby reducing the operator's workload and allowing them to concentrate on the task at hand.

It also offers auto-redundancy to keep the vehicle working even if damaged and greatly simplifies maintenance, whilst providing remote internet access for upgrades and support.

SMD: Meet FLO

As price pressures continue in the ROV industry, the need for operators to reduce operational costs through the adoption of new technologies is increas-

FLO Specs	
Length	3.5m
Width	1.9m
Height	1.0m
Weight	2.5te
Depth	2000msw
Power	150kW
Max speed (no tether)	6.1 knots
Payload	200kg



Left:
SaabSeaeye Leopard.
Right:
FLO from SMD.

ingly apparent. For areas such as seabed mapping and pipeline inspection, where traditional work class ROV systems remain the preferred choice, SMD has recognized the limitations of the current technology available and developed FLO, a new high-speed survey and inspection ROV system. Traditionally, standard work class ROVs have speed limitations due to their size, weight and hydrodynamics. They can also be unsteady operating at higher speeds.

SMD engineered FLO, a high-speed variant based on proven SMD ROV fleet technology, to perform tasks faster and more efficiently. The new system has a top speed of 6 knots and the ability to hold position in currents up to 4 knots

from any direction. FLO also boasts 50% faster survey times compared to conventional work class ROVs and is capable of significantly extending the operational window in areas where high currents are prevalent, especially within the renewables sector.

From concept to manufacture, the new high-speed ROV by SMD, has been designed around the latest sensor payloads it would be tasked to carry in order to perform offshore, while also providing the most stable and acoustically quiet platform possible to gather quality survey data.

In order to provide this level of performance, FLO uses SMD's advanced ROV drivetrain technology in a low profile hydrodynamic package less than half the height and half the weight of a typical Work Class ROV. Coupled with eight open water vectored thrusters and SMD's advanced ROV control automation, FLO is able to accurately navigate and remain stable at high speeds while close to the seabed.

FLO can also be operated in free swimming mode for shallow water and uses a tether management system (TMS) in deeper water. Although travelling at high speed creates drag on the ROV umbilical, in water depths of 500m in free swimming mode, FLO has the power to achieve speeds greater than 4 knots.

When using a TMS for deep water operation, the umbilical drag is transferred to the surface vessel allowing the high speed ROV a high degree of maneuverability on a short 50m tether. This mode allows a calculated maximum speed of 5.6 Knots in depths over 2,000m.

FET's New XLe Spirit

Forum Energy Technologies launched a new electric remotely operated vehicle (EROV) range. Designed and manufactured in-house at Forum's Kirkbymoorside Yorkshire facility, the XLe Spirit is the company's first of a new generation of electric ROVs.

The vehicle is the smallest in the new range but is powerful enough to perform subsea maintenance and repair work with the use of its optional electric or hydraulic five function manipulator arm. The vehicle's self-regulating power feature compensates for tether losses

Blue Robotics

Blue Robotics

ensuring a constant and stable power delivery to the vehicle regardless of tether length.

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

The control electronics pod fitted to all Forum XLe electric vehicles is designed to enable superior connectivity and expansion capabilities when compared with other ROVs on the market. Ethernet interfacing allows for seamless integration with other industry sensors using common IP architecture and ease of remote data transfer.

Blue Robotics: Retrofit Kit

Blue Robotics released a retrofit kit which provides the components needed to upgrade to the BlueROV2 Heavy Configuration. The upgrade allows the ROV to have four vertical thrusters, external thruster guards, and additional buoyancy. The additions enable the vehicle to gain 6 degree-of-freedom control and active stabilization in roll and pitch, making the BlueROV2 Heavy the most stable but maneuverable mini ROV on the market. Since this kit has been in the works since before the BlueROV2 was launched, every ROV in the wild already has the necessary mounting holes for the upgrade. Kits are $599 and are shipping with a two week lead time.

Forum Energy Technologies

Forum

Top 5 Trends
to watch in Offshore Wind

1. Follow the Leader

Offshore wind's established leader, Europe, will continue to show the way forward and build capacity. At the end of 2016, nearly 88 percent of the world's offshore wind installations were located in European waters. In 2017, Europe saw a record 3,148 MW of net additional offshore wind capacity installed, with 560 new offshore wind turbines across 17 wind farms, according to WindEurope. Europe's total installed offshore wind capacity is 15,780 MW, which corresponds to 4,149 grid-connected wind turbines across 11 countries.

Growth in this sector is expected to continue. WindEurope said in its 2017 "Scenarios for 2030" report that total installed capacity offshore could increase fivefold to 70 GW by 2030 according to the central scenario, or by as much as 99 GW in the high scenario. The majority of offshore wind installations will occur in the North Sea, with almost 48 GW installed by 2030 in the central scenario. In the Baltic Sea, where 1.5 GW of offshore wind is online today, projects in Poland, Estonia, Germany, Denmark and Sweden could add 9 GW installed by 2030. In the Atlantic Sea, where there is almost no capacity today, close to 8 GW could be reached thanks to installations in France, the U.K. and, on a smaller scale, Portugal. The U.K. will also install the majority of the capacity in the Irish Sea, which will total close to 6 GW. Italian and French installations could boost capacity in the Mediterranean Sea to 0.5 GW.

2. Bigger is Better

Across the globe, offshore wind projects are incorporating the latest innovations in wind turbine technology as manufacturers are building larger turbines on advanced foundation designs in even greater water depths. Larger turbines that are able to capture more energy and are more efficient allow fewer installations and lower maintenance costs and are therefore key in the industry drive to minimize costs and maximize efficiency. This trend toward increased size and scale will continue.

In March 2018, GE Renewable Energy announced it will invest more than $400 million over the next three to five years to develop and deploy the Haliade-X 12 MW, a new world's largest offshore wind turbine featuring a 12 MW capacity, 220-meter rotor, a 107-meter blade. Towering 260 meters over the sea, Haliade-X will produce 45 percent more energy than any other offshore wind turbine presently available and will generate up to 67 GWh annually, GE said.

3. Costs Cutting Continues

The offshore wind industry set a goal to decrease prices toward the target of 100 euro/MWh by 2020. With the help of larger and more efficient turbines, auction prices in many instances have far exceeded the cost reduction targets with projects delivering bids significantly below that level. "All of a sudden offshore is competitive with onshore wind, and the repercussions have been felt across the world, setting the stage for a round of large investments in offshore not only in Europe, but also in Asia and North America," the Global Wind Energy Council said in its Market Forecast for 2017-2021 report.

As cost reductions continue, new opportunities will arise and new ground will be broken. For example, in March this year, the Dutch Government awarded Vattenfall a tender to develop the twin 350 MW Hollandse Kust Zuid offshore wind farms, which when built

GE is developing a 12 MW capacity Haliade-X turbine

GE

by 2022, will be the world's first to be built without public subsidy. This follows another landmark zero-subsidy offshore wind tender in Germany last year which was the first to attract zero subsidy winning bids, but will be built later in 2024-2025.

4. U.S. an Emerging Player

With the U.S.'s first commercial offshore wind project online (Deepwater Wind's five-turbine 30 MW Block Island Wind Farm off Rhode Island) others will follow suit. The success of a first project, together with decreasing global costs and stronger state policy commitments have led to increased confidence in the nation's offshore wind market. In the U.S., a total potential capacity of more than 54GW of wind energy generation is currently being planned, with a total capital investment of over $1.5 trillion by 2030, according to the Business Network for Offshore Wind. Most coastal states have at least one planned offshore wind project in the pipeline, with several states having enacted new policy or bolstered their existing policy to support project development.

5. The Future is Floating

Once written off as infeasible, floating offshore wind farms are gaining momentum. The 30MW Hywind Scotland wind farm operated by Statoil in partnership with Masdar 25 kilometers offshore Peterhead, Scotland began production as the world's first full-scale commercial floating wind farm in October 2017. And in its first months of production, Hywind Scotland has performed better than expected. During the winter, when the wind is at its strongest, the typical capacity factor for a bottom-fixed offshore wind farm is 45-60 percent. By comparison, Hywind Scotland achieved an average of approximately 65 percent during November, December and January, Statoil said.

Floating wind turbines hold potential for locations where the water is too deep for typical fixed-bottom turbines. This promise will become greater as technological advances and cost reductions continue, much as they have in the bottom-fixed segment. Statoil sees key markets for its Hywind technology in Europe, Japan and West Coast U.S., and predicts there could be nearly 13 GW floating wind capacity installed by 2030.

David Millar

Government Accounts Director, Americas

Fugro

I read with interest Fugro's support of GEBCO's Seabed 2030 initiative. For those not aware, can you describe the project and Fugro's role in it?

Despite the fact that mankind has produced high-resolution maps of the moon and Mars, more than 80% of the world's oceans remain unmapped using modern survey methods. The Nippon Foundation-GEBCO Seabed 2030 Project is a global initiative that aims to correct this data shortfall by producing a definitive, high-resolution bathymetric map of the world's oceans by the year 2030. The project originated during the 2016 Forum for Future Ocean Floor Mapping in Monaco and became operational in February of this year under the leadership of The Nippon Foundation and GEBCO [General Bathymetric Chart of the Oceans]. The goal of the project is to enhance global policy decisions, improve ocean sustainably, and advance scientific research.

A project of this scale can only be successful by focusing and coordinating the efforts of governments, academia and the private sector. Fugro has been leading private sector involvement through our participation in the development and review of the Seabed 2030 roadmap and business plan, through our work on the Seabed 2030 Establishment Team, and most significantly, through our commitment to contribute data to the project. We have begun acquiring and contributing high-resolution multibeam bathymetry data collected from Fugro vessels during transits in and between projects. In addition to these crowd sourcing efforts, we have also initiated a dialog with Fugro clients—who generally own the data we collect on their behalf—regarding the contribution of their existing multibeam bathymetry data to Seabed 2030.

As Fugro is a business, and data – particularly data that does not currently exist – is a valuable commodity, what is the point of 'donating' the data to Seabed 2030 as opposed to using it for your own commercial end?

A significant portion of our business is derived from the ocean, and given that Seabed 2030 will help inform global policy, improve sustainable use and advance scientific research of the oceans, it only makes sense that we not just support, but also actively engage in Seabed 2030. As a global company operating in and on the oceans, our participation is socially responsible, contributes to ocean stewardship and, quite simply, is the right thing to do.

It is our belief that Seabed 2030 will not eliminate the need for our marine site characterization services, but rather increase its demand. Only through a comprehensive mapping of the ocean will areas of interest become known, and we fully expect that within those areas of interest, Fugro's high resolution mapping services will still be required to support our customers' projects and activities. Even before this, however, we anticipate that crowd sourced bathymetry data will not fully map the oceans, and Fugro hopes to participate in the ocean basin mapping campaigns that could inevitably be part of Seabed 2030.

That said, how is Fugro benefitting tangibly from participating in the project?

Even though our participation in Seabed 2030 is very new, Fugro is already benefiting in multiple ways. First, I think it is safe to say that our brand is enhanced through our participation in, and leadership on, such an important and socially responsible project. Second, the publicity that we are receiving regarding our participation in Seabed 2030 helps promote our capabilities and services, particularly our Remote Services and Ocean Mapping Services. Finally, I think our staff are genuinely proud to be involved in such

(Photo courtesy Fugro)

an important and relevant global initiative. They truly appreciate the opportunity to "give back" to humanity through our work and actions.

Walk me through the creation of Fugro OARS: what was the impetus to create OARS?

OARS stands for "Office Assisted Remote Services" and refers to a cloud-based technology that enables qualified staff working in centralized command centers to perform offshore survey tasks as if they were physically on board the vessel. The system was conceived in response to market demands for reduced survey costs several years ago and is now fully functional, with three command centers strategically located around the globe, operating 24/7, 365 days a year. OARS is instrumental to our Seabed 2030 crowd sourced bathymetry methodology, making it possible for us to collect in-transit data with minimal impact to our normal business operations.

Aside from feeding Seabed 2030, how is Fugro using OARS?

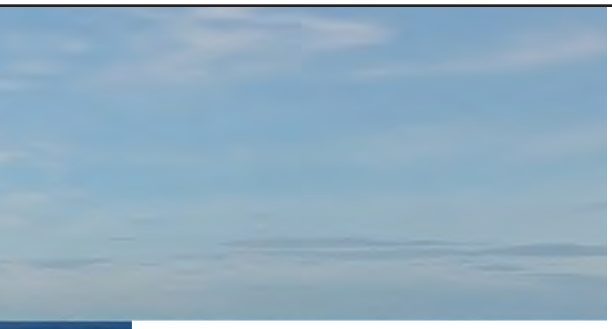
Fugro is working with clients to implement OARS on projects all over the world. We have utilized the technology on rig moves, barge operations, geophysical and hydrographic surveys, and subsea inspection, repair and maintenance projects to name a few. The immediate benefits to our clients are a reduction in vessel POB [people on board] levels, HSE [health safety and environment] exposure, and logistical requirements for personnel mobilization.

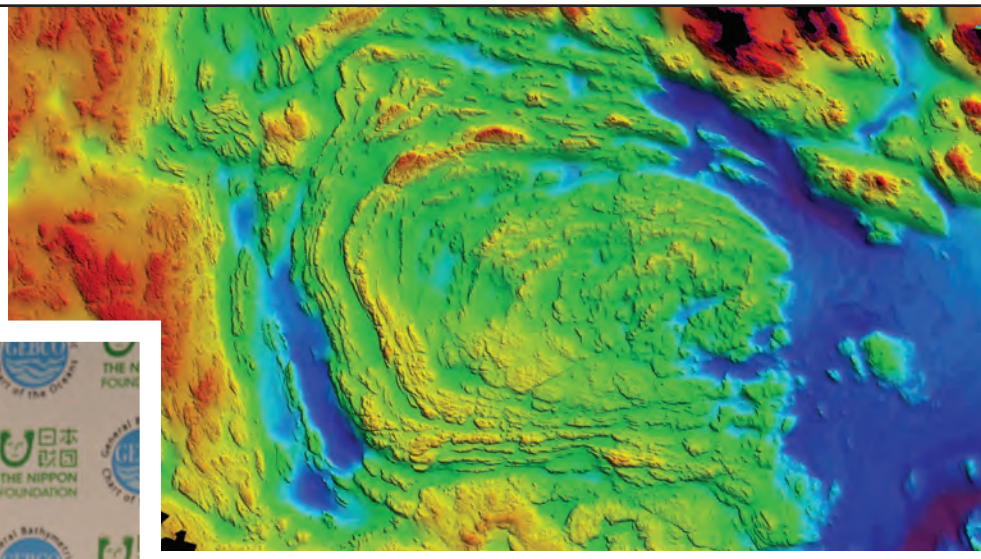
Today it is on 2 ships; tomorrow 4 ships ... what is the long-term vision for OARS?

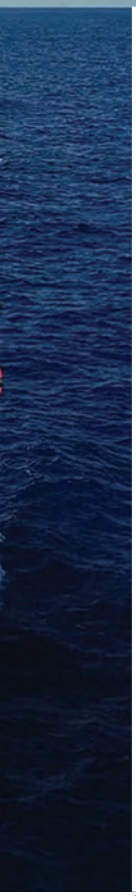
In terms of in-transit data collections, we started off slowly, originally working from just one vessel since the fall of 2016 to develop the systems and processes that would support remote command and control of multibeam data acquisition, as well as upload and transfer of these datasets. Once the capability was proven and documented, we implemented the approach on a second vessel in the fall of 2017, and most recently added the capability to two additional vessels. We ultimately plan to scale this up across our global fleet of survey vessels, so that all are contributing crowd sourced bathymetry data to Seabed 2030 as they transit between projects. The same service can be modified and offered to cruise lines and maritime shipping companies, who obviously operate vessels that are already equipped with satellite communications and navigation systems.

With the demand for geophysical data perhaps blunted by the offshore energy downturn, discuss where, today, you see opportunities for your products and services.

There is no doubt that the offshore energy downturn has been hard on Fugro and other companies that were heavily focused in that sector. Even in the downturn, however, Fugro saw an expansion in our seabed seeps mapping (a type of geophysical survey) business and, in recent years, we have been surveying in excess of 1,000,000 km2 per year for customers who continue to invest in frontier exploration programs. Similarly, we have seen continued expansion of both marine site characterization and asset integrity activity in support of the offshore wind energy sector, which helps to diversity our overall portfolio. In general, however, we see







Center: Fugro survey vessel Kobi Ruegg.

Far Left Lower Corner: Fugro OARS - Office Assisted Remote Services – survey staff from centralized command centers have direct access to offshore survey projects, allowing for the optimization of crew size and access to Fugro's subject matter experts around the world.

Above: Example of high-resolution deepwater bathymetry data.

Left: David Millar speaking at the NF-GEBCO Seabed 2030 Project press conference in Tokyo.

All Photos courtesy Fugro

increased demand for reducing the human footprint offshore, while producing more efficient and more cost-effective operations. As a result, we are developing and offering services with increased automation, not only in terms of autonomous and unmanned vehicles, but also in terms of command and control technologies, such as OARS, and processing techniques, such as artificial intelligence machine learning.

How has the energy swoon impacted Fugro? How is Fugro most the same, most different, from 5 years ago?

Fugro is a leaner, more customer-focused organization today than it was 5 years ago. The offshore energy downturn has forced us to improve our organization, improve our innovation, improve our staff, and standardize our operations. OARS is but one example of an innovation that was implemented in response to the energy swoon and the need to increase operational efficiencies. Our customers have benefited, however, as they now have a tiered service offering that ranges from unmanned operations to fully manned operations. We are still a global company that provides customers with services locally, but we are doing so in a smarter, more efficient manner that focuses on integrating Fugro services into site characterization and asset integrity solutions.

How is Fugro investing today?

Fugro continues to focus on research and development and technology innovation. Despite the offshore energy downturn, we have maintained the same level of R&D investments [as a percentage of revenue] and we are innovating in key areas. As mentioned previously, we see the markets seeking increased automation and as a result, we are working with clients and scientific partners to further the capabilities of automated vehicles, automated command and control, and automated processing.

MG3 &

Satellite Derived Bathymetry

By Kevin Corbley

Operation of marine survey vessels in shallow-water coastal environments is a dangerous endeavor. A subsurface obstruction can tear a multi-beam sonar from its tow cable, resulting in loss of the expensive device and potential delay in the expedition. Lost equipment, however, is a minor inconvenience compared to the equally real possibility of the ship running aground in poorly charted waters, endangering the safety of its crew and incurring millions of dollars in damage.

For this reason, survey vessel operators invest considerable time and money to minimize the risk involved in each voyage. They are always on the lookout for new technologies to enhance the safety of their personnel and equipment while also improving the bottom lines of their projects. With this goal in mind, MG3 Survey UK Limited has turned to Earth observation satellites flying hundreds of miles overhead to get a better idea of what obstacles lay beneath the waves in the most perilous coastal zones.

One of MG3's vessels recently returned from completing a survey in the Caribbean where the planning team relied on multiple bathymetry products, including satellite-derived data, to perform a 'desktop mapping' of the numerous jagged coral reefs in the area. This work was done long before the ship embarked on its voyage. In fact, MG3 employed the data even before it submitted a bid on the project.

SATELLITE DATA

Based in Warminster, England, MG3 is a marine geoscience survey firm. MG3 maintains a fleet of three multi-role DP1 vessels capable of operations in the offshore and coastal areas, each outfitted with a variety of side- and multi-beam sonar as well as towed magnetometer devices for subsurface surveying.

"We work extensively on geophysical surveys for oil and gas, wind farm siting in renewable energy and cable-laying projects for telecommunications," said Steve Jackson, MG3 Group Quality Health Safety & Environment Manager, adding that MG3 now routinely incorporates satellite derived bathymetric data into multiple planning phases of its projects.

The firm became acquainted with the uses of satellite imagery for marine applications about five years ago when it teamed on bathymetric survey bids with TCarta, a geospatial solutions company (then called Proteus Geo) based in Bristol, UK. At the time, TCarta was establishing itself as a provider of a new type of near-shore water depth map data called satellite derived bathymetry.

"As business partners, our companies worked collaboratively because we could provide an offering that combined the MG3 deep-water hydrographic survey data with our coastal satellite derived bathymetry product," said Richard Flemmings, Operations Director for TCarta.

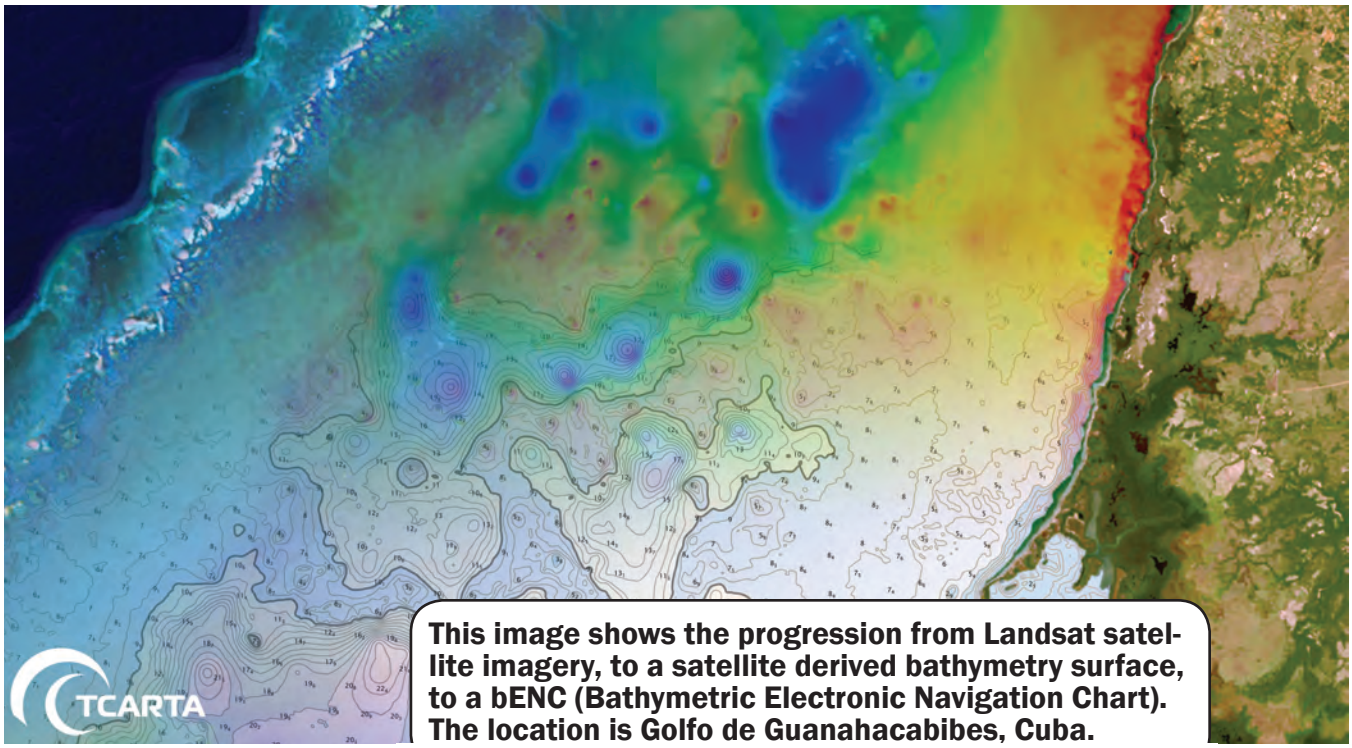
The TCarta product appealed to MG3 because the satellite imagery could provide accurate seafloor depth data in the shallow coastal areas where it's often too risky to take survey vessels or tow costly equipment even a few meters below the surface.

DERIVING WATER DEPTH

TCarta commercialized the proprietary technique to extract water depth measurements from satellite imagery and now creates the products. During production, TCarta processes eight-band high-resolution multispectral imagery captured by the DigitalGlobe WorldView satellites over coastal zones. The processing derives seafloor depths with an accuracy of two meters to a depth of about 20 meters. TCarta applies rigorous quality control to ensure data accuracy.

"The satellite derived process is more cost-effective than airborne or shipborne methods of bathymetric data collection," said Flemmings. "It costs about one-tenth that of other techniques."

In addition to its financial attractiveness, satellite derived bathymetry became instantly popular for several reasons with businesses operating in the coastal zone. Safety is the primary one, as the technique requires putting no boats or personnel in the dynamic and dangerous near-shore environment. Just as



This image shows the progression from Landsat satellite imagery, to a satellite derived bathymetry surface, to a bENC (Bathymetric Electronic Navigation Chart). The location is Golfo de Guanahacabibes, Cuba.

Photo credit - Aaron Sager

importantly, damage to the environment is eliminated since the remote sensing process does not involve contact with the water or shore. "There are no airspace concerns with satellite imagery," added Flemmings. "The DigitalGlobe satellites fly high above airspace restrictions with almost daily access to every spot on the Earth's surface."

PLANNING A BID

In a typical marine survey project like the recent one in the Caribbean, MG3 first employs the bathymetric data during the tender phase. Steve Jackson and his team obtain satellite derived bathymetry and a complementary Marine Basemap product for the area of interest (AOI) from TCarta. The Basemap is a stylized bathymetric image created by TCarta for use as a marine GIS backdrop, primarily in offshore environments. It shows depth grids and contour lines at 90m resolution.

In the Caribbean, Jackson used the 90m data to get an overall snapshot of the deep offshore segments of the AOI. At this point, he was primarily interested in charting any obstructions in the deep water that might pose a hazard to the vessel and equipment. He also noted the most efficient routes into and out of the area.

Closer to the shore, project planning focused on the satellite derived bathymetry. Again, Jackson examined the data for the presence of reefs in the shallow Caribbean waters. He used this information to plan survey lines and to determine which towed equipment could be deployed in various parts of the AOI. The various towed sensors have water depth thresholds at which they are most efficient.

"This is for commercial purposes where we can complete the project as quickly as possible for the client," said Jackson.

MG3 used the information – voyage time, survey lines and equipment usage – to put a price tag on its project bid. Each vessel costs tens of thousands of dollars per day to operate, with towed devices adding to the expense. This means determining the fastest route there and most efficient survey lines on site potentially shaved time off the project, which put the UK firm in a better position to win the job.

SAFETY FIRST

An accurate tender bid, however, is not the only use for the satellite derived bathymetry. As Jackson examines data for efficiency, he is also keenly evaluating risk. The data sets have the fidelity and accuracy to reveal obstructions on the seafloor that must also be considered from a safety perspective when planning each segment of the survey work near the shore. Seafloor depth and submerged obstructions will dictate where the ship can go and where towed equipment can be deployed.

For every project conducted in a remote location, Jackson uses the data to plot the fastest egress routes from the AOI to the closest population center in case a crew member becomes ill or injured. With this information, the vessel commander always knows where the closest hospital is located and how to get there quickly and safely.

"We have to take into account the safety issues of grounding the vessel and being stranded…and it's crucial we don't hit the bottom with our equipment, and damage or lose it," said Jackson. "All this information is calculated into a risk matrix where we plan the job to conduct it in the safest possible manner."

Jackson acknowledged that some coastal areas are simply too treacherous to navigate one of its vessels. In such cases,

they try to find an alternative way of capturing the survey data requested by the client, which may include putting a smaller boat in the water. But that option presents its own risks.

"During the tender stage, we can go back to the client and convey the risk of near-shore operations [in specific areas]," said Jackson.

"In some areas, we have suggested the client rely on the Satellite Derived Bathymetry instead of the ship."

In the shallow coastal waters of the Caribbean, MG3 was able to navigate the entire near-shore area requested by the client without incident. No equipment was lost, and the MG3 vessel successfully avoided the submerged reefs identified in the satellite data. The project was completed on schedule and on budget.

ACCESSING THE SATELLITE DATA

According to Jackson, the accuracy of TCarta marine products has compelled his team to acquire them for numerous projects in recent years. And now MG3 has played a role in making these and products more readily accessible to a wider group of end users in the marine community.

In 2016, TCarta and DHI won a grant from the European Space Agency to help pay for development of an online portal to support direct sales of the off-the-shelf Satellite Derived Bathymetry data along with other geospatial marine products. The ESA grant required TCarta and DHI to include existing clients in the development of the portal, and MG3 gladly served that role, offering its insights into how the online data should be packaged, formatted and delivered.

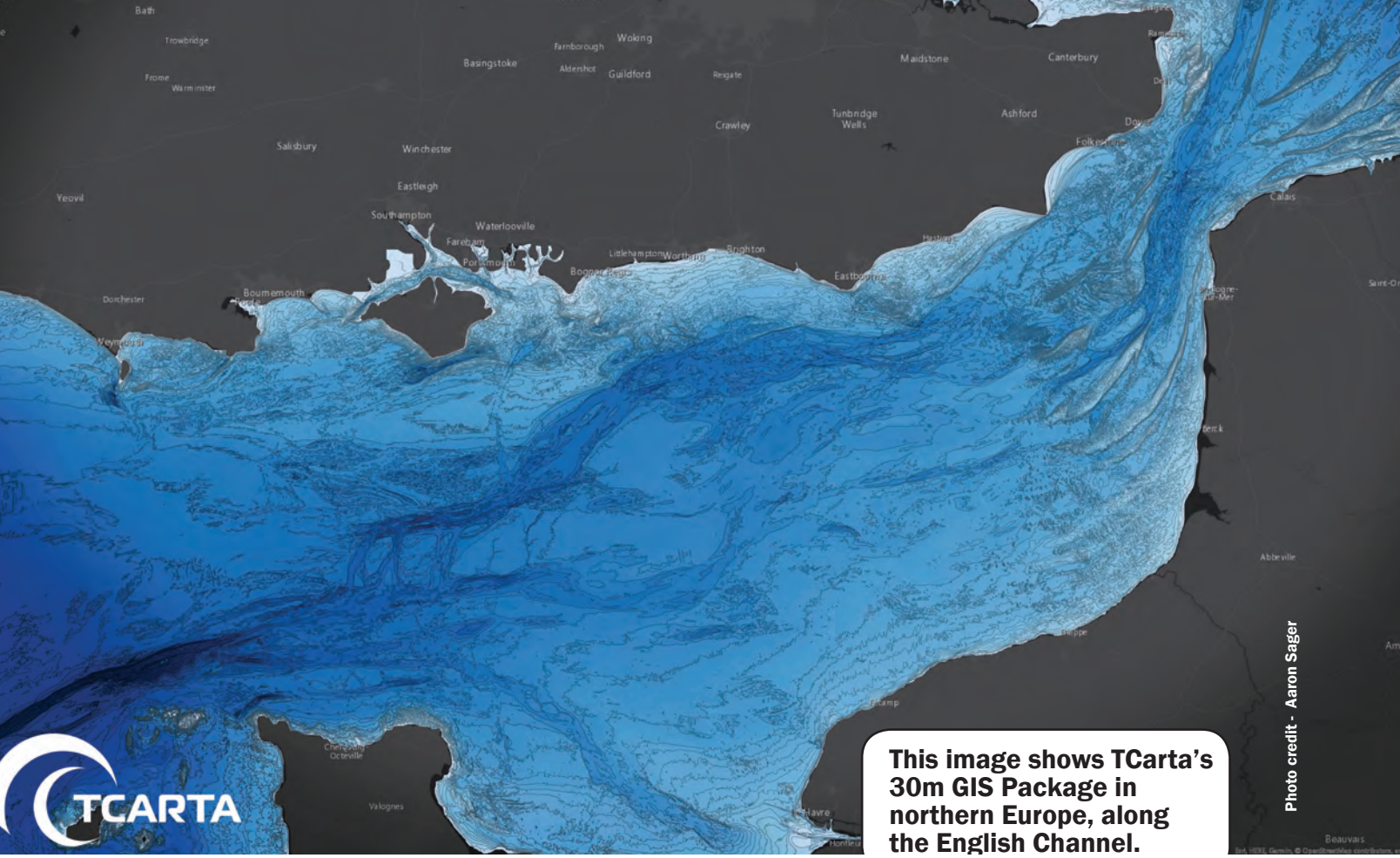
Until then, the custom-produced bathymetry products were used mostly by government agencies, energy exploration companies, infrastructure engineering consultancies and other large organizations with interest in near-shore coastal areas. As TCarta generated products for customers operating in the Red Sea and Arabian Gulf, it began to build an impressive archive of highly accurate Satellite Derived Bathymetry that could be sold as off-the-shelf data sets.

"We set our sights on making our marine products available more affordably to smaller organizations by selling on-demand data sets in small tiles on a per-kilometer basis," said Flemmings.

The Bathymetrics Data Portal went live in 2017 providing users the ability to search for data availability through a map or coordinate-entry interface, preview the bathymetric data onscreen and then pay for just the area-of-interest they need via an e-commerce module. The product streams directly into common GIS or mapping software package used by the customer.

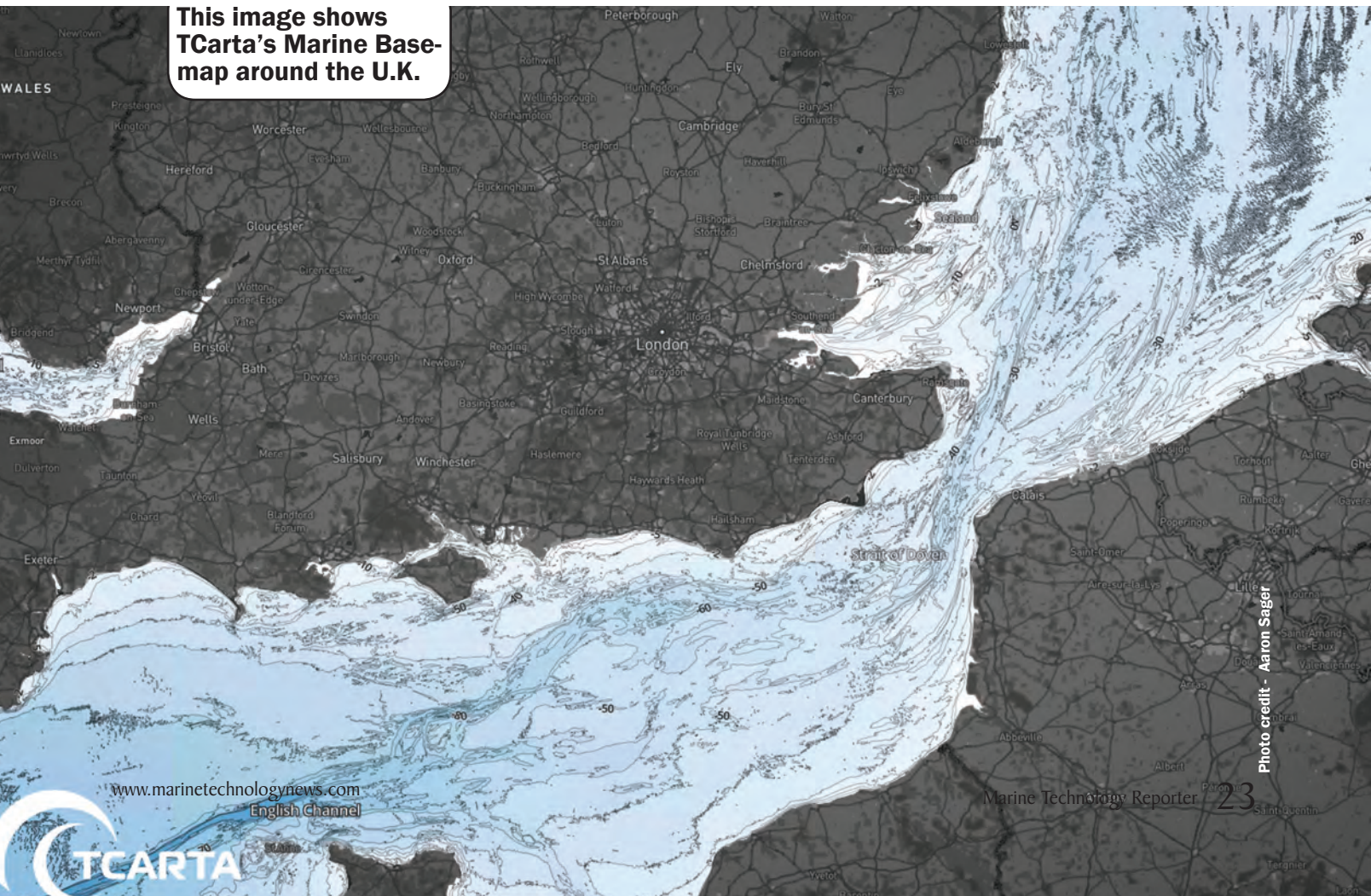
Based in England, MG3 is a marine geoscience survey firm. **MG3 maintains a fleet of three multi-role DP1 vessels** capable of operations in the offshore and coastal areas, each outfitted with a variety of side- and multi-beam sonar as well as towed magnetometer devices for subsurface surveying.

Image Courtesy MG3



This image shows TCarta's 30m GIS Package in northern Europe, along the English Channel.

Photo credit - Aaron Sager



This image shows TCarta's Marine Base-map around the U.K.

Photo credit - Aaron Sager

Ocean Autonomy

Marine autonomous systems are high on the agenda in Norway. Elaine Maslin learned more from **Professor Asgeir Johan Sørensen.**

By Elaine Maslin

Marine autonomous systems working independently and in connected systems are fast becoming a growth sector within the ocean industry space, including the oil and gas industry.

The emergence of new marine autonomous systems appears to be a weekly occurrence. As costs have reduced in numerous areas, from sensors to satellites, some of these systems are also coming within the grasps of ordinary citizens, as well as ocean scientists, looking to unlock the secrets of the deep.

Part of the drive for these systems, in the oil and gas industry at least, is to reduce use of manned surface vessels, which are costly to operate and emit fumes, at best.

A goal set for Norway's Norwegian University of Science and Technology (NTNU) is to reduce use of surface vessels by 80% in several oil and gas operations. The NTNU's Center for Autonomous Marine Operations and Systems (AMOS) has the task of finding solutions to meet that goal, as well as targets to increase mapping and monitoring coverage by 10 at a tenth of the cost. Another goal is for "safe marine operations anywhere at any sea state at one tenth of the cost," says Asgeir Johan Sørensen, Professor and Director of AMOS.

Norway has other incentives to produce advanced ocean technologies. The country has ocean areas 5-6 times larger than its land mass, says Sørensen. Its key industries span fisheries, ocean transport and, for the last 50 years, oil and gas. "We are moving now into offshore wind and aquaculture," says Sørensen. "To be competitive, we (Norwegians) always

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Photo from NTNU AMOS, by Thor Nielsen

> "Automation is how you perform well-defined tasks without human intervention. **Autonomy is when dealing with an unstructured environment and uncertainty.** You typically go in with unmanned systems when there are the three Ds: dull, dirty and dangerous."
>
> **Professor Asgeir Johan Sørensen**

have to have high quality and low cost," which is why firms are exploring use of autonomous systems. "Norway also has a huge responsibility when it comes to governance and management of the oceans, including into the arctic."

Initially, it was work in the oil and gas sector, to avoid risk to divers, that led to Norway to pursue remote operated subsea technologies. It's been more recently that the industry has been looking to develop more autonomous subsea systems, from processing equipment to subsea vehicles, such as pipeline tracking autonomous underwater vehicles.

Within the past year, Norway's Statoil has been working towards subsea resident vehicle concepts, deploying two different remote operated vehicles (ROVs), one from Houston-headquartered Oceaneering (the e-Novus) and one from Norway-based IKM, on multi-week and even month deployments. However, while these deployments meant the vehicles were autonomous in that they no longer needed a support vessel, they were still tethered and operated by staff onshore.

The next step will be vehicles that can operate without a tether, such as Oceaneering's new Freedom concept, which it unveiled at the Subsea Valley Conference in Oslo. It's a resident ROV concept, based on a hybrid vehicle, that would live in a subsea docking station and be able to fly out on missions in either tethered (remote operated) or untethered (autonomous) mode. It would have onboard batteries that would be recharged at its docking station and a tooling "magazine" it could select from. The firm is hoping to perform offshore trials with a prototype, expected to be about 3.3m-long, next year, Arve Iversen, ROV operations manager, said at Subsea Valley.

Much more is being done to develop autonomous systems, however. NTNU AMOS was set up between The Departments of Marine Technology and Engineering Cybernetics at NTNU, working with other international research partners and Norwegian companies, as a Centre of Excellence (CoE) support by Norway's Research Council, from 2013 for 10 years. Since 2013, it has already notched up 53 PhD students and multiple other spin-outs, including drone firm Scout, and BluEye,

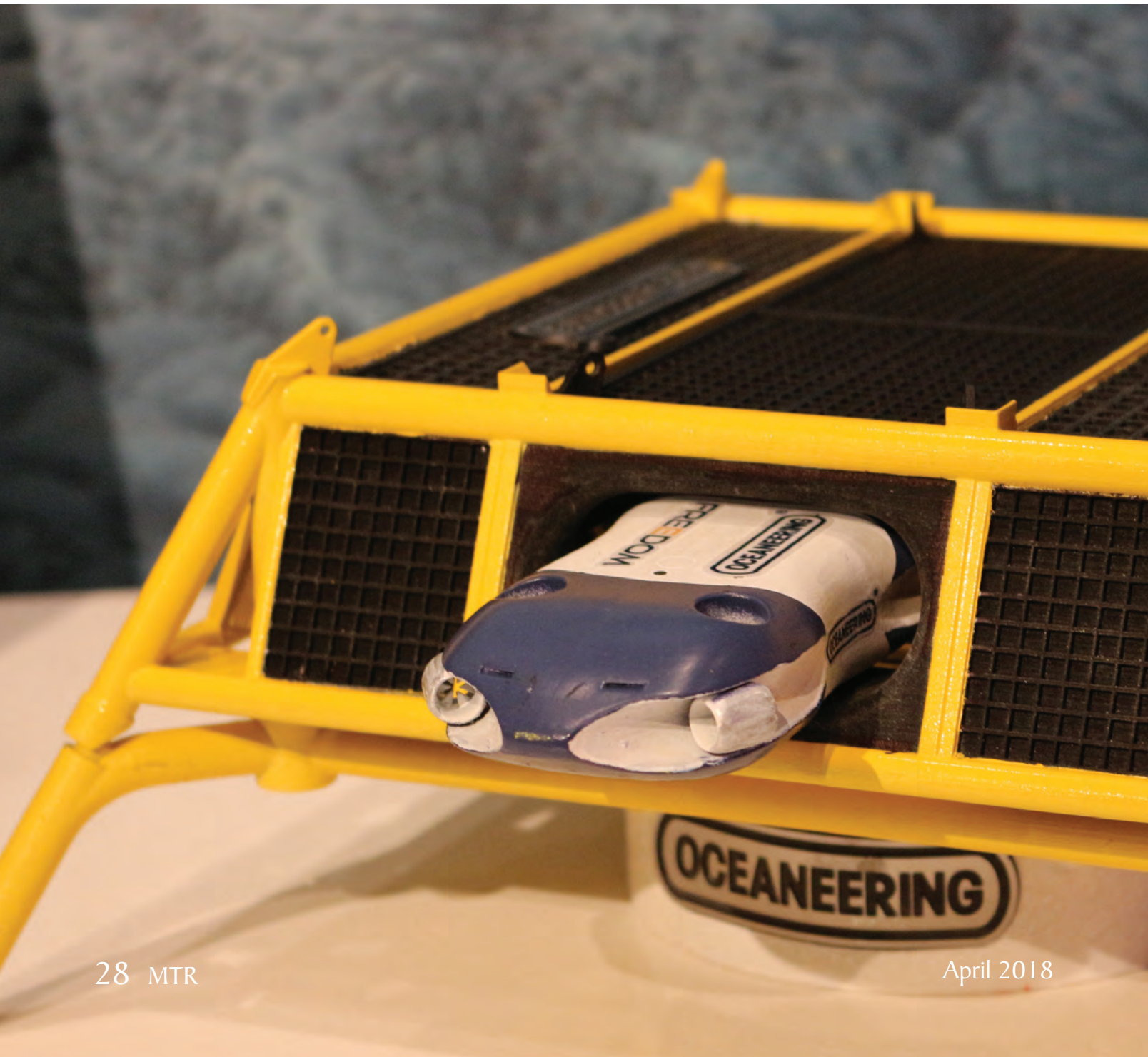
an observation ROV (deepest underwater commercial drone) company, with Go-Pro style usability. This mix of companies gives an idea of where the research is heading, i.e. interconnected networks of systems.

As well as also working on improving intelligence in systems, such as power systems, making them more intelligent to optimize energy consumption and battery use, AMOS is also looking at swarms and heterogenous systems, involving in air and subsea drones, as well as unmanned autonomous surface vessels, which would reply on satellite infrastructure for communication and connectivity.

Helpfully, the cost of sending up a satellite into space has reduced, to $390,000-$520,000, says Sørensen. “While they have limited functionality and only last 3-5 years, they’re important for autonomous systems,” he says. “We can use a satellite, send out a drone, working with unmanned ships, for joint operations.”

Norway is becoming a testing ground for these technologies, with a number of areas designated as test beds, including Trondheimsfjord in Northern Norway, Storfjord in the northernmost part of western Norway, an area with several ferry crossings deemed suitable for testing and developing sensor technology and management systems, and Horten on the Oslo fjord in southern Norway.

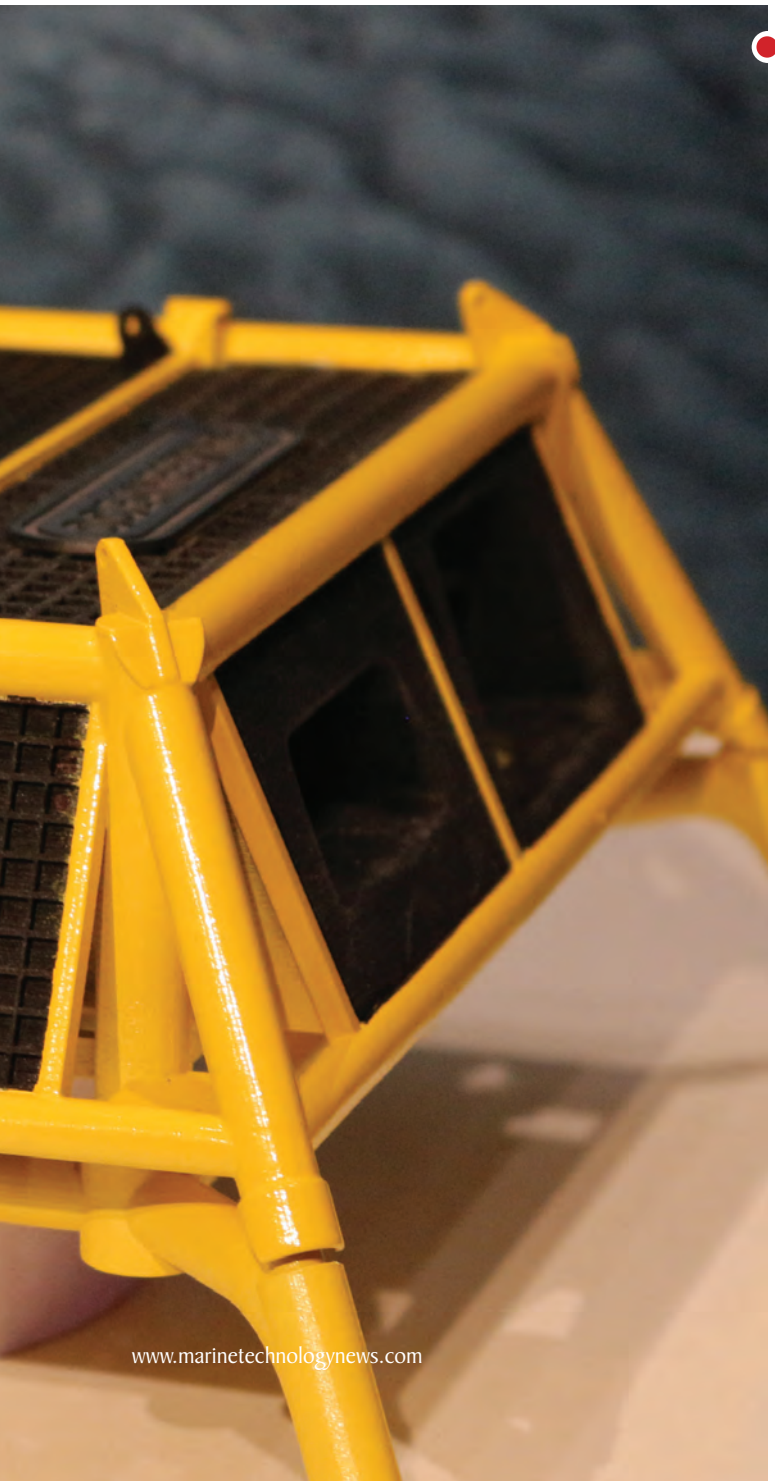
Indeed, Kongsberg, which is working heavily in autonomous shipping, including an “autonomous and all-electric”



container ship, the Yara Birkeland, is working with NTNU unmanned, underwater resident "snake" robot spin-out Eelume. Kongsberg is also heavily involved in a number of other projects (having established its position in the autonomous underwater vehicle (AUV) market with the Munin and Hugin AUVs), including the Sea-Kit, a hybrid AUV-ASV, which will sport a Kongsberg K-MATE autonomous surface vessel control system.

But, we need to be careful in how we define autonomy, compared with automation, says Sørensen. "Automation is how you perform well-defined tasks without human intervention. Autonomy is when dealing with an unstructured environment and uncertainty. You typically go in with unmanned systems when there are the three Ds: dull, dirty and dangerous. Autonomous is when we don't have links and that's also why subsea is leading this field. It (a system or vehicle) has to be there on its own and make decisions. Pre-planned missions is not autonomy. It's only autonomy when an unplanned event happens and it has to make a decision."

There are also different levels of autonomy, he says and different approaches. One, the human is still in the loop. Two, management by consent, using teleoperators, a field which started in the space industry because of the time delay in relaying signals. Three, management by exception. "A lot of oil and gas rigs and offshore installations are on level three, management by exception. On ship there's thousands of signals



Oceaneering's Freedom concept, displayed in 3D-printed model form at the Subsea Valley conference in Oslo.

Images from Elaine Maslin

just to control the power plant. So the system is more or less autonomous. Four, highly autonomous. Sørensen says fully autonomous tends not to be used – the discussion gets rather philosophical.

How autonomy is implemented can also take different forms. Platforms can sense then act, or sense, model, plan and then act. While something like Kongsberg's power management system for dynamic positioning has autonomy, its not so much able to reconfigure and make deliberative choices, says Sørensen, giving an example. Similarly, an unmanned platform isn't autonomous, it's reactive, he says. It could be made more autonomous by introducing deliberative control architecture. Take it another step and the system can learn by sensing and by doing.

Critically, situational awareness needs to be built in, to provide a high level of autonomy. "That's one of the crucial areas that's related to sensor technology," influencing how perceptive of the environment a system can be. "Is it able to perceive and sense information and then start to project that information in to future (i.e. make predictions and act on them)? That's one crucial research areas we are working on."

Examples of this include mapping systems which are able to detect, by themselves, any gaps in the data they have collected and go back and fill them in, during a mission. An intelligent system like this was used to track plankton in the water column, having had to find the plankton in the first place then follow it. These capabilities will be crucial when systems are working with and around subsea oil and gas systems, which is expected to be one of the main areas where autonomous systems are required, along with ocean science, says Sørensen.

For whatever the purpose, be it oil and gas exploration, renewables or aquaculture development, shipping or ocean science, the range and capability of subsea equipment and ancillary and support systems is expanding by the day, aided by developments in ICT, nanotechnology and even biotechnology (for the snake motion used by Eelume, for example), including new materials, microe-electric-mechanical systems, and big data. As an example, systems are being developed which could sense and distributed forces along the body of an underwater vehicle, in order to compensate for or reduce drag, says Sørensen. He also cites micro to macro actuation and sensing, and machine vision systems using hyperspectral sensing which can take in any wavelength to classify and detect things that we haven't been able to before. The possibilities are vast.

Sørensen also sees a "democratisation" of this space. With cheaper satellites and commercial underwater drones available to the public, "everyone can be an ocean scientist." It's a timely availability of technology, Sørensen says. "Everyone should be aware of the oceans, and how we care for them. Putting plastics in the ocean, we will not get away with that, the public will see it more and more.

"We see there is huge potential for unmanned autonomous systems, from space to the seafloor for mapping and monitoring of the oceans," says Sørensen.

How this world will be ruled and regulated in yet to be answered. There are also concerns about cyber security. But, people also need to look at their business models, says Sørensen. "Where ever you are sitting, I would be worried about my business model. There are changes going on, you need to be awake," says Sorensen.

Kongsberg's Yara Birkeland unmanned container ship concept. Image from Kongsberg.

Images from Kongsberg

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Lander Depth

Record Set for the Peru-Chile/ Atacama Trench

By Kevin Hardy & Dr. Osvaldo Ulloa

Kevin Hardy, Global Ocean Design LLC, San Diego, CA, USA, and Dr. Osvaldo Ulloa, Professor, Universidad de Concepcion, Chile, Director, Instituto Milenio de Oceanografía (IMO-Chile)

Abstract: A Chilean-led expedition to explore the ocean trench off it's own coast succeeded in launching and recovering a benthic lander named "DOV Audacia" (Audacity), three times to deeper than 8,000 meters, the last to a record depth of 8,081 meters deep. Using a Mocness Trawl the expedition also collected plankton at a record depth of 5,000 meters. The Atacamex 2018 expedition represent a milestone for marine science in Chile, as researchers there pursue seminal work in deep-sea exploration and research.

The hadal zone is the deepest region of the ocean, from 6,000 to 11,000 meters below sea level. Their access and study is extremely difficult due to the high pressures and great difficulties of reaching these depths. For these reasons - not for lack of interest - this area has remained practically unexplored. The hadal zone comprises more than a score of trenches, many forming the Pacific Ring of Fire, where the Earth swallows part of its crust due to the sinking of one tectonic plate under another, giving rise to island chains and mountainous areas such as the Andes. Ocean trenches can erupt unexpectedly in intense seismic activity, producing shattering tremors and destructive tsunamis.

Along the west coast of South America lies the Peru-Chile (Atacama) Trench, the longest of the planet, with a maximum depth estimated by sound of 8,065 meters, making it the tenth deepest trench in the world.

This past 25 January – 02 February 2018, on the Atacamex 2018 Expedition, Chilean investigators from the Instituto Milenio de Oceanografía (IMO-Chile), led by Professor and Institute Director Osvaldo Ulloa, made the first observations and gathered samples from the absolute deepest depths, 8,081m in the Atacama Trench. The Chilean scientific vessel Cabo de Hornos, operated by the Chilean Armada, was the surface support ship.

Achieving the historic exploration first required finding a way other than the massive winch and long wire normally used to plumb the hadal depths. Instead, the reseachers relied on the design and construction of a custom hadal-class free vehicle, a benthic lander. Made from modern materials, the

Figure 1:
The Chilean benthic lander Audacia is lowered into the sea at the start of its third, and record setting dive, to 8,081m in the Atacama Trench.

Images Courtesy Kevin Hardy and Atacamex 2018

high-tech, and compact autonomous deep-ocean vehicle was designed and built by Global Ocean Design (San Diego, CA). Dr. Ulloa named his benthic lander "Audacia" (Audacity), to recognize the boldness and fearlessness needed to challenge an unexplored frontier. The benthic lander "Audacia" is 96"/244cm tall x 25"/64cm wide (49"/125mm wide with the side variable flotation pods) x 21"/53cm deep, with an weight of approximately 400-lbs/182kg. In water, the lander was trimmed to float like a spar buoy with 40-lbs of positive buoyancy. An expendable anchor weighing 80-lbs/36kg, took the lander to the bottom at about 1m/sec rate. Lateral offset by a surface current would not have much affect. If a surface current were 100m thick, the lander would blow through it in 1min 40 sec. The benthic lander "Audacia" was designed and built by Kevin Hardy, Global Ocean Design (San Diego, CA), a world expert in the design and construction of deep-sea hadal landers for exploration. It utilized components from a number of international companies.

The benthic lander made three dives during the Atacamex 2018 expedition, all of them to depths of over 8,000 meters. After anchor release, it returned to the surface close to the point of deployment.

The main achievements of "Audacia" in the Atacama Trench are:

- Carrying out in-situ measurements and observations below 8,000 meters of depth;
- Registering a depth greater than the historic record value (8,065 meters), establishing a new record of 8,081 meters;
- Collecting samples of seawater at more than 8,000 meters of depth, which will allow first-time observations of what type of microorganisms inhabit the waters of the Atacama Trench, as well as some of the chemical properties of ultra-deep seawater in this region of the Pacific;
- Obtaining photographs of the seafloor of the trench at more than 8,000 meters deep;
- Obtaining amphipods (crustaceans) at more than 8,000 meters of depth using a baited trap that was deployed autonomously by the lander;
- Imaging the active and dense biology living in the benthic boundary layer;
- Demonstrating the use of highly adaptable benthic landers, allowing increased exploration of the deep ocean at a lower total cost.

THE BENTHIC LANDER

The benthic lander is an untethered free vehicle, meaning once it is over the side, all physical connection to the ship is severed. The ability of the lander to transit down and back is based on controlling density in accordance with Archimedes' Principle: if the lander is heavier than seawater it sinks, if it's lighter, it floats. An expendable anchor provides the negative weight to sink, fixed flotation provides the displacement to float back to the surface once the anchor is released.

Benthic landers are the most cost-effective way to get to midwater or benthic locations. They can carry traps, samplers, and sensors. They can travel to any depth, and remain for short periods of time to multiple years. Landers can be released with

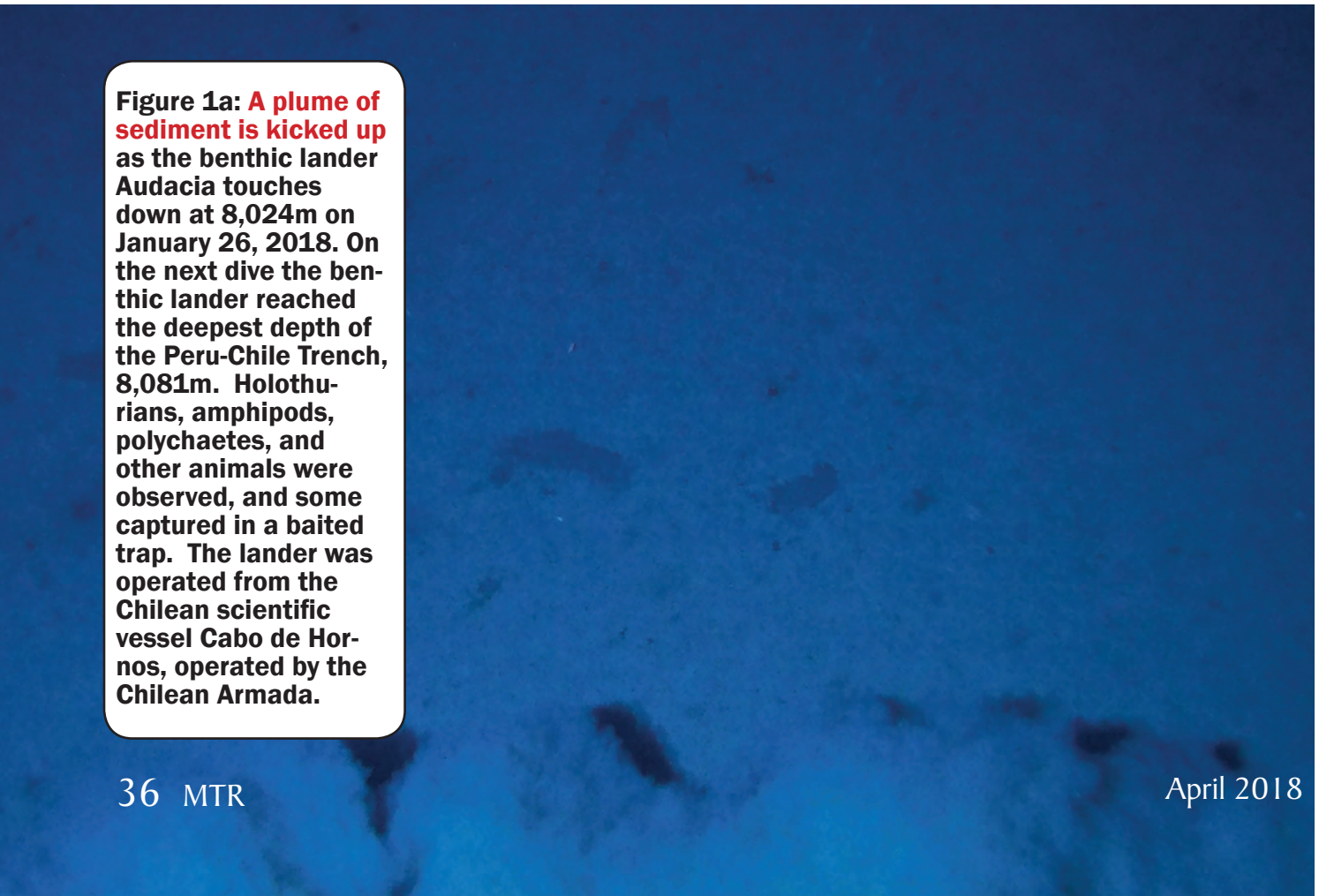


Figure 1a: A plume of sediment is kicked up as the benthic lander Audacia touches down at 8,024m on January 26, 2018. On the next dive the benthic lander reached the deepest depth of the Peru-Chile Trench, 8,081m. Holothurians, amphipods, polychaetes, and other animals were observed, and some captured in a baited trap. The lander was operated from the Chilean scientific vessel Cabo de Hornos, operated by the Chilean Armada.

Images Courtesy Kevin Hardy and Atacamex 2018

Figure 2:
The benthic lander Audacia is raised over the side for deployment by the deck crew of the modern Chilean scientific vessel Cabo de Hornos, operated by the Chilean Armada. The glass spheres put bouyancy high, while the instruments put the weight low, creating inherent stability.

Images Courtesy Kevin Hardy and Atacamex 2018

countdown timers, acoustic command, galvanic time releases (GTR), or by a pre-programmed event trigger. Operations may be conducted on smaller charter vessels from ports close to the site of interest, freeing researchers from the significant cost and scheduling issues of dedicated oceanographic vessels. Some are small enough to be lifted with one hand from the ocean, but strong enough to journey to the bottom of any ocean trench. Expanding uses include exploration, science, research, and environmental monitoring. They can be deployed singlely, or in large numbers to survey a large area from a small vessel. Once the lander is deployed, it is free of the ship, while at the same time the ship is free if the lander. Landers can be configured to communicate with each other, or with a surface platform such as an oil platform. Many of the same sciences proposed using the cable-to-shore OOS networks can be done with benthic landers, with the limitation that data is not available 24/7. Devices designed for mating to the OOS can be qualified using landers.

Deployment of DOV Audacia utilized a crane, taglines, and a quick release. Upon return to the surface, a pair of Zodiacs pulled the lander to the ship, Cabo de Hornos, where a sling was attached to hoist the lander back on-board using the crane. The lander was secured in a vertical orientation so both sides of the lander were accesible for sample removal and data download.

The buoyancy budget is managed by use of plastics over metal for the frame and side panels. Two 17" borosilicate glass spheres (Nautilus Marine Service, Buxtehude, DE) provide both flotation and housings, and are lighter than syntactic. Through-hull adapter fittings and vacuum/purge ports in the glass were provided by Global Ocean Design. Underwater connectors were provided by MacArtney/SubConn.

Pairs of 10" flotation spheres, rated to 10km depth, added one to each side up to a maximum of 8, provide variable buoyancy of up to 72lbs/33kg. The 10" spheres may also provide auxillary instrument spheres for guest researchers who wish to "catch a ride" on the Chilean lander. A ballast weight tray at the bottom provides convenient attachment of trim weights.

A 40-kg anchor weight pulls the benthic lander to the seafloor. To rise, the anchor is released by either the BART acoustic command system (EdgeTech, West Wareham, MA) or a back-up countdown timer (Global Ocean Design). The EdgeTech BART board developed for this mission features 2 burnwires, and three additional commands, all of which could likewise be converted to burnwires.

Radio Direction Finding (RDF) and strobe recovery beacons were made by Xeos (Dartmouth, NS, CAN). These worked very well. A custom GPS beacon board (Global Ocean Design) and interior LED strobe, worked well. Satelitte covereage in the southern hemisphere slowed the rate of determining true position transmitted to the ship.

Chilean researchers requested twin 30-liter water samplers be included on their lander for microbial studies. These were provided by Ocean Test Equipment (Miami, FL).

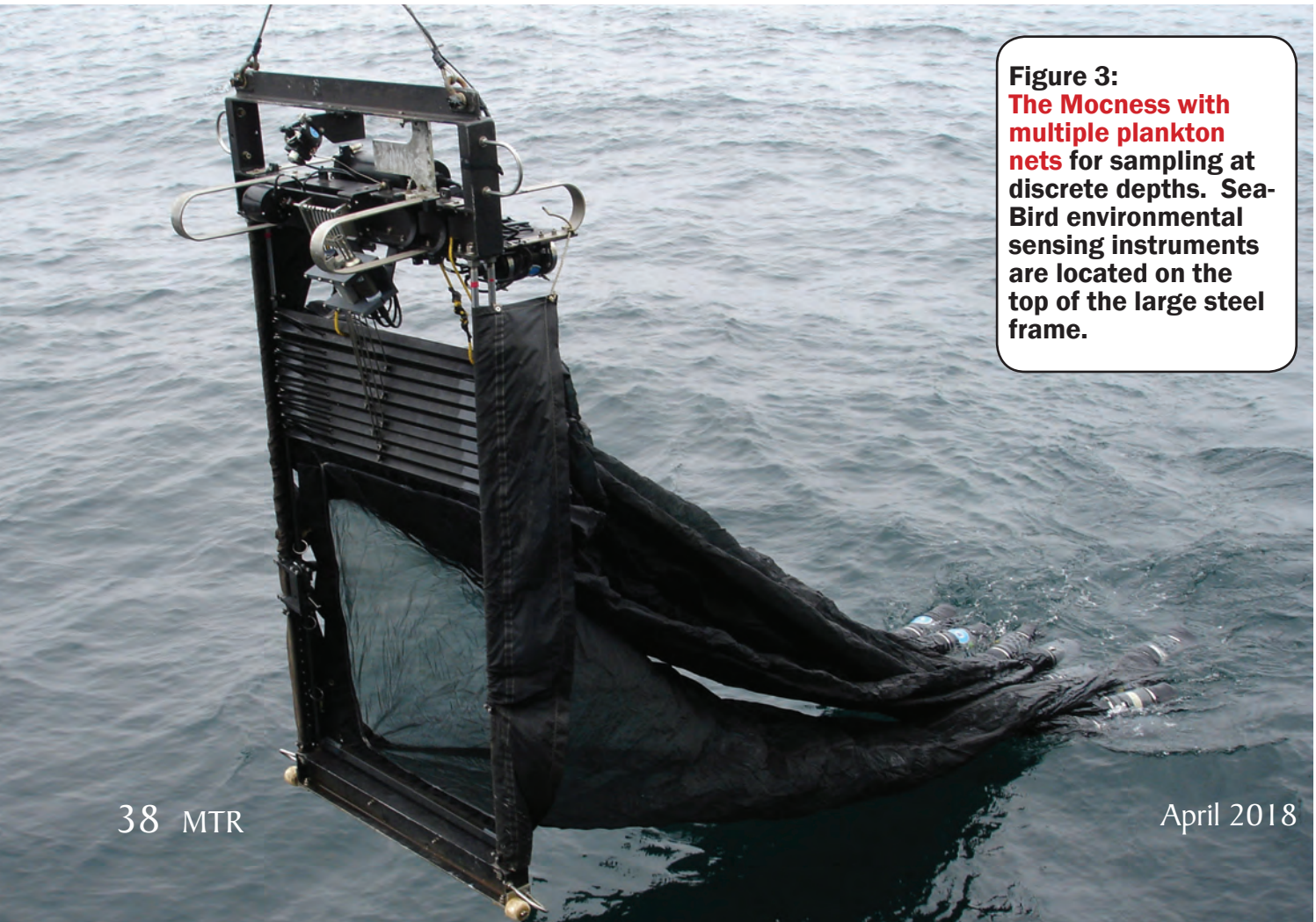


Figure 3: The Mocness with multiple plankton nets for sampling at discrete depths. Sea-Bird environmental sensing instruments are located on the top of the large steel frame.

Images Courtesy Kevin Hardy and Atacamex 2018

The tiny "Duet" P/T sensor (RBR, Ottawa, ON, CAN) worked very well to maximum depth, providing a cross-check to the main Sea-Bird sensor, as requested by the Chilan researchers. A Deep 19 CTD with DO sensor (Sea-Bird Scientific, Bellevue, WA) was the primary sensor package preferred by the Chilean scientists. The CTD sensors worked flawlessly to full trench depth, while the DO sensor did not work below 1500m.

The self-recording underwater video camera was developed for this project by SubAqua Imaging (San Diego, CA), and Pisces Design (La Jolla, CA). The 14.8vdc/32Ah battery pod with internal BMS to power the LEDs worked well (Global Ocean Design). The pressure compensated LED lights have some improvement needed to function more reliably.

With the trench so close to the shore, Hadal Explorer James Cameron, who stayed in touch with the expedition, surmised that gigantism might be observed among the Atacama Trench benthic amphipods. Samples of large amphipods were indeed captured in baited traps.

Benthic landers allow any institution or agency of any size, in any country, the opportunity to explore their own seas to any depth they'd like, from the shallow continental shelf to the ocean trench floor, for a time period of their choosing. It's disputive technology that empowers everyone.

THE MOCNESS

Along with the benthic lander "Audacia", the Atacamex expedition utilized other latest-generation equipment: the Mocness (short for "Multiple Opening and Closing Net, with an Environmental Sensing System"), a large plankton net with different compartments that open and close through an electroacoustic mechanism, permitting the collection of samples at different depths (Biological Environmental Sampling Systems (BESS), N. Falmouth, MA). Erich Horgan (BESS) and Dr. Rubén Escribano reported another historic world record for this region of the ocean, "obtaining, for the first time, samples of plankton from a depth of 5,000 meters." The Mocness, the only one of its kind in the Southern Cone of the South American continent, collected a large quantity of new deep-sea organisms, including fish, which will now be studied in the IMO laboratories for identification and better understanding of their biology.

From the Chilean Navy research vessel AGS-61 Cabo de Hornos, Dr. Osvaldo Ulloa, Atacamex 2018's lead scientist, declared that "we achieved repeated access to the bottom of the trench, to an even greater depth than reported, and from there we were able to collect water, organisms, images, and hydrographic information. The possibilities of putting sensors, to carry out —for example—seismological or current measurements, are there. With that, we're pointing to the path to bring about a national, multidisciplinary program for the exploration and scientific study of the Atacama Trench.

CONCLUSION

Figure 4: A small, delicate shrimp, alive and in perfect condition, collected by the Mocness plankton net.

Images Courtesy Kevin Hardy and Atacamex 2018

"Atacamex 2018 demonstrates that Chilean science, developed with passion, ingenuity, international collaboration, and audacity can contribute to the worldwide understanding of the planet. As a country, Chile possesses the human resources, the industry, and the tools to lead the exploration and study of the eastern South Pacific Ocean—the least known region on the blue planet."

Hardy added, "With their new benthic lander, and the experienced and talented IMO benthic lander team, Chile and its marine scientists have put themselves on the leading edge of deep-ocean investigation of the Atacama Trench and other areas of the southern oceans. They are an exceptional group, among the best I've ever sailed with. I'm very happy to have been part of this grand international adventure in search of new knowledge."

The oceanographic investigation, whose participants include researchers from Universidad de Concepción, the Pontifical Catholic University of Chile, and Universidad de Antofagasta, is being carried out thanks to the support of the Millennium Science Initiative (ICM), the National Commission for Scientific and Technological Research (CONICYT), the Chilean Navy, and private parties.

THE AUTHORS:

Kevin Hardy (right), founded Global Ocean Design LLC after retiring from the Scripps Institution of Oceanography. He previously designed and built the landers for James Cameron's DEEPSEA CHALLENGE Expedition.

Dr. Osvaldo Ulloa, (left) is Profesor Titular, Departamento de Oceanografía, Universidad de Concepción, Director of the Instituto Milenio de Oceanografía (IMO-Chile), and lead scientist of the ATACAMEX 2018 expedition.

Figure 5:
A large amphipod recovered from the Atacama trench during ATACAMEX 2018.

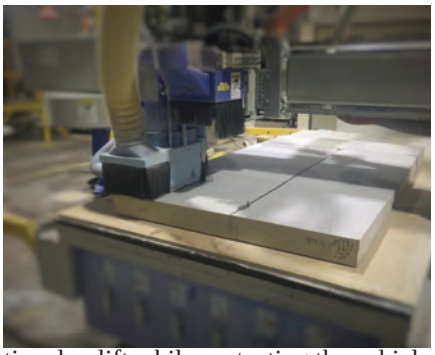
Images Courtesy Kevin Hardy and Atacamex 2018

Figure 6:
Chilean marine scientists collect samples from the benthic lander Audacia after its third trip to the trench floor, reaching 8081m.

Customization for Buoyancy Applications

Subsea vehicles and structures are required to minimize their weight in water, which necessitates the use of a lightweight materials that incorporate hollow glass microspheres (HGMS) that can resist the crushing pressures of the ocean. These HGMS can be customized via surface treatments, material chemistry selection, density specifications or particle size distribution, thereby optimizing their impact on the final subsea composite. When combined with a host of polymer matrices the resulting composites have spawned a host of high functionality subsea materials such as efficient static buoyancy, thermal insulation and buoyant fairing components.

The combination of these solutions can be seen in the operation of an ROV/AUV vehicle. The static buoyancy packs provide most of the uplift required to maintain stable operation. Thermoplastic fairing components provide additional uplift while protecting the vehicle from impact and abrasion. Umbilical and cabling use a thermoplastic sheathing or core to reduce weight while maintaining electrical performance. In addition to these, are a host of floats used on the equipment the ROV is servicing or deploying.



Trelleborg

ROV blocks being machined onsite at Trelleborg's Boston location.

Buoyancy Testing

When choosing a supplier for buoyancy, manufactures should look for a company that not only manufactures HGMS but can also carry out testing of density, strength, moisture content and more. Additionally, the finished buoyancy package should go through its own testing to ensure the final product meets the density, weight and strength parameters for the project. Typical buoyancy tests include:

- Hydrostatic testing of full cubic feet buoyancy blocks
- Cycle testing for 1,000 times
- Full testing to hydrostatic pressure on random samples
- 10% of manufactured blocks tested at service pressure for 24 hours

Through customization and testing of high–tech hollow glass microspheres, deep-sea exploration vehicle manufacturers are able to meet their strength and weight specifications for each unique vehicle.

Balmoral's Boltless Restrictor

Balmoral Offshore Engineering has launched a new product for the SURF sector which it claims will reduce current installation times by up to 80%. The company has extended its range of polyurethane bend restrictors to include a boltless version (patent pending) in response to industry demands for project cost savings and as part of a wider product improvement drive. Designed as interlocking elements, restrictors prevent over-bending at the interface between flowlines, umbilicals, cables and rigid structures such as wellhead connections, J-tube exits, rigid pipe crossovers and PLET connections by mechanically locking up.

Although there are products on the market that claim to be boltless, Balmoral says none of them actually are. The new boltless restrictor is capable of:

- rapid assembly to minimize installation times
- performing on flying leads, umbilicals, risers and flowlines
- enduring long-term loading conditions
- enduring hot, wet conditions
- managing large bending loads

Balmoral Offshore Engineering

DeepWater Buoyancy

DeepWater Buoyancy, made its exhibitors debut at Oceanology International 2018, using the venue to introduce visitors to its Pop-Up Buoy Recovery System (PUB) which it has added to its line of subsea buoyancy products and the StableMoor, which is specifically engineered for high current applications, designed to reduce drag and increase mooring stability in extreme flow regimes.

David Capotosto, DeepWater Buoyancy Director of Business Development was on hand for the three full days of exhibition in London and reports a strong interest from the show.

Chesapeake Technology: SonarWiz

Chesapeake Technology announced the release of SonarWiz 7.1 and two new modules.

Users now have the option to buy SonarWiz Magnetometer and SonarWiz Multibeam as standalone licenses, giving users both a lower priced entry point and an upgrade path.

"I have used SonarWiz a lot for sidescan data, but this was my first experience using it with magnetometer data," said Doug Bowlus, Santa Cruz Island Foundation. "Previously I've processed magnetometer data in a competing product, and I must say I like what you've done.

"The anomaly picks are quick to make and the contour plotting really helps to visualize the data. The process was quick and efficient, perfect for running after each day of survey."

The SonarWiz 7.1 release adds productivity enhancements and automates many steps.

Drag and drop bathymetry dramatically increases the speed of the import and merge process, and the automated vessel creation saves time. New Multiple EGN tables streamline workflow and speed up signal processing.

Unified waterfall windows with sidescan, bathymetry and backscatter allow users to pick contacts and digitize features across 3 data types simultaneously.

The enhanced color palette support makes it much easier to adjust individual files, and user specified tide and sound velocity during data acquisition gives users greater control and precision.

JW Fishers: New Proton 5

JW Fishers Mfg. is celebrating its 50th year in business and has been producing magnetometers since 1979. The new Proton 5 boat-towed magnetometer is a fully digitized system that displays the current 5-digit measurement on an easy to read 6-inch LCD screen that is backlit for night operations. Up to 80 of the previous measurements are displayed graphically in a history plot on the screen and the optional altimeter (displays towfish distance from ocean bottom) is displayed on the LCD screen. User friendly menus allow easy configuration of all operation settings. The "auto tuning" feature greatly simplifies set-up when operating in different locations. Done directly from the control box the "auto tune" functionality allows the user to quickly tune the magnetometer without having to disassemble and manually configure the device. A unique feature of the towfish is its ability to be separated into two parts so that it easily fits into a watertight Pelican case for storage and transportation.

JW Fishers

The Diver Mag 1 is a top performing, microprocessor driven marine magnetometer detection system with a one nano-tesla sensitivity that works equally well on land and underwater. The magnetometer will locate pipe lines, cables, cannons, dredge parts, and just about any ferrous metal object of any size. The Diver Mag 1 is a commercial grade unit and designed with user friendly controls for ease of operation.

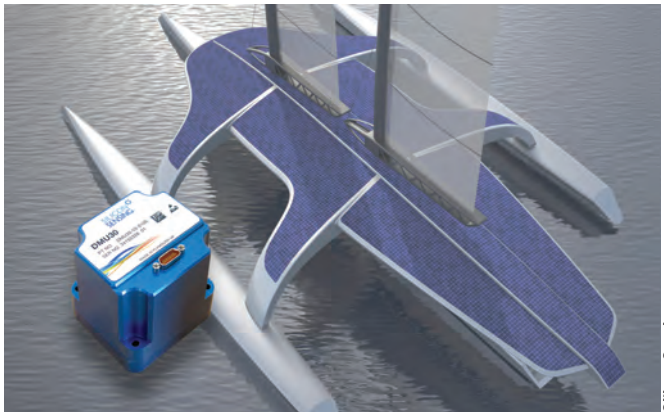
Out of the water, the handle grip makes the mag easy to carry. An adjustable sensitivity switch makes pinpointing even the largest of targets extremely easy. The readout is displayed on an easy to see 5-digit LED for murky water or night operations and an audio output allows the diver to operate the system without the need to watch the LED display.

All of JW Fishers products are backed by a two-year, unconditional warranty.

DMU30 Featured on MAS 400

Silicon Sensing Systems latest DMU30 inertial measurement unit (IMU) was chosen to provide accurate ship's attitude data to the autopilot that will navigate the ground-breaking Mayflower Autonomous Ship (MAS 400) as it travels the world.

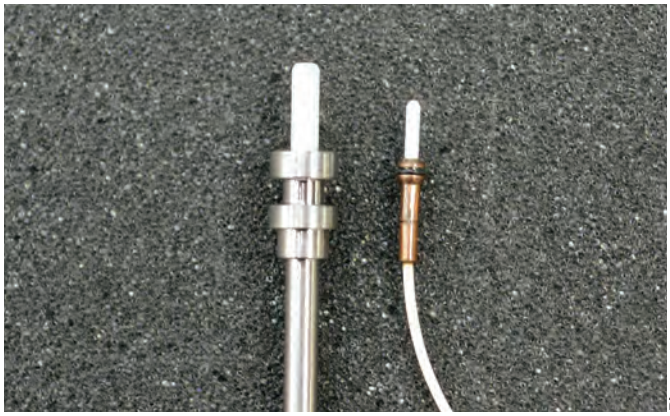
The DMU30 is the company's latest high performance micro-electro mechanical system (MEMS) IMU and is designed for use where there are exacting motion sensing requirements, as with the MAS 400. DMU30 is a full 6 degree of freedom (DoF) IMU that uses the company's own gyros and accelerometers to create a small, rugged and cost-effective unit that offers the high levels of performance more typical of larger, heavier and more costly fibre optic gyro (FOG)-based devices.



Silicon Sensing

Birns Offers Options

Birns, Inc. added a new 1.25mm optical ferrule for its Birns Millennium connector series—a high performance, high density dry-mate connector range suitable for applications to 6km depth. The series can be used with molded or oil-filled cables in straight or 90° configurations and is available in high and low voltage, coax, fiber-optic, and hybrids of electro-coax, electro-optical and electro-opto-mechanical formats. The 1.25mm ferrule provides single-mode and multi-mode options. The new ferrule is available in addition to the existing 2.5mm ferrule offered in the series, with both made of ceramic zirconia.


Birns

New In-line Dry-mate Connector from TE

TE Connectivity revealed its new DEUTSCH high density optical in-line dry-mate connector. TE said it developed the multichannel fiber optic connector from high pressure/high temperature (HP/HT) fiber optic technology that is backed by more than 30 years of performance in the field. According to TE, the DEUTSCH high density in-line connectors offer a cost-effective solution for multichannel fiber optic management, packing 12 to 24 fiber optic channels (FO) in standard versions and up to 48 FO upon request.


TE

Tritech's New Multibeam Imaging Sonar

The new 720im sonar from U.K. manufacturer Tritech International Limited is said to be the world's smallest multibeam imaging sonar. As the latest addition to Tritech's Gemini range, the small sized and competitively priced sonar brings multibeam imaging technology to situations not previously possible. At 500g and 63mm wide, the 720im is significantly smaller than comparable sonars, yet it delivers superior quality sonar imaging from an ultra-compact unit thanks to state-of-the-art microelectronics. Having a 90° horizontal field of view and 50m range, with an update rate up to 20Hz, the Gemini 720im brings real-time imaging to places where multibeam was never possible before, the manufacturer said.

Tritech

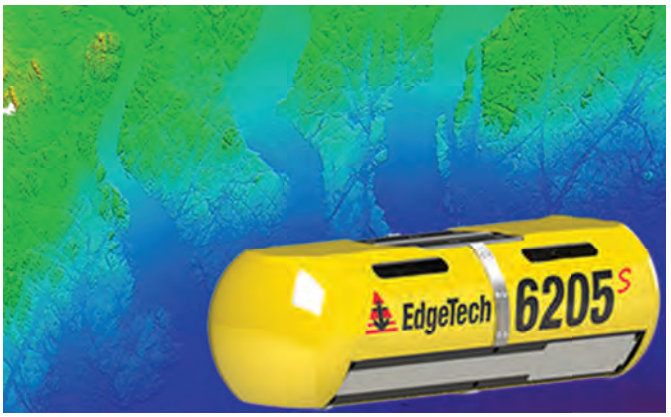
New Products

Nautilus Marne

New Hyperbaric Pressure Testing System

Nautilus Marine Service GmbH, the German manufacturer of VITROVEX deep sea pressure housings started operation of a new hyperbaric testing system simulating hydrostatic pressures found at water depths up to 13,000 meters. As of January 2018, Nautilus Marine Service GmbH operates a hyperbaric testing chamber with capability that extends to full ocean depth and beyond (1.300bar/18.850psi).

Nautilus Marine Service is integrating and expanding its in-house capabilities by being able to verify and test all of its own products and components to the highest standards possible.



Edgetech

EdgeTech Next Gen Swath Bathymetry & SSS

EdgeTech 6205s is introduced as a next-generation Swath Bathymetry & Side Scan Sonar System. The 6205s is redesigned in a smaller, lighter package with additional features and functions that are designed to make on-water survey operations more effective and efficient. The 6205s produces real time, high resolution, 3D maps of the seafloor while providing an enhanced and fully integrated swath bathymetry and dual frequency side scan sonar system.

The system offers co-registered dual frequency side scan and bathymetry with swath coverages up to 200° with a selection of equidistant and equiangle output options. New, higher-resolution, shallow-water-optimized, frequency pairs are also available in the 6205s.

Riptide

Riptide Debuts 2G Micro UUV

Riptide Autonomous Solutions launched its second generation "micro" unmanned undersea vehicle (UUV) product, with a focus on performance and manufacturability improvements. Through a near-total redesign of internal electronics the new MKII μUUV offers a nearly 70% reduction in hotel load power to 3.5 Watts, extending vehicle endurance across the vehicle speed regime. New manufacturing approaches, including increased use of molded, rather than 3-D printed, parts allows for expanded depth ratings, faster production times and improved quality assurance.

TE

Customized Umbilical Winches

Greek Assodivers Underwater Contractors have taken delivery of two MERMAC winches from MacArtney: one 19.5 ton AHC (active heave compensation) winch and one 6 ton umbilical winch. These winches form part of a project relating to Denmark's biggest offshore wind farm Kriegers Flak located in a shallow area in the Baltic Sea between Denmark, Sweden and Germany. The AHC winch is intended to relocate huge stones from the seafloor, and the umbilical winch is to be used for pulling a cable plough. Electric AHC winch solutions are often preferred for ROV systems and for handling equipment that is to operate near or on the seabed.

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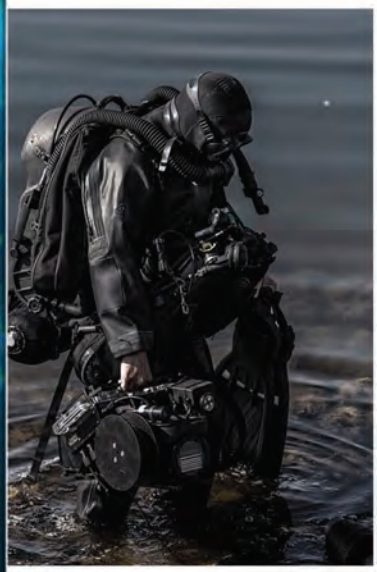

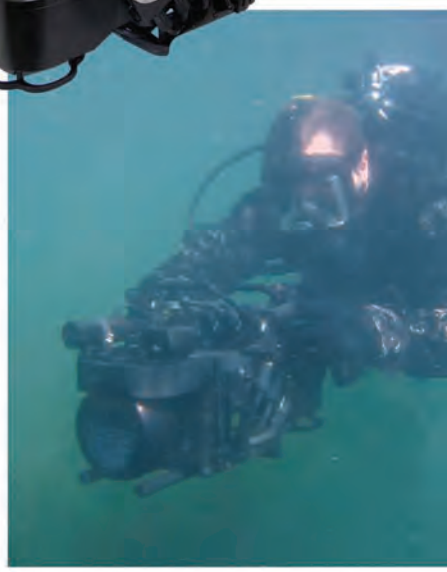

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