MARINE TECHNOLOGY REPORTER

March 2016

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Subsea Technology Digs In

Autonomy Rules
Dan Hook, ASV Weighs In

Fiber Insights
CWDM for Subsea Market

Seafloor Mapping
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On the Cover

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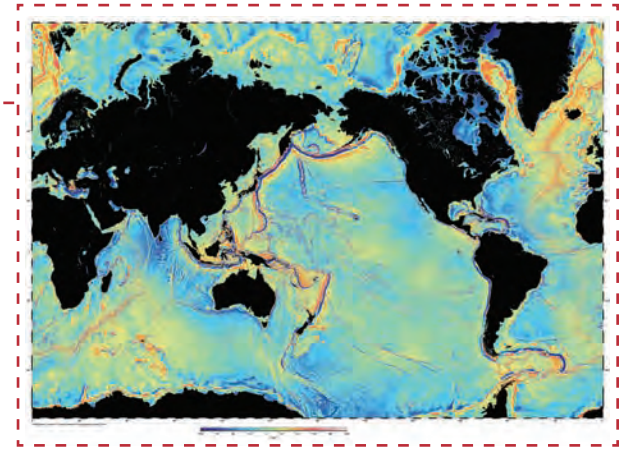

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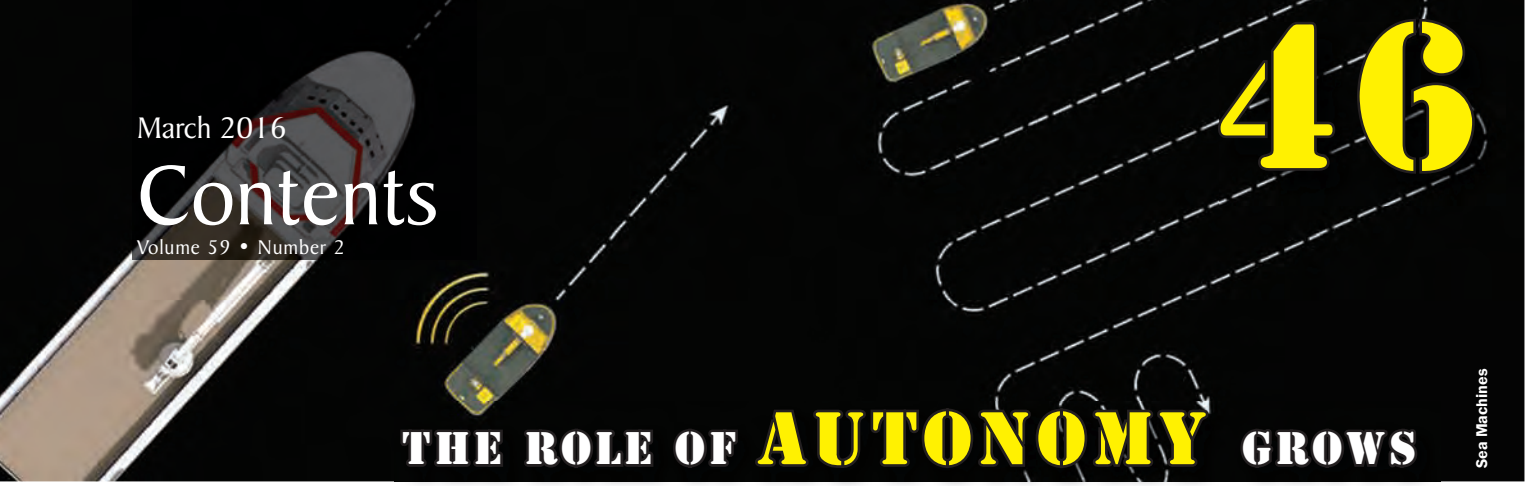

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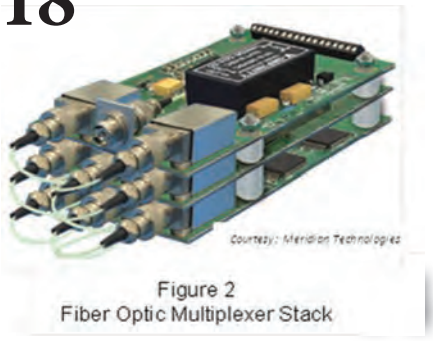

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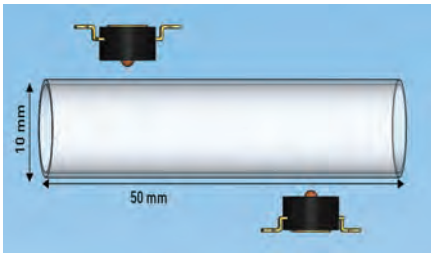

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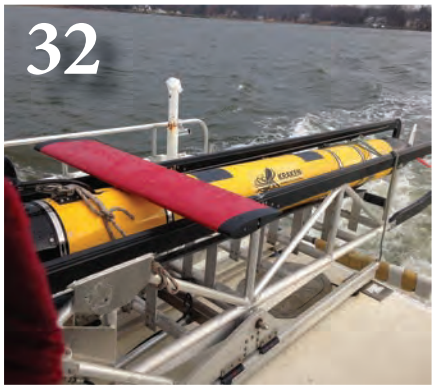

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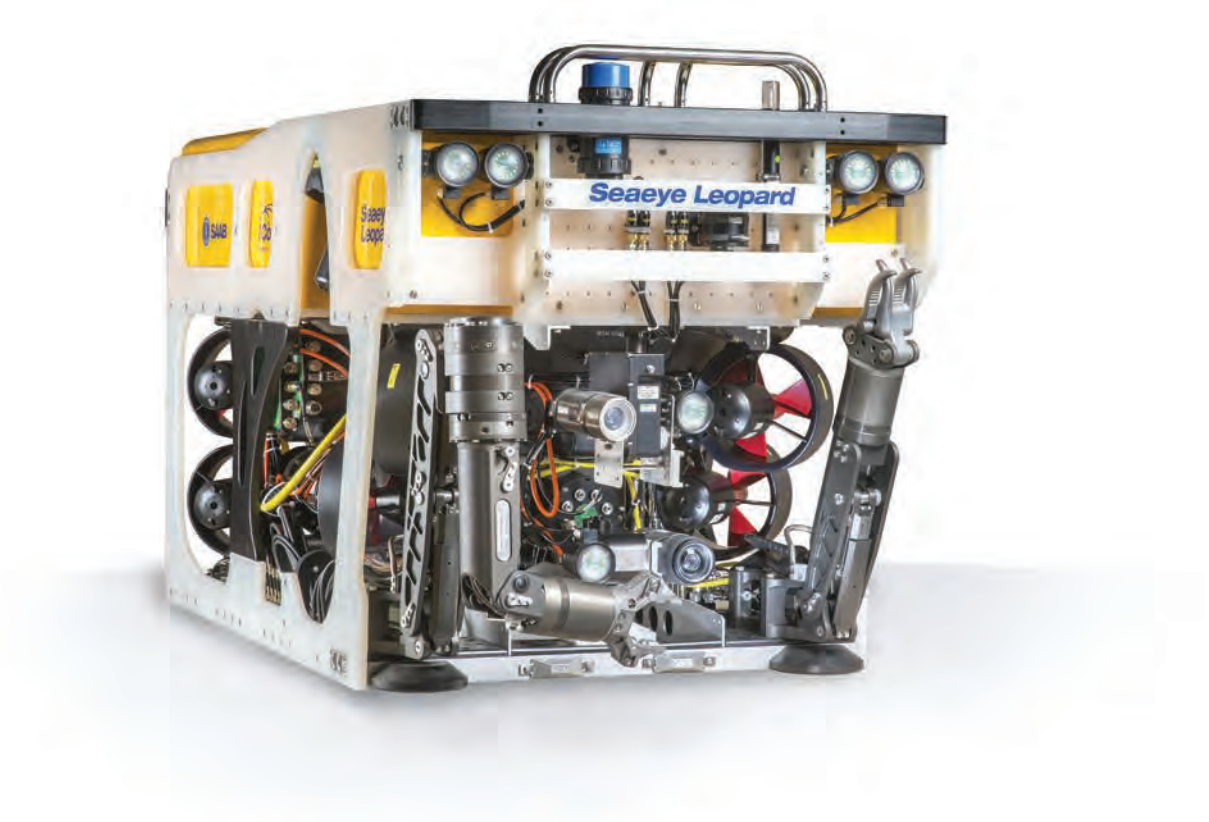

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Many readers of MTR are acutely aware of current market conditions premised on the continued low price for oil and gas, as business in the offshore sector has come to a crawl as the collective industry awaits the economic and political circumstance that will collectively – and inevitably – conspire to drive energy prices higher. While you would be hard pressed to find anyone who truly enjoys this cyclical 'shaking of the trees,' there could be a long-term silver lining for the subsea sector, particularly for companies and technologies moving forward faster on autonomy, as it is times like these that tend to produce some of the more profound innovations in terms of efficiency and cost-effective operations.

To that end, our "View from the Top" interview is with **Dan Hook**, managing director of ASV. ASV is a company that has grown steadily and strong from a two-person start-up to a sector leader in the business of delivering state-of-the-art autonomous surface vessels. Read Hook's insights on the pace and direction of the industry as a whole, starting on page 10. Autonomy is also covered more broadly by contributing writer John Haynes, who starting on page 46 contends that the age of unmanned surface vessels has evolved 'from concept to service.'

For those visiting Oceanology International 2016 in London and in need of a final 'tech fix,' we offer our preview starting on page 70 of new technology scheduled for unveiling and display March 15-17 at the Excel in London.

Switching from technology to markets, the centerpiece of this edition is our conversation with **Zdenka Willis**, Director, U.S. Integrated Ocean Observing System (IOOS). In mid-February 2016 NOAA officially released its report which aims to give shape and size to the U.S. Ocean Enterprise, a collective entity estimated to be in excess of $7 billion annually. Simultaneous with the report release MTR was afforded the opportunity to question Willis for her take on this initial survey and her perspective of its impact on the U.S. market. Details on the report and her insights start on page 42.

MARINE TECHNOLOGY REPORTER
www.marinetechnologynews.com
Vol. 59 *No. 2*
ISSN 1559-7415
USPS# 023-276
118 East 25th Street,
New York, NY 10010
tel: (212) 477-6700
fax: (212) 254-6271

Marine Technology Reporter (ISSN 1559-7415) is published monthly except for February, August, and December by New Wave Media, 118 E. 25th St., New York, NY 10010-1062. Periodicals Postage Paid at New York, NY and additional mailing offices.

POSTMASTER: Send all UAA to CFS. NON-POSTAL AND MILITARY FACILITIES send address corrections to Marine Technology Reporter, 850 Montauk Hwy., #867, Bayport, NY 11705.

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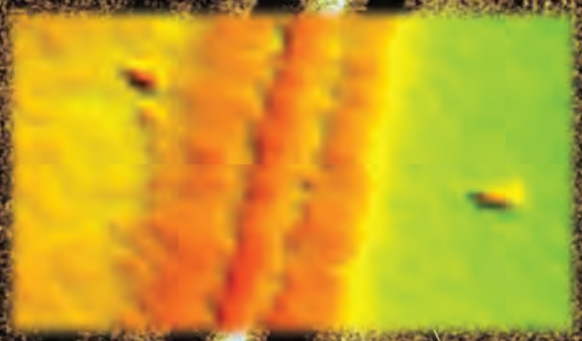

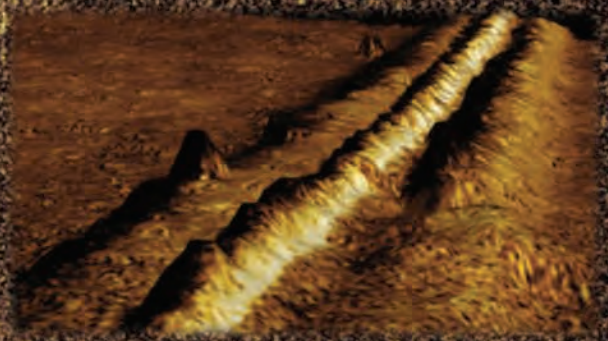

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Dan Hook, ASV

Earlier this year MTR met with Dan Hook, Managing Director of ASV, an innovator in the delivery of next-gen, high-tech autonomous vehicles. Hook discussed how ASV has evolved from a 2-person start-up to a sector leader.

By Greg Trauthwein

For our readers not familiar with ASV, please provide a brief overview of your company.

ASV is a highly motivated team of people designing, building and operating Autonomous Surface Vehicles and their control systems. The company has approximately 70 employees with facilities in the UK and US. ASV provides systems to a wide number of users around the world in defense, offshore energy and oceanographic applications. As well as providing complete integrated systems including platforms, payloads and control equipment we also provide our control software and hardware to other boat manufacturers and operators for integration with their vessels.

ASV has grown from 2 to 70 employees. What has been the primary driver(s) for this growth?

From the very outset of ASV we took the strategic decision to develop systems for defense, offshore energy, hydrographic survey and science. This approach was ambitious and hard work but has paid off as we have seen all of these markets grow in terms of unmanned vehicle application. We have


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delivered good equipment to some high level customers who came back for more and this has allowed us to grow the team in terms of design, production and support staff.

Thomas Chance, who is well-known in subsea circles, has had a hand in the development of ASV. Put in perspective his contribution.

Thomas Chance is our Chairman and very much involved with the business in terms of strategy and financial planning. The experience that Thomas gained by introducing AUVs to commercial operations is really helping us to do the same with ASVs.

What is in the works at ASV that our readers will look forward to in 2016 and beyond?

The team worked really hard in 2015 to develop and test some new platforms and technical capabilities that will be launched in 2016. We will be launching our C-Worker 5 vehicle at Oceanology International which is a commercial grade vehicle designed specifically for the Hydrographic Survey market. The 5 meter long vessel can run with a full survey spread in parallel with a conventional survey vessel for days on end offering huge operational efficiency benefits. We will be offering a lease model for these systems with four vessels in the lease pool in the spring with more to follow. We will

C-Worker 6

(Photo: ASV)

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I am sure all of the readers would agree that we need more data from the Oceans but with the increasing costs of sending ships to sea we need to look towards other technologies and methods. Unmanned systems (including satellites) offer a huge potential in this area, they can operate for long periods of time gathering data for comparatively low costs.

also be launching our larger C-Worker 7. This diesel electric 'work class' ASV is constructed with redundant systems and ideal for offshore energy applications.

The large moon pool (2.5m long, 1m wide) can be equipped with a wide range of payload frames including USBL, winches, sonars and even an inspection ROV system. The last exciting development that I will mention here is the launch of some significant enhancements to our control software and hardware system "ASView."

With the support of some UK Government innovation grants (Innovate UK) and our own internal investment we have been developing an over the horizon satellite communications capability. This will be complete with new operator assistance tools including COLREG compliant collision avoidance and multi-sensor fusion to give a navigational picture for safe operation.

Looking at "Autonomy" as a whole in the maritime sector, can you put in perspective for us how (and if) attitudes, acceptance, and adoption of autonomous vehicles has evolved over the past few years.

At ASV we see a very varied use and understanding of the words 'autonomy' and 'unmanned'. Different customers in different markets can mean very different things when talking about levels of autonomy and remote supervision. We have certainly seen a very encouraging movement in acceptance and adoption of unmanned supervised systems where a trained operator is 'in the loop' of control. How frequently the operator directly interacts with control inputs and the bandwidth available for two way data exchange between the system and operator varies considerably between applications and operational scenarios. A trend over the last few years and certainly one we expect to continue to see over the next few years is that increasing levels of autonomy will allow for the safe reduction in frequency of interaction and data exchange or bandwidth requirements. However we do see that for nearly all real-world applications a human will remain in the loop for some time to come, it may just be that they are able to operate multiple vehicles or spend more time focussing on the data and results generated by the system.

Looking back, from the time you started your career to today: What technology do you attribute with having the greatest influence on the ability to explore and work underneath the water more efficiently and effectively, and why?

We have certainly seen huge leaps forward in battery technology, inertial reference units, USBL accuracy and sonar performance all allowing for more accurate and efficient operations. I think for me though the 'technology' making the biggest difference is the internet, allowing people to more rapidly share ideas and data to accelerate the development and adoption of other technologies. The international sales reach the internet provides allows people to sell more equipment which has an impact on reducing the prices, allowing more people access to the technology for exploration and work. It is a positive cycle!

When you look at your industry as a whole, and looking at the myriad of serious issues that we face as citizens of this planet, what do you see as the burning issues of the day that will put the work that you do in the world's oceans front and center for the next generation?

I think there are three issues here that I would like to talk about, reducing costs, increasing safety and enhancing the amount and accuracy of information we have about the oceans. With the current low oil price and commercial challenges of offshore renewable energy

I think there is a huge opportunity for ASVs to offer cost effective means of undertaking both support to installation and through life inspection work. We have already proven in several different applications that the adoption of ASV technology can have a positive impact on the 'bottom line' and I hope that the work we are doing will allow for cost reductions of generating energy offshore.

Safety is a high priority in everybody's mind, especially those that have had the chance to work offshore in challenging conditions. There is no doubt that by adopting unmanned vehicles we can put operators and offshore professionals in safe environments and allow them to remotely operate platforms

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in the extreme temperatures and sea states that have unfortunately claimed so many lives before. Unmanned technology certainly provides the opportunity for the current and next generation to have an even safer working life.

It is often repeated that we know more about the Moon than we do our Oceans and rather than Planet Earth it should really be called Planet Ocean or Planet Water seeing as over 70% of the surface is water! I am sure all of the readers would agree that we need more data from the Oceans but with the increasing costs of sending ships to sea we need to look towards other technologies and methods. Unmanned systems (including satellites) offer a huge potential in this area, they can operate for long periods of time gathering data for comparatively low costs. As they become more widely adopted they will reduce in cost and become even more widely used, another positive cycle!

If you had a crystal ball and could envision how this industry will look and operate in the year 2025, what would you see?

I think we will see more and more data in real time for everything we are doing offshore. This will allow for decisions to be made more quickly and effectively and for an increase in safety and reliability. I predict we will see more remote data and remote operations centers onshore where professionals will be on hand to work across a number of drill sites, or marine observatories rather than offshore at just one at a time.

Every business, every industry has its challenges. What do you consider to be the greatest challenge to your business today, and how are you investing to overcome that challenge.

Unmanned systems offer advantages in terms of cost savings and increased safety. One of the biggest challenges faced by the unmanned platforms industry is that their systems don't have personnel onboard for minor repairs yet have to operate at equivalent or higher levels of reliability than conventional vessels. We have been investing heavily in additional levels of redundancy, fault tolerant operations and health monitoring and actually now see opportunities to increase reliability because there are no people onboard! We have invested in our trials team and facilities to allow for more testing in different environments. This has included a temperature controlled test tank and new offshore workboat for trials. We are investing in working with local universities with expertise in accelerated environmental testing and statistical analysis of fault logging and reliability optimisation. We have seen great results already and take this industry challenge seriously.

Dan Hook's Career Path

I completed a Masters of Engineering in Ship Science and Naval Architecture at the University of Southampton. The University had strong links with what was then the Southampton Oceanography Centre and is now the National Oceanography Centre. It was there that they developed the Autosub series of AUVs and this sparked my interest in unmanned systems. After graduating I worked for approximately ten years in the development and testing of powerboat hull forms, system design and naval architecture consultancy whilst working on ASVs in the evenings and weekends. During this time I became a Chartered Engineer and rose to become Technical Director at a company called Seaspeed. Eventually in 2010 I had the opportunity to focus on ASV full time as the Managing Director and quickly recruited an excellent team to take it forwards. I have thoroughly enjoyed my career so far and found that working in the area of unmanned marine systems exposes you to a fascinating blend of technologies, people and places and would strongly encourage any student readers to choose it as a career.

(Photo: ASV)

CWDM for the SubSea Market

Originally developed for the Metro Telecom market, CWDM (Coarse Wavelength Division Multiplexing) technology has become ubiquitous in all telecom markets as well as the subsea market.

By Ed Miskovic

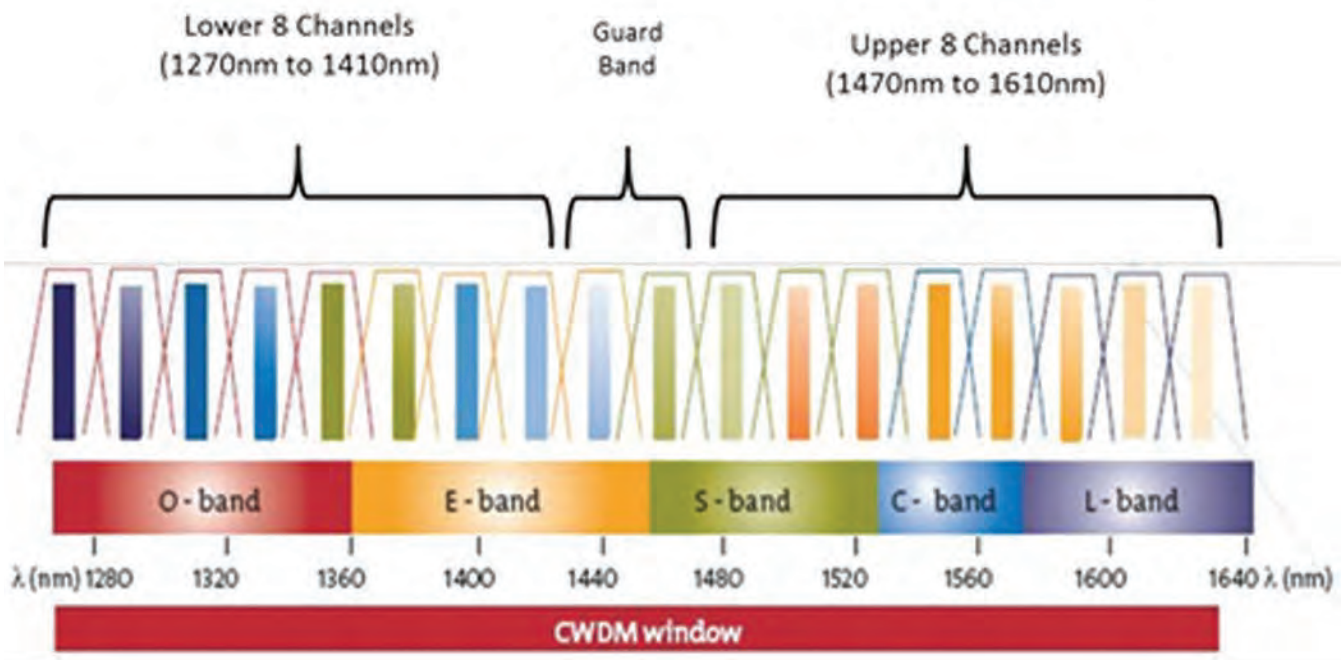
CWDM is a cost-effective and technology-efficient way to multiplex a number of signals on one fiber. There are a number of wavelength multiplexing techniques that can be utilized, depending on the number of wavelengths. Standard WDM (Wavelength Division Multiplexing) utilizes either two, three or in some instances four wavelengths using standard lasers. CWDM technology can multiplex up to 18 individual wavelengths onto a single fiber. DWDM (Dense Wavelength Division Multiplexing) can typically multiplex 40 or 80 wavelengths on a single fiber. More elaborate DWDM techniques allow even higher density wavelength multiplexing. The most common method for wavelength multiplexing in the subsea market is CWDM where lower cost lasers and laser drivers can be used while maintaining the ability to multiplex a wide variety and quantity of unidirectional and bidirectional signals.

While CWDM technology is available for both single-mode and multimode systems, single-mode is the most common type as it offers increased multiplexing and distance capabilities. Most CWDM systems area available in increments of 4 wavelengths or channels (from 4 to 16 wavelengths). Figure 1 illustrates the CWDM wavelength plan. The first or lowest wavelength is 1270nm while the longest wavelength is 1610nm in increments of 20nm. While some systems are available with 18 wavelength, most utilize up to 16 wavelengths leaving the middle two (1430 & 1450nm) as a guard band when combining the lower 8 with the upper 8 wavelengths.

There are three unique elements in a CWDM system – Wavelength-specific laser, CWDM multiplexer and CWDM demultiplexer.

Lasers – Lasers used in CWDM systems are the type known as DFB (Distributed FeedBack) lasers. The main characteristic of these lasers that is important in CWDM systems is the narrow spectral width, or wavelength spread of the laser's light. The more common laser used in many fiber systems is the FP or Fabry-Perot. These lasers have a spectral width on the order of 3-6 nm while the DFB lasers have a spectral width of 0.1 nm or less, making them perfect for use in CWDM and DWDM (Dense Wavelength Division Multiplex) systems. As the curve in Figure 1 illustrates, these DFB lasers for CWDM systems range in wavelengths from 1270nm to 1610nm, in increments of 20nm. One of the advantages of CWDM systems over DWDM is that the CWDM lasers do not require

Figure 1



(Courtesy: The Light Brigade)

temperature compensation in order to keep the wavelength from drifting. The wavelength variation of these DFB lasers as a function of temperature is on the order of 0.1nm/DegC. The passband of the CWDM multiplexer and demultiplexer is on the order of 10nm to 13nm, depending on manufacturer and design. In addition, the absolute wavelength of the lasers can vary by a couple nanometers. As such, the operating temperature range of the lasers and transmission equipment is approximately 70 to 100 degC, typically around 80 degC. Taking into account the various component tolerances and the laser's temperature drift, this results in an operating temperature range of approximately -10 oC to +70 oC – well within the range of subsea systems. DWDM systems, on the other hand, require elaborate wavelength stabilization circuits to keep the laser's wavelength from drifting at all as a function of temperature and performance variations.

CWDM Multiplexer/Demultiplexer – CWDM mux/demux devices are typically available in 4 or 8 channel increments. The common bands are as follows:

Band 1 (4-channel) ..... 1510 through 1570nm
Band 2 (8-channel) ..... 1470 through 1610nm
Band 3 (12-channel) ..... 1310 through 1370nm
Band 4 (16-channel) ..... 1270 through 1610nm

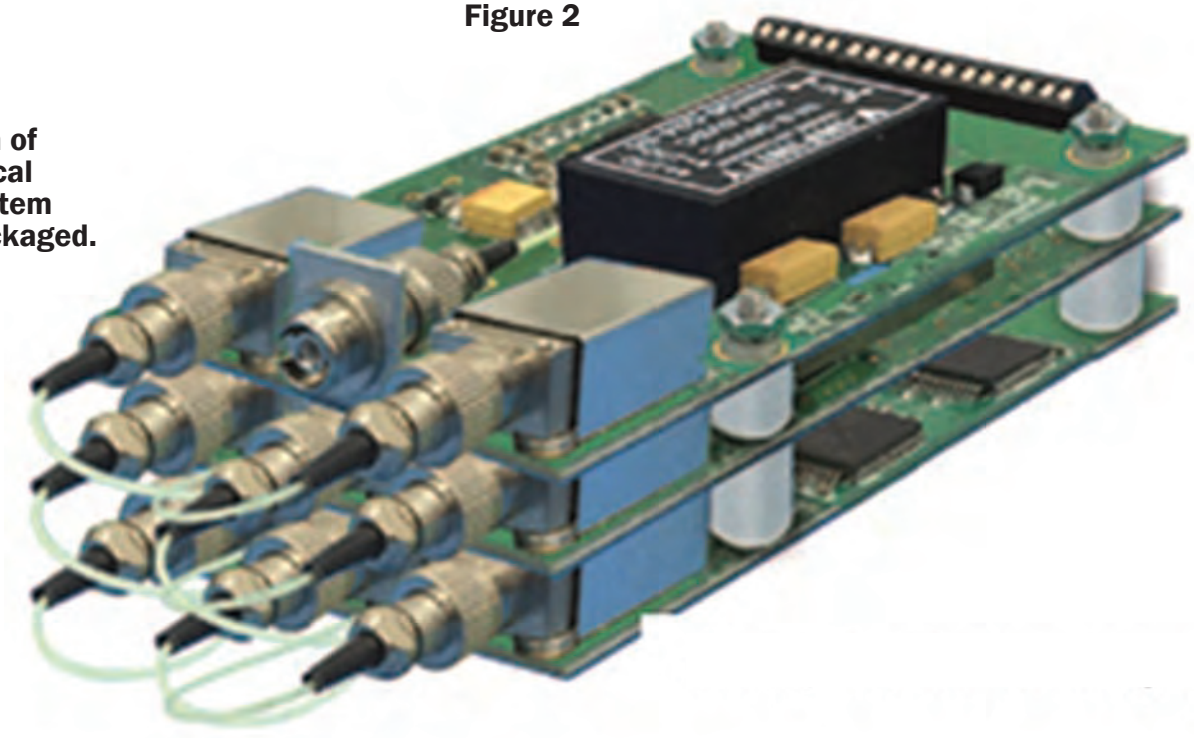
All of these wavelength channels are separated in increments of 20nm. Note that the individual wavelengths will be listed as either even or odd wavelengths such as 1530nm or 1531nm. The original CWDM wavelength plan had the lasers identified with even wavelengths. In 2003 the ITU (International Telecommunications Union) revised the specification by 1nm so that the wavelength overall CWDM plan goes from 1271 to 1611nm instead of 1270 to 1610nm. CWDM and mux/demux manufacturers may specify the wavelengths in either format. They are interchangeable.

Bidirectional Transmission – CWDM technology offers an excellent platform for bidirectional transmission of a number of signals over one single-mode fiber. In order to facilitate bidirectional transmission of signals (e.g., Ethernet, data, etc.), two wavelengths must be assigned – one for each direction of the signal. Using TDM (Time Division Multiplexing) each wavelength can support a number of signals. For example, using two wavelengths, you can transmit multiple videos as well as one direction of data or Ethernet while the second wavelength supports the return direction of the data. Since fiber optics is signal agnostic, each wavelength can support any type of signal from the simplest of a contact closure or TTL to the more complex, high bandwidth HDSDI and GigE signals. A typical 8-ch CWDM mux/demux can support a significant amount of both unidirectional and bidirectional signals. These signals generally include the following: Analog video, HDSDI video, Ethernet (either 10/100 or GigE), data, and TTL. Depending on the ROV type and the specific mission, other signals such as audio, USB and contacts might be transmitted.

System architecture – The optical transmission devices are somewhat unique in CWDM & DWDM systems. From the transmit standpoint, each of the CWDM lasers has a unique

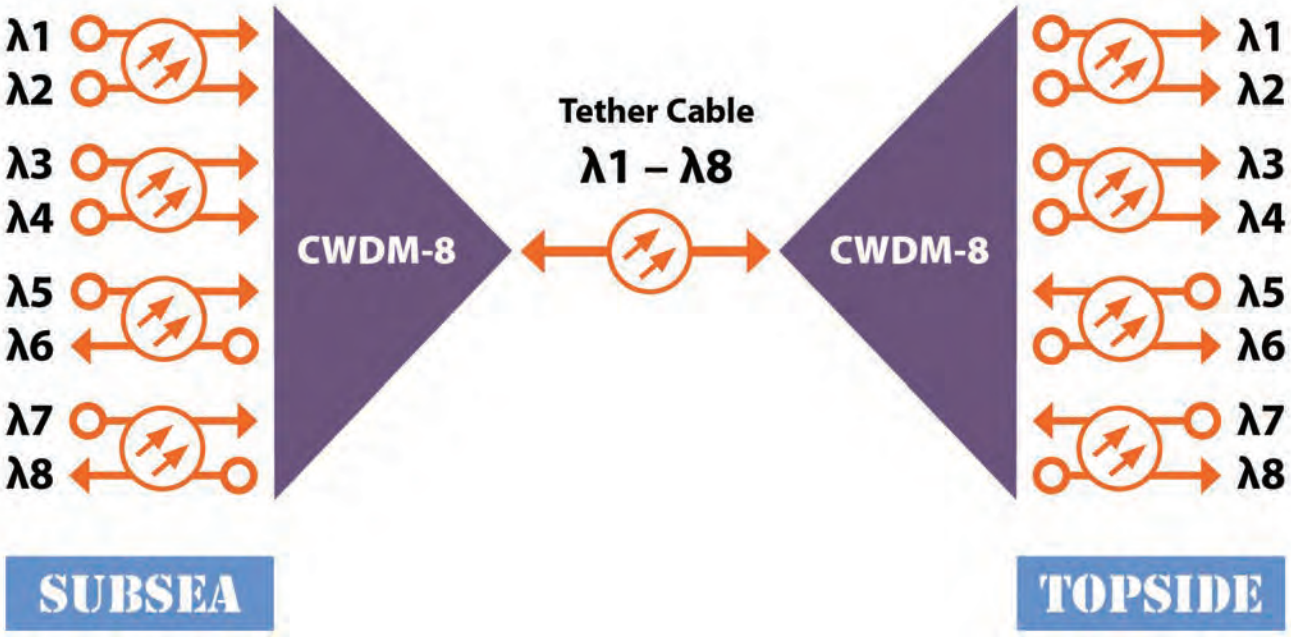
Figure 2

Illustration of how a typical CWDM system can be packaged.



(Courtesy Meridian Technologies)

Figure 3



(Courtesy Meridian Technologies)

8-ch CWDM Mux/Demux

wavelength and is connected to its complementary wavelength port on the CWDM multiplexer. The optical receiver, on the other hand, uses a broadband optical detector that will respond to all wavelengths over the entire CWDM wavelength plan (1270 through 1610nm). The wavelength separation is accomplished in the CWDM demultiplexer. Therefore, the receivers do not have any wavelength specific devices that would mate to unique wavelengths on the CWDM demultiplexer. For example, if a 4-ch CWDM system utilizes 4 HDSDI signals, each operating on a separate wavelength, there would be 4 unique parts numbers for these transmitters (one for each of the 1510 through 1570nm wavelengths). However, since the wavelength demultiplexing or separation is done in the demultiplexer, all four of the HDSDI receivers would have the same part number and would be interchangeable. In general, the CWDM multiplexer and demultiplexer can be the same part #. While the specifications are slightly different for the mux & demux devices, since most of the subsea applications will utilize bidirectional signal transmission, the CWDM mux device will work well for both the subsea and topside equipment.

The CWDM mux/demux modules are small and can be housed in between any of these boards. Small 900µm fiber patch cords from each of the fiber Tx/Rx cards are connected to the internal CWDM mux module. The output of the mux is a single optical port which is then connected to the tether for transmission topside. The fiber inside the tether then connects to the topside receiver card and connects to the input of the CWDM demultiplexer. This module then separates each of the wavelengths from the subsea transmission equipment and adds any wavelengths from the topside equipment that are to be transmitted to the subsea unit. Note that the typical optical connector interface will typically have a UPC (Ultra Physical Contact) end finish so that optical reflections are kept to a minimum. It is important that this UPC finish be on both ferrules of a mated connector. While it may be common practice to use the typical "grind and polish" technique for ship-board terminations, it is not recommended as connector losses and optical reflections will be higher than expected and there exists the possibility for damaging the connector ferrules when mating ferrules with different end polishes. This will be discussed in more detail in a subsequent article on connector terminations, cleaning and inspection.

Wavelength Testing – Since the power from all the transmitted wavelengths are present on the common tether fiber simultaneously it requires a special power meter to identify the presence of each wavelength on the tether and its optical power level. Traditional power meters have a wide, non-selective wavelength detector. Since the tether fiber has all the wavelengths this power meter will read the sum of all of these wavelengths and will not identify the power associated with each wavelength. In order to utilize a standard power meter, an optical CWDM demultiplexer must be used to separate each of the wavelengths before being connected to the power meter. While this will work, it will introduce an additional part (demultiplexer) which will have its own optical loss, thus compromising the test results. As shown in the above fiber multiplexer stack, gaining access to the output of each demux port may be difficult for use with a standard power meter.

Figure 3 illustrates a typical bidirectional CWDM optical interconnect application. Wavelengths 1-5 and 7 are used to transmit information topside while wavelengths 6 & 8 receive data from the topside location. These 'return' signals may be Ethernet data, contact closures, etc. Each fiber at the input/output of the optical mux carries its own unique wavelength. Therefore a standard power meter will work to measure the wavelength's optical power on its associated fiber. However, the common port of the mux/demux contains all of the wavelengths on the one fiber. This is where the CWDM power meter becomes useful.

CWDM power meters will demultiplex each of the individual wavelengths present on the tether's fibers and report their associated power either in a graphical or tabular format. These meters have various features which allow individual wavelength's power to be displayed or displayed as a group and output for further processing. Considering how ubiquitous CWDM is in the ROV market, it would seem prudent to have one of these CWDM power meters as part of the technician's equipment list.

CWDM provides a significant amount of signal transmission versatility. The combination of TDM and CWDM gives the system an almost unlimited ability to view, monitor, and control all aspects of an ROV's functions over significant distances with zero latency. As this article highlights, CWDM is a proven technology with exceptional capabilities and expansion potential. Other articles will address such topics as optical connectors, connector cleaning & inspection, active devices and system performance testing/evaluation. **For more information email the author at emiskovic@nc.rr.com.**

CWDM power meter.

(Courtesy: JDS Uniphase)

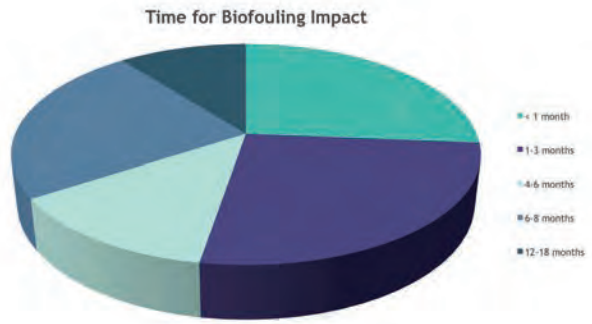
Biofouling Control in Marine Instruments via UVC LEDs

By Hari Venugopalan

Biofouling is the accumulation of microorganisms, plants, algae, or other organisms on wetted surfaces. The mechanism of fouling involves the initial bacterial attachment and formation of a biofilm on the surface, followed by the attachment of larger marine organisms. Biofouling affects a range of systems and components across many industries, especially those in the coastal and marine environments where the impact on optical sensors can occur within a week of deployment.

In the marine environment, biofouling affects both optical and non-optical sensors used for water quality and conductivity measurements as well as acoustic sensors (sonar) for ocean current measurement, underwater cameras, lighting, and lenses used for optical communication. In ocean monitoring, biofouling has long been considered as a limiting factor to the length of deployment for underwater instruments and sensors. The Alliance for Costal Technologies has estimated that maintenance costs due to biofouling can consume as much as 50% of operational budgets.

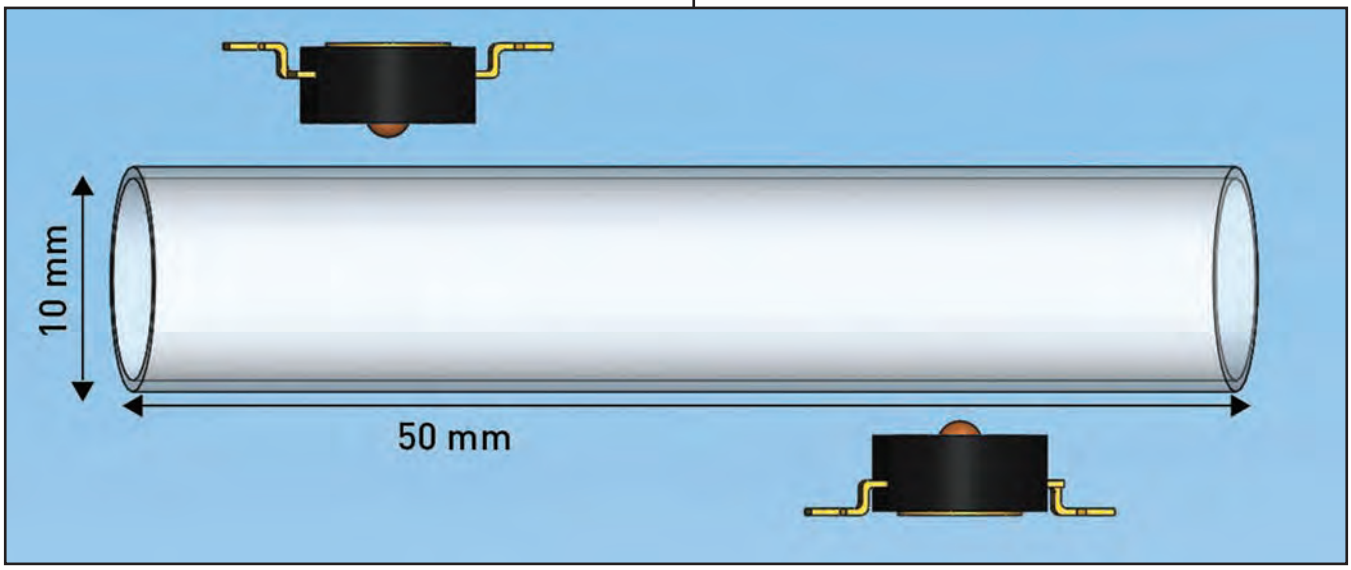
Figure 1
Duration of deployment before biofouling negatively impacts monitoring equipment.
Source: M. Faimali et al., Report on biofouling prevention Methods, 2014]



Traditional Biofouling Control Methods

There are several methods of biofouling control that have been traditionally used with limited success. Biocides have been used due to their high level of effectiveness, but they are largely being phased out due to environmental regulations. The most common biocide over the past 40 years, Tributyltin

Figure 2
Arrangements of two UVC LEDs outside the quartz conductivity cell to achieve uniform distribution of light within the cell.



(TBT), was banned in 2008 due to its toxicity to other organisms and the environment. Other non-toxic coatings have been used to prevent biofilm, however most of them are not transparent, thus eliminating their feasibility for biofouling control in optical sensors. Mechanical options, such as wipers, have a high failure rate, relatively high power consumption, and are ineffective on complex surfaces. Other techniques, such as copper or tin plating, have been used to limit and slow organism growth but are not effective in all environments.

Controlling Biofilm

UVC irradiation offers a better method than the existing options as it is non-contact, non-chemical, and can be used across a range of instruments. Radiation in the UVC range of 250 nm -280 nm can be used to control biofouling by preventing biofilm formation. Light in these wavelengths deactivates bacteria, viruses, and other microbes by destroying the genetic information inside the DNA. By deactivating the microorganism, UV light prevents the formation of a biofilm, thereby preventing the later phases of biofouling where larger organisms attach to the instrument and render the instrument inoperable.

Although the potential of UV radiation for biofouling control has been known for some time, traditional UV lamps containing mercury are not a feasible option in many aquatic settings due to their bulk, fragility, high power consumption, and the toxic nature of mercury. These lamps are also difficult to start in cold environments. LEDs that emit UVC light offer a more suitable solution that overcomes the limitations of mercury lamps. They consume less power, have a smaller footprint for more design flexibility, and high brightness in the necessary germicidal wavelengths. Newly available high performance UVC LEDs offer greater reliability and lifetime than the early commercialized devices. This makes them suitable for long deployments in marine environments.

Simulations using UVC LEDs

Instrument manufacturers select biofouling control methods that offer optimal protection while maintaining the integrity of measurements and overall instrument design. In general, protection can be classified as volumetric, where the protection is acting in a small volume around the sensor area, or surface, where protection is directly acting on the sensing area. For example, irradiation of water in a conductivity cell to prevent microbe growth is volumetric protection while irradiation of a sensor electrode in that cell is considered surface protection.

The amount of UVC radiation needed to prevent biofilm in an application is referred to as the required UV dose. The effective UV dose is comprised of

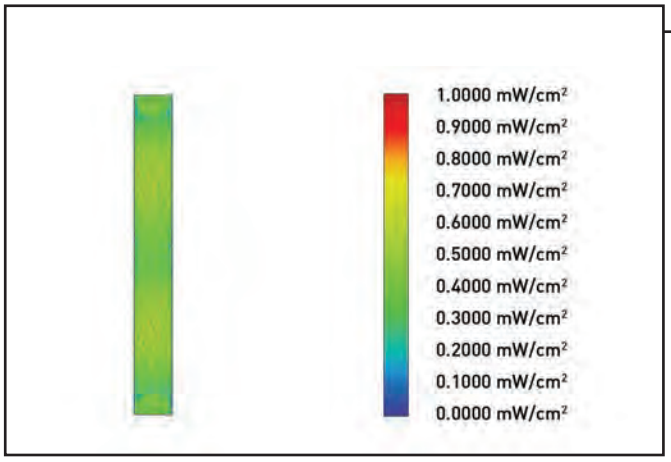
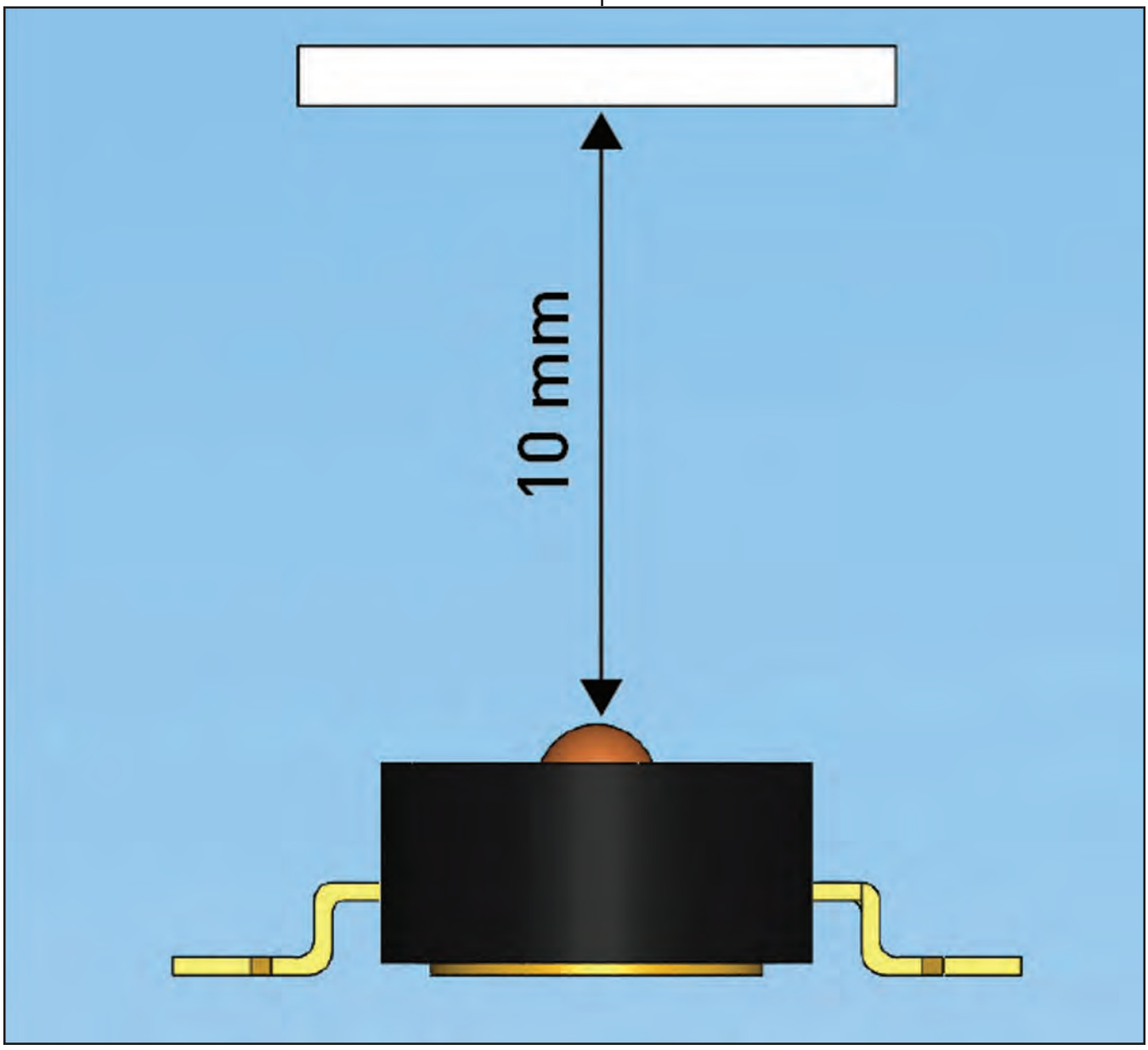


Figure 3
UV irradiation pattern within the conductivity cell.

Figure 4
The position of a single UVC LED 10 mm from a surface to be protected from biofouling.



two factors—the intensity of the light and the length of exposure time. Dosage is typically measured in milli-joules per centimeter squared (mJ/cm2) and is the product of UV intensity (in mW/cm2) and the exposure time (in seconds). Industrial engineers and instrument designers use the relationship between these two parameters to develop an effective system. Figures 2 and 3 show a volumetric protection example with a required UV dose of 10 mJ/cm2. The cell has an external diameter of 10 mm and a length of 50 mm. Two UVC LEDs, each emitting 2.5 mW, are used to achieve a fairly uniform intensity throughout the volume of the water in the cell to ensure that the full volume receives sufficient UV light. As seen in Figure 3 the irradiation pattern in this example is fairly uniform. However, it is important to note that it is the minimum, not the average, irradiance that engineers must consider for appropriate protection. In this example, 0.2 mW/cm2 is the minimum irradiance of the system, so to achieve the target dose of 10 mJ/cm2 the cell requires a minimum exposure of 50 seconds.

Figure 4 shows an example of surface protection on a flat surface 10 mm x 10 mm which requires a UV dose of 40 mJ/cm2. The intensity distribution on the surface depends on the distance between the UVC LED and the surface to be irradiated, the light output of the LED, and the light emission pattern. In this example, the surface is 10 mm from the light source and the UVC LED emits 2.5 mW in a radiation pattern of 100 degrees. Another critical design parameter is the repetitive cycling required for UV irradiation. Specifically, cell division of colonized bacteria and colonization of fouling organisms happens during the intervals between UV radiation exposures. So, in addition to the calculated exposure time, designers need to consider the duty cycle for the LED as an important process parameter. Duty cycle is the percentage in one period in which an LED is turned on, for example an LED operating at a 50% duty cycle would be turned on exactly half of the time and off half of the time. By operating at a duty cycle the LED is periodically turned on to deactivate DNA and then turned off to minimize power consumption. The optimal duty cycle for a system is typically determined by lab testing. The small footprint and high brightness of UVC LEDs enables use in a variety of sensors, including remote monitoring in far areas of the world. By controlling biofilm growth, UVC LEDs allow manufacturers to extend the duration of in situ deployments in marine environments while reducing maintenance costs. Integrating UVC LEDs into these instruments for biofouling control is an emerging trend that will become one of the mainstays of the industry in the coming years.

Evolution of Ocean Exploration

Mapping the Seafloor with Geodesy

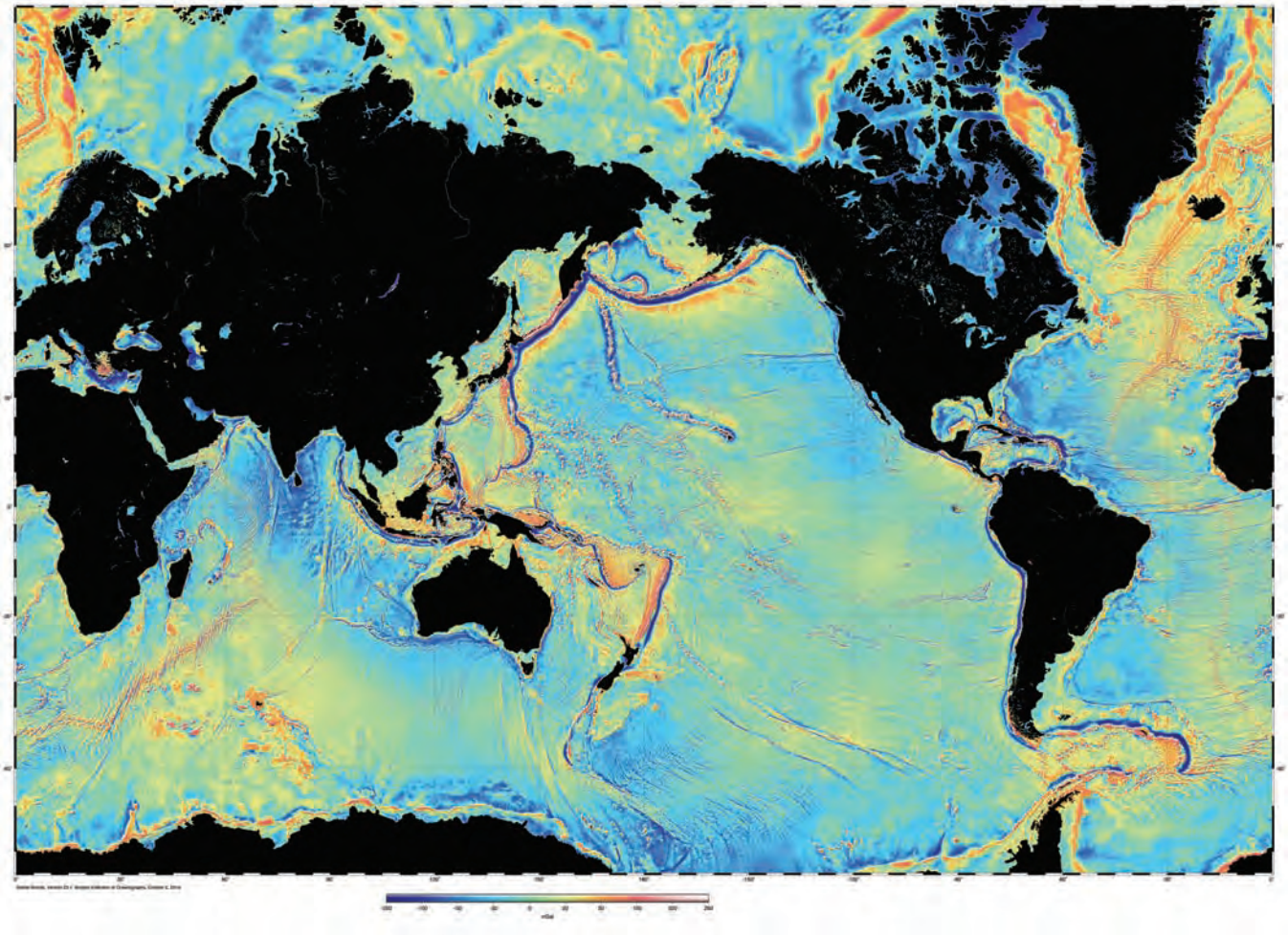
By Kira Coley

In an age where the surface of Mercury and Mars can be mapped in great detail, it's difficult to imagine how around 85-95% of our ocean floor remain enigmatic. While advanced sonar technology has allowed ships to create highly detailed topographic maps, it would take 125-200 ship-years to survey the deep oceans alone, costing billions of dollars. Gravity models are powerful tools for charting large areas of the ocean where tectonic structures and deep ocean basins remain unmapped by ships or hidden under thick sediment.

Now, the new marine gravity model announced by a team of international scientists' shows unprecedented resolution

Global map of the variations in the pull of gravity derived from satellite radar altimetry.

http://topex.ucsd.edu/grav_outreach



of the seafloor uncovering several new tectonic features. It is an exciting time for ocean exploration as each new year reveals more of the uncharted oceans, catalyzing new developments in plate tectonics, navigation, petroleum exploration and earthquake forecasting.

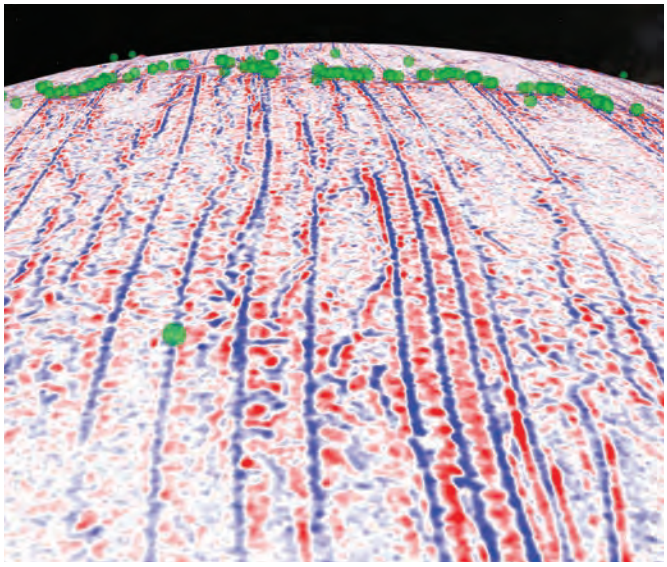
While ship-based surveys remain a vital and valuable tool, topographic mapping is limited by the number of ship crossings. As such, only around 11% of the seafloor has been mapped at high resolution and 17% at lower resolution to date. In 1978, NASA's Seasat altimeter was the first to demonstrate the ability to gather seafloor bathymetry from Space.

"When I was a graduate student I worked on Seasat, which was a NASA altimeter satellite," said David Sandwell, Scripps Institution of Oceanography. "When the data came out from Seasat everyone realized that the data we were looking at looked like the ocean floor – we were looking at the ocean surface topography, but it looks like the seabed. That was probably then we realized we could use gravity field data to map the ocean floor."

The broad bumps and dips of the ocean surface mimics the topography of the seabed. The extra gravitational attraction of features on the seafloor produces minor variations in the pull of gravity that produce tiny variations in ocean surface height. These bumps and dips can be mapped using a very accurate radar altimeter mounted on a satellite.

For decades, David Sandwell from the Scripps Institution of Oceanography and Walter Smith from the National Oceanic and Atmospheric Administration (NOAA) have been using Earth's gravity field data from the civilian and military satellite operators. By combining new radar altimeter measurements from satellites such as the European Space Agency's (ESA) CryoSat-2 and NASA CNES Jason-1 with existing data, a global marine gravity model was constructed that is two times more accurate than previous models. The team of scientists included R. Dietmar Müller from the University of Sydney, Emanuel Garcia of NOAA and Richard Francis from ESA. The data they collected regarding gravity measurements and sea surface heights have formed unprecedented detailed maps of beneath the oceans' surfaces.

"We've been doing this for a long time – at first we got data from a satellite called Geosat which was a U.S. Navy satellite launched in 1985. A breakthrough in altimeter coverage became available in 1995 when the United States Navy declassified the data from their mapping missions. The next big breakthrough was the CryoSat-2 ESA, which maps of the changing topography of the icecaps and over the ocean. It's really a wonderful platform because it has



Variations in the vertical gravity gradient of the southern mid-Atlantic Ridge. Earthquakes with magnitude > 5.5 are shown as green dots and highlight the current location of the spreading ridges and transform faults. The large fracture zone signatures record the rifting and spreading between South America and Africa.

http://topex.ucsd.edu/grav_outreach

Variations in the pull of gravity over the North Atlantic reveals the fracture zones which map out the rifting an opening of the Atlantic ocean over the past 200 million years. Red dots are locations of significant earthquakes (magnitude > 5.5)

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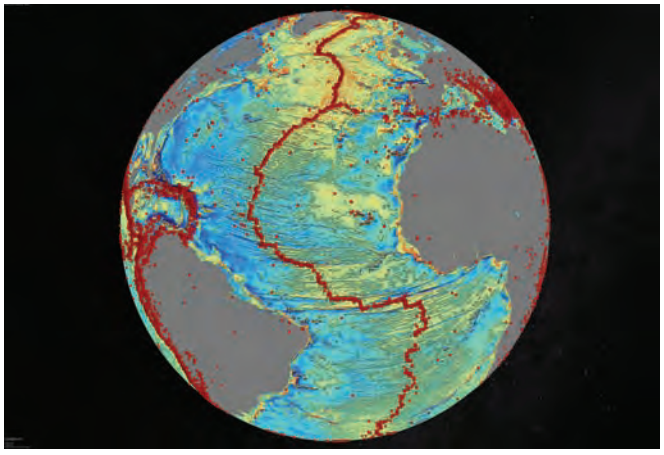


better accuracy and coverage than all previous altimeters," said Sandwell.

Global maps constructed using satellite-derived gravity data will never replace the ships. The resolution of this new method is limited by the ocean depth because the potential field which gets smooth as you go from the bottom of the ocean to the surface. Whereas, the standard ship-based multibeam echo-sounders resolves features on the seafloor in high resolution about 100 meters across. The problem is in our lifetime we will probably never see the complete mapping of the seafloor by ships. Which makes the satellite data vital to filling in the gaps.

The main challenges scientists face in developing these gravity field models is improving the resolution from the satellite altimetry data. Sea surface topography is a noisy measurement as the waves roughen the ocean's surface making the range measurement less precise.

The Age of Charted Oceans

The two big areas of discoveries this model has already uncovered is found on the flanks of the seafloor spreading ridges; there's a fabric called the Abyssal Hills. These hills are parallel to the spreading ridge and were yet to be resolved in the old gravity fields. "These hills are important because when the water moves across the bottom of the oceans due to the tides, it hits the hills generating 'internal waves'. These internal waves propagate up and mix the ocean, keeping the ocean from always being warm on top and freezing on the bottom. So, understanding where theses hills are and how they interact with the tides is important and a big science project," said Sandwell.

The second big area is at the continental margins, which is where the plates split apart during rifting, forming fracture zones and transform faults. These are locations typically buried under sediments on the flanks of the continental margins, making them difficult to detect using ships. This new data allows researchers to see the fracture zones under the sediment which can be used in detailed plate tectonics as well as identifying sedimentary basins when searching for oil.

Ocean Exploration with Marine Gravity Models

One the real uses of the gravity field for seafloor mapping is identifying features that are unmapped, but also big in size such as large sea mounts and other structures. This allows researchers and commercial operators to target ship surveys to complete detailed mapping.

"The original reason these altimeters were launched by the U.S. Navy was to map out the variations in the pull of gravity their effects on moving platforms. The military applications are obvious and provided the rationale for the $80 million cost of the Geosat mission," said Sandwell. "When you're in a submarine you can't use your GPS because you're under the water, so you use these precise accelerometers to measure your trajectory but you also have to know the gravity field, otherwise you might think you're turning but you're actually going straight. It's called 'inertial navigation'. Air-

crafts also use this." The global gravity grids also revealed half of all volcanoes on the seafloor reaching heights greater than 1000m, which were previously uncharted. The large petroleum exploration companies also use satellite altimeter gravity data from Geosat and ERS-1 to locate offshore sedimentary basins in remote areas. This information is combined with reconnaissance surveys to determine where to collect or purchase multi-channel seismic survey data.

Evolving Marine Gravity Models

The project is still evolving and the interpretation of the results is yet to be completed. As these gravity fields are developed, the fine detailed of tectonic structures formed up to 150 million years ago will need to be interpreted. The objectives of this work will be to unravel the marine tectonics environments and other types of data that needs to be combined into current models.

"In terms of improvements to the marine gravity models, CryoSat is still up there and will run till at least 2017 hopefully – and every year of data it gives us another improvement in the resolution of the gravity fields so that's good. There's another altimeter up there launched by the French and the Indians called SARAL which has improved technology with better resolution than CryoSat. It's a slow process but over the years the gravity resolution will improve," said Sandwell. "Also, there is not a good global compilation of ship mapping locations or data, because it is done by dozens of different countries and companies. The big improvement would be to assemble all the data that's ever been collected and figure out where the holes are so we can go out systematically and map them."

In January 2016, Google replaced its global seafloor map with an improved version constructed using the latest gravity predictions and the available multibeam sounding data. NASA has a planned swath altimeter mission, SWOT, scheduled for a launch in 2020, that could provide another factor of 5 improvement in global ocean floor bathymetry.

Satellite technology is always evolving, helping scientists follow the movements of Earth's tectonic plates over time and target areas to study further using sonar scanning. While the increased use of non-invasive methods promise a more environmental friendly future, the continuous discoveries of new seafloor features in deep-sea marine territories marks a huge milestone in understanding our planet.

Acknowledgements

Professor David Sandwell, Scripps Institution of Oceanography

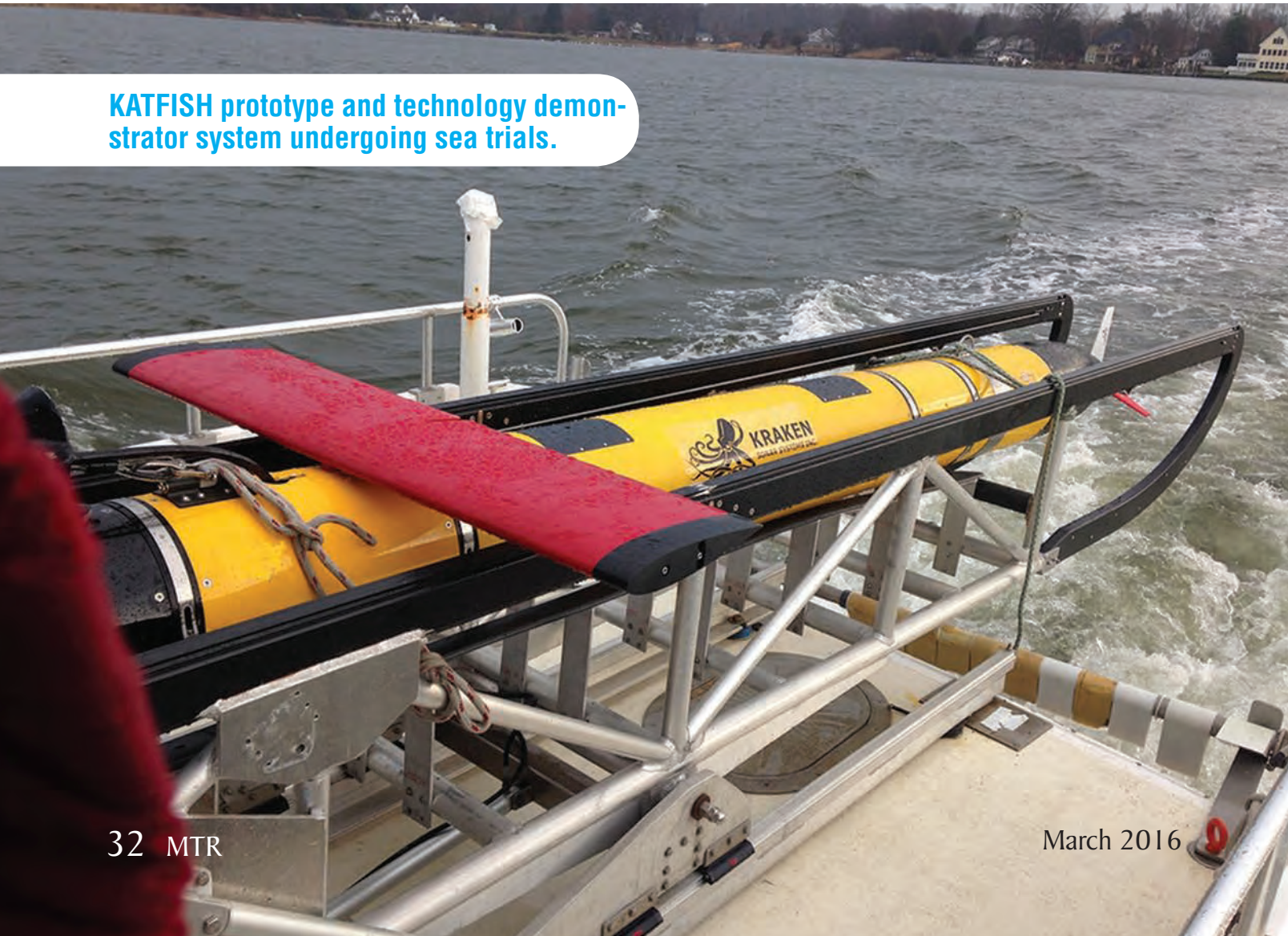
KATFISH

A High Speed Synthetic Aperture Sonar Platform for Seafloor Mapping

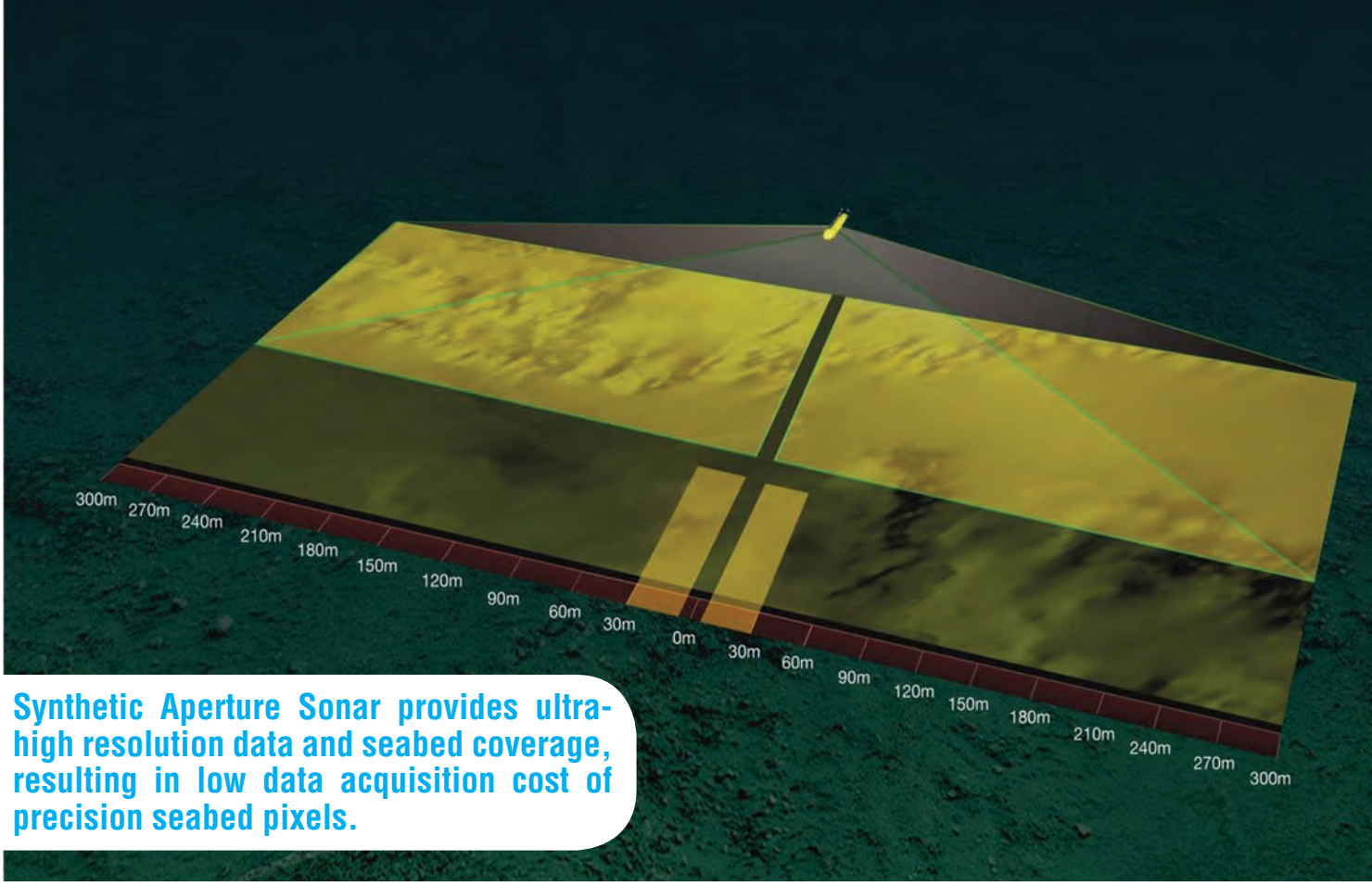
By Gina Millar, P.Eng, Program Manager, Underwater Systems, Kraken Sonar Systems Inc.

Despite recent advances in terrestrial mapping and surveillance, the seafloor remains largely uncharted and unexplored. With burgeoning interest in underwater defense and commercial applications, the collection of detailed bathymetric data is increasingly important. Due to the scarcity of seafloor data, traditional 3D bathymetric charts depicting large area seafloor coverage are essentially artist renditions. It wasn't until recently that concerted efforts in the public and classified domains have been made to compile bathymetric data to produce higher resolution 3D digital terrain models of the seafloor.

Synthetic Aperture Sonar (SAS) could be an invaluable tool in the future of seafloor imaging and bathymetry. Conventional instrumentation, such as sidescan and multibeam sonars, suffer from some basic limitations. First, the imaging resolution, or the system's ability to distinguish closely spaced objects, is not constant over the entire range and rapidly degrades at longer ranges. Second, when high-resolution imaging is required, the area coverage rate (ACR) of conventional sonars is exceedingly low. These limitations could theoretically be overcome by increasing the length of the array, or "aperture."



KATFISH prototype and technology demonstrator system undergoing sea trials.



Synthetic Aperture Sonar provides ultra-high resolution data and seabed coverage, resulting in low data acquisition cost of precision seabed pixels.

In reality, however, the logistics of manufacturing and deploying an array of that size is impractical. SAS overcomes these limitations by using the platform's trajectory to increase the data resolution. The forward motion of the sonar is used to synthesize an array that is much longer than its physical length by combining multiple pings in software rather than relying on costly hardware.

SAS uses sophisticated digital signal processing and motion compensation techniques to compare multiple observations of the same area of seafloor. The image resolution of the seabed is significantly increased – often by an order of magnitude. In essence, the resolution becomes independent of range and of frequency. SAS systems can achieve imagery resolution of a few centimeters even in very deep waters.

In addition to reflectivity images, SAS can produce highly detailed hydrographic charts of the seafloor by detecting the angle of arrival of seabed echoes. In a configuration known as Interferometric SAS (INSAS), two vertically separated arrays produce bathymetric charts that are exactly co-registered with the corresponding SAS images. This combination of synthetic aperture processing and interferometry solves the inherent limitations of low resolution and area coverage rates encountered with conventional swath bathymetric sonars and multibeam echo sounders.

While SAS has been around for over a decade, military applications such as naval mine countermeasures have been its major development driver. However SAS is a multi-use technology with great potential for offshore oil and gas surveying, hydrographic surveys, underwater archaeology, benthic habitat mapping and deep sea mining. Reducing the cost and complexity of marine survey operations can profoundly impact the economics of many marine industries. Driven by

The Seagull Unmanned Surface Vessel from Elbit Systems can be fitted with Kraken's KATFISH sonar payload for mine countermeasures and underwater intelligence, surveillance and reconnaissance missions.

lower revenue and energy prices, today's oil and gas sectors are now seeking new seabed survey technologies and tools that could lead to higher productivity, increased cost efficiencies and improved business models that rely less on expensive conventional manned systems.

With high resolution INSAS it is possible to use image fusion techniques, such as those provided by CARIS Onboard, to combine the bathymetric data with reflectivity data to create a true 3D representation of objects on the seabed. Now large volumes of raw data can be converted, algorithms applied and bathymetric surfaces or mosaics can be generated in near real time. The in-stride automation of many of the standard processing steps required in a modern sonar survey not only reduces subjectivity but allows human resources to work on more important tasks. By the time the survey platform has completed its mission a fully geo-referenced and processed dataset is available for final quality control and incorporation into products.

From Sensors to Platforms

The use of Unmanned Underwater Vehicles (UUVs) over traditional hull mounted bathymetric and imaging sonars for seafloor imaging is rapidly being adopted. Hull mounted sonars suffer from resolution limitations, especially in deeper water, and the motion of the vessel affects both image quality and the data geo-location. Underwater vehicles address both these issues since they are able to operate closer to the seafloor. The lower operating altitudes achieved by UUVs increase the data resolution as well as decouple the sonar from detrimental surface effects. There are several types of underwater platforms that are suitable for the SAS technology, but the two most common are towed systems and AUVs.

Autonomous Underwater Vehicles (AUVs) are ideal sonar platforms, and provide an extremely stable platform for acoustic and optical imaging in a variety of water depths. However, for the purposes of seabed survey, AUVs present a number of challenges. AUVs are often speed limited to 3 - 4 knots, which limits the effective ACR they can achieve, particularly in shallow water where limited depth prevents the higher survey altitudes required to yield a large range.

Typically powered from rechargeable batteries, most AUVs have an endurance of less than 24 hours and must be recovered and recharged in between mission operations. Also, due to the limited bandwidth available from acoustic modems, real-time full-resolution sensor data is not available and operators must wait until the AUV is recovered in order to process the complete dataset. In the context of a commercial survey or military mine warfare applications this severely limits the operational benefits of the AUV and may not align with the concept of operations.

Towed sonar systems (also known as towfish) overcome some of these AUV limitations while sacrificing autonomy and complete decoupling of the platform from surface effects. Towfish are ideal for surveys where high ACR and access to real-time data are priorities. Providing full-resolution sonar data to the operators onboard the surface vessel in real-time is a critical feature for search and survey operations where the earliest possible prosecution of seabed targets is required. Another advantage of onboard real-time processing of sonar data is real-time online quality monitoring.

Passive towfish are the standard for shallow water towed sonar surveys. A passive towfish does not have any active control surfaces or intelligent control system and therefore cannot actively control its attitude, heading, depth or altitude. Despite their widespread use, passive towfish have a number of limitations.

The depth (or altitude) of a passive towfish is achieved by controlling the amount of cable payout and the speed of the surface vessel, which are under the control of the operator. If these factors are improperly managed there is a high risk of data loss or damage to the vehicle. In addition, the lack of active control means that a passive towfish is unable to compensate for any motion disturbances introduced by the surface vessel as a result of ship motion or environmental conditions such as sea state. This can yield poor quality data and result in lower area coverage rate.

Actively controlled towfish provide a superior platform for seabed survey, particularly for INSAS surveys. An actively controlled towfish can compensate for surface vessel disturbances, greatly improving the platform stability and the overall image quality. In addition, intelligently controlled active towfish can control their depth and altitude using sophisticated bottom following and bottom avoidance routines. SAS data is especially sensitive to platform stability leading Kraken Sonar to develop the Kraken Active Towfish (KATFISH) - an actively controlled, intelligent towfish that combines Kraken's AquaPix Miniature Interferometric Synthetic Aperture Sonar (MINSAS) technology and real-time SAS signal processing algorithms into a tightly integrated platform for real-time data collection and observation.

Placing the survey sensor closer to the seafloor will result in the acquisition of significantly higher resolution data. When the sensor is integrated to a high speed, intelligently stabilized towed platform such as KATFISH, better quality data is acquired at a faster rate, thus improving efficiency and lowering both operational and data acquisition costs. Such an integrated platform can provide the highest resolution seabed pixels at the lowest data acquisition cost compared to conventional survey sonars such as side scan and multi-beam.

Actively controlled towfish also have the potential for a higher level of autonomy. Launch and recovery, active winch control for terrain following, and even object identification such as Automatic Detection/Classification and Target Recognition (ATR) have the potential for automation. In fact, most

of the towfish operations can occur with minimal operator interaction creating opportunities for deployment from non-traditional surface vessels such as remotely operated Unmanned Surface Vessels (USVs).

Applications of Towed SAS and the Future of Towed Sonar Technology

The underwater defense market is evolving rapidly as a response to changing threats, tensions in the Middle East and Asia, and economic and budgetary pressures. There is a growing eagerness by modern navies and developing countries alike to procure and deploy ocean drones such as UUVs and USVs as the future of naval warfare continues to evolve toward smaller vessels, littoral operations and intelligence, surveillance and reconnaissance missions. For those systems that are required to economically survey and detect small objects hidden on the seabed, SAS technologies are ideal for UUV and USV solutions.

UUVs have been used for many years, mostly for mine countermeasures, oceanographic research and oil & gas surveys. In contrast, USVs, essentially the naval equivalent of Unmanned Aerial Vehicles (UAV or "aerial drones") have not been widely used. While the technology for USVs is in its infancy compared with the aerial drones, this situation is about to significantly change.

Unmanned Surface Vessels, like UAVs, provide military forces with reach and capability without the risk of manned systems. They keep the dull, dirty and dangerous jobs away from human personnel, while also providing a significant cost savings over traditional manned vessels.

USV technology is maturing rapidly and signals a coming sea change in the makeup of the overall unmanned maritime systems market. New unmanned systems, such as the recently announced Seagull multi-mission USV developed by Elbit Systems Ltd., are paving the way in remotely operated and autonomous towfish systems. Kraken's KATFISH is the primary Synthetic Aperture Sonar for Seagull's mine-countermeasure missions.

The commercial viability of SAS as a high-resolution seabed survey sensor is a proven and logical progression for seabed surveys. When a SAS payload is deployed operators will realize lower data acquisition costs, ultra-high quality image and bathymetry resolution and higher area coverage rates than that achieved with traditional survey sonars.

The Role of Underwater Robotics in

Marine Conservation

The large reserves of hydrocarbons and biologically productive waters of the UK continental shelf support a wealth of maritime users. As use of this busy stakeholder space is restricted by the growing presence of marine protected areas, there is a pressing demand for comprehensive evidence to back management decisions. New partnerships have now been formed between conservation groups, technology manufacturers and government bodies to determine if marine robotics can provide a high-quality and cost-effective evidence base to support Marine Conservation Zones (MCZs) and help manage this quickly expanding network.

By Kira Coley

Since the designation of the UKs first MCZs in 2013, a second announcement this January has seen the expansion of the nations protected "Blue Belt" to almost 8,000 square miles. In the wake of challenges from maritime users and further sites to be announced in 2018, the UK Government has begun the search for efficient and cost-effective methods to assist in the long-term management and monitoring of the newly protected marine habitats.

The UKs National Oceanography Center (NOC) has used autonomous underwater vehicles (AUVs) in challenging environments such as beneath Antarctic ice sheets and in deep-sea canyons. As the base for one of the largest global fleets of autonomous vehicles, supported by government investment, organizations such as the Department for Environment, Food and Rural Affairs (Defra) and the Royal Navy are increasingly looking to the NOC for information as to how they might also benefit from this technology.

"Defra works in an environment where one of the key stakeholders are the fishing industry. Bottom trawled gear can damage vulnerable seabed habitats such as cold water corals. So to have good visual evidence of where the coral is within a MCZ, its spatial extent, and what ecosystem it supports is very powerful in stakeholder meetings. Robotic systems can provide this evidence, including in areas where research vessels struggle to collect good data," said Professor Russell Wynn, NOC project leader on part-secondment to Defra.

The last decade has seen the rise of underwater robotics through advancements in platforms and power efficient oceanographic sensors. Now, the potential of this technology in marine conservation is being explored through novel ventures and fresh national collaborations.

Case Study: Deep Sea Canyons MCZ

The Canyons MCZ forms part of a national network that is being expanded as a second round of designated sites announced by Defra this year. The rugged 3D canyon environment poses difficulties for the use of vessel-based systems. Operated from the sea surface, conventional mapping tools struggle to image deep vertical and overhanging surfaces found in these environments.

AUVs are able to survey within the canyons in 3D close to the seabed, providing a highly detailed map. This allows operators to target Remotely Operated Vehicles (ROVs) missions, which collect high-resolution video and still images of the seabed, charting the presence and scope of corals or other features. By using a variety of marine robotic vehicles and the research ship, RRS James Cook, scientists at the NOC have made a series of detailed maps of the site at scales from tens of kilometers down to a few millimeters.

"Whether it's a propeller-driven AUV or a tethered ROV, Defra now understands the benefits of these tools. By surveying the Canyons MCZ, an active site where evidence was needed to support the management measures for that location, it was a really good case study of what we can do with a small amount of ship time. By running the ship, deploying AUVs and conducting data collection with a ROV, all at very good quality and high resolution data, it shows the impact and the cost benefits by having robotic vehicles in place,"

Two new USVs (developed by ASV and MOST AV in partnership with NOC) being deployed during a trial from the Isles of Scilly.

said Wynn. As a deep-sea canyon over a mile deep, the team benefited from using a mixture of survey approaches to tackle this challenging site. Ship-based seafloor mapping provided information on the overall shape of the canyon from the surface. Within the canyon, the Autosub6000 AUV was used to make more detailed maps of coral habitats. In parallel with the Autosub6000 deployment, the NOC's ROV, ISIS, was launched to map steep canyon walls and collect images and samples that confirmed the presence and species of the coral.

By using these robotic vehicles in combination, the team were able to collect a vast array of high-quality data in just three days, demonstrating how robotic vehicles can augment expensive ship operations in deep water sites.

Developing Marine Robotics for MCZs

A large research vessel working beyond the continental shelf could cost around $22k to $36k a day. Reducing the amount of ship time by using robotic vehicles and supplementing the ship-based mapping offers substantial cost benefits.

While there are obvious advantages to this technology in deeper waters, part of the work being conducted by the NOC is to assess the potential of marine robotics in dynamic shelf water environments. At these locations, less than 100 meters deep, operating a smaller vessel can be more cost effective. The use of AUVs in strong tidal currents, typical for much of the UK shelf, also offers operational challenges that need to be assessed.

In light of this, the NOC trialed AUV mapping at Greater Haig Fras, one of the second tranche MCZs located off Cornwall, and the only area of rocky reef on the shelf in the southwest. Scientists first mapped the site in 2012 but returned three years later to assess the suitability of AUVs for monitoring such sites in the future. This includes navigational accuracy and the technologies ability to identify changes on the seabed through time.

"We used the Autosub6000 AUV and ROV to collect high resolution data as part of the Defra R&D work looking at how suitable these vehicles are in a more typical shelf environment. The repeat mapping with the AUV was successful, and the vehicle also collected thousands of seabed photos that indicated natural changes to the seabed fauna in the three-year period. We still need to do some work to improve the accuracy of AUV mapping in strong tidal flows, but overall we are very happy with the result," said Wynn. In August 2015, the NOC began the latest in a series of ambitious marine robotic vehicle trials off the UK coast. Working in partnership with the World Wildlife Fund (WWF), a submarine glider and an unmanned surface vehicle (USV) was launched into the Celtic Deep area of the Celtic Sea. The USV was designed to collect a range of data from different trophic levels, from ocean temperature to plankton density and fish shoals. The vessel was also equipped with cameras and passive acoustic monitors (PAM) that can pick up echolocation of cetaceans from the surface.

"USVs are still in development and relatively new. We're very much in the trials phase, where getting these new vehicles in the water is key to building a rugged and reliable platform that can be deployed for months in remote offshore regions. As the technology matures then end-users will gain confidence that it is ready to use for science programs and marine conservation objectives," said Wynn. "In the meantime, it's important to get this technology in the water and keep testing it through storms and biofouling."

The NOC have also partnered with technology manufacturers in southern England, ASV Ltd. and MOST AV, to develop new USVs for science. Further trials will take place this spring with one of the new USVs and a submarine glider, as

The MARS fleet based at NOC, in front of the £75M RRS Discovery. The fleet includes submarine gliders, AUVs, ROVs and USVs.

a continuation of the WWF project. The trials will focus on the technologies application for marine conversation, through proof-of-concept work on how the cameras and PAM could be optimized to track mobile species.

The Future of Robotics in Marine Conservation

While the technological capabilities for detailed seabed mapping using shore-based launch vehicles is not currently available, the NOC hope to have the ability to deploy AUVs with this capability from land within the next 5 to 10 years. This will enhance the benefits of using this technology for monitoring the shallower shelf sites. The size of oceanographic instruments, data quality and battery power are quickly advancing, which will improve future long-range capabilities of AUVs and gliders.

New subsea cameras which can be operated in turbid conditions, typical of UK coastal areas, are also in developed as part of a different EU project, UTOFIA. The prototype camera can see two to three times further underwater than existing systems. One of the applications for this novel technology is to help facilitate with marine species management where numbers and lengths of individuals can be calculated. While still at development stage, advancements such as this will be hugely beneficial in the future for understanding the long-term responses of marine life to MCZ management strategies.

Having a dispersed fleet of robotic vehicles, which are power efficient and able to operate more autonomously for months at a time, is a direction in which these systems are heading. With large overseas territories and UK Marine Protected Areas covering hundreds and thousands of square kilometres, USVs collecting oceanographic and biological data, or long range AUVs mapping the seabed far from land, will have an important role in the future.

"One of the reasons why I'm so supportive of the technology is the move away from research ships which use a lot of fuel, but can also be noisy and intrusive objects. So utilising USVs that harvest their energy from the ocean uses clean, efficient technology that's far less intrusive on the marine environment," said Wynn "It's not just our overseas territory that makes this technology important. Developing states that might not have access to a £75m research vessel still have an urgent need to manage their waters responsibly. These are the end users in the future that I can see this technologically being a real benefit for."

Acknowledgements

Professor Russell Wynn, Chief Scientist, NOC Marine Autonomous and Robotic Systems (MARS)

The U.S. Ocean Enterprise

$7B & Counting

In mid-February 2016 NOAA officially released its report which aims to give shape and size to the U.S. Ocean Enterprise, a collective entity estimated to be in excess of $7 billion annually. MTR spoke with Zdenka Willis, Director, U.S. Integrated Ocean Observing System (IOOS), for her take on this initial survey and her perspective of its impact on the U.S. market.

By Greg Trauthwein

It is well-stated within, but in your own words and being as brief as possible, what was the original intent, and what is the point of producing "The Ocean Enterprise" study?

Our objective is to determine the breadth and value of the U.S. ocean observation enterprise to the US economy. We used the term "ocean enterprise" as a direct reference to "weather enterprise," which has been in use for over a decade and brought a great deal of interest and attention to firms and organizations working to improve atmospheric measurement, observing, and forecasting. Ultimately, we would like to see this study bring the same gravitas and recognition to the ocean enterprise.

What does "The Ocean Enterprise" report say?

This study demonstrates that for profit and nonprofit business activity in the ocean enterprise is thriving. Not only does the ocean enterprise generate $7 billion in the U.S. every year, but also more than 85% of these firms have been in business over 5 years and expect to maintain their size or grow in the near future.

What does it not say?

This study does not consider return on investment of observing systems as applied to end user benefits, nor does it investigate the full supply chain. While that information is very important, it was outside the scope of this study.

What were the biggest challenges in putting this report together?

The biggest challenge was identifying the companies to be included in the survey group. A large part of the motivation for this study is that this level of work isn't easy to tease out – for one thing, the NAICS codes don't resolve themselves to a level that distinguishes maritime work in these areas--and so we did a great deal of work developing our group. We worked with a variety of sources: trade groups, government program contact lists, industry trade shows, and through advertising and web announcements.

What are the primary limitations of the study?

This study is descriptive but not a full valuation as it does not consider the end-user values or the full supply chain. It's a snapshot of the ocean enterprise at one point in time, and ultimately the most value will come from repeating the study again in the future to show growth, trends, and overall changes.

"IOOS and NOOA can now see the extent and value of private sector ocean enterprise in the blue economy, and with that information are better able to find ways to engage with it and forge stronger, mutually beneficial partnerships."

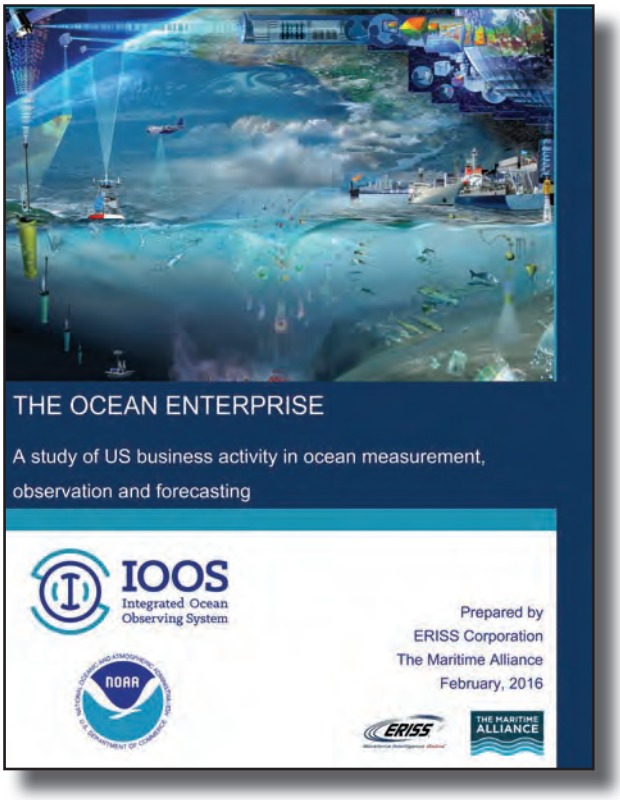
Zdenka Willis, Director, U.S. Integrated Ocean Observing System (IOOS)

What percentage of respondents omitted Financial Information?

About one third of the main financial questions that weren't answered by all respondents. However, we were able to acquire publicly available revenue data about most companies who did not respond. The chief question people bypassed was a figure for total annual revenue.

Seemingly this financial information is critical information to gauging market size. In your estimation, what could be done to bolster this percentage?

If this survey is repeated, the best advantage we could have is for the participating companies to see the value in providing accurate information. This study highlights their work, and the key figure is to show revenue and jobs. The more we can refine those numbers, the more important this study



The Ocean Enterprise: A Study of U.S. Business Activity in Ocean Measurement, Observation and Forecasting
This study, prepared by ERISS Corporation and The Maritime Alliance, sought to lend insight on the size, shape and impact of the collective 'ocean enterprise' in the United States. The full report is a fascinating read, packed with data and statistics that will be of use to any company serving the subsea market. Some highlights:

• A Big Industry

$7B: This is the estimated annual revenue generated by the U.S. Ocean Enterprise.

• Exporting Prowess

$1.4B: This is the estimated annual exports generated by the U.S. Ocean Enterprise.

• A Growing Business

54%: The percentage of respondents that expect their Ocean Enterprise business to grow in the coming year.

• A Diverse Market

The top four market niches served by respondents, starting with the largest, include: Environmental Monitoring; Academic Research; Oil & Gas; and Ports and Harbors.

• Strong Regional Hubs

While the Ocean Enterprise touches many states, there is a predictable pattern of **major hubs**: the Northeast U.S.; Southern Florida; the Houston area; Southern California and the Pacific Northwest.

will be over time, and the more likely it is to continue.

How will the results of this study tangibly impact NOAA?

As a descriptive study, this is valuable to NOAA informationally. IOOS and NOOA can now see the extent and value of private sector ocean enterprise in the blue economy, and with that information are better able to find ways to engage with it and forge stronger, mutually beneficial partnerships. It extends beyond NOAA to the Department of Commerce, not only in providing them with valuable domestic industry data, but also by including figures for export data generated by the study.

Obviously there is much information within to digest. In your opinion, were there any 'show stoppers'? Any results that completely surprised you or your colleagues?

The study didn't yield any show-stoppers, but it is great that we now know that private-sector ocean enterprise work brings in $7 billion annually, about the same as the NFL. It's a real number we can look at now and back to in the future, and quantifies that industry cluster for the first time. I am excited to see how enthusiastic the companies were about participating and seeing the study come out. The ocean enterprise is spread around so many more generalized industries, the feedback was overwhelmingly positive from participants as we went through the process.

There were numerous reference within that this study was a 'first shot.' What's next, specifically what is the plan moving forward for future reports?

If resources allow, we would like to conduct this study again within 2 years. There's value in keeping the survey instrument the same so that we begin to build comparable data sets, however we may revisit and refine some of the revenue questions to tease out more detailed revenue information.

IOOS
Integrated Ocean Observing System

Zdenka Willis, Director, U.S. Integrated Ocean Observing System (IOOS)

Zdenka Willis, Director, U.S. Integrated Ocean Observing System (IOOS) Prior to her assignment as Director of U.S. IOOS Program, Ms. Willis served as Director of NOAA's National Oceanographic Data Center. Ms. Willis is a retired Navy Captain with career service as a Meteorology and Oceanography officer in the United States Navy. She has promoted interagency cooperation as the Naval Deputy to NOAA; worldwide sea ice analysis and forecasting as Director of the National Ice Center; and as the satellite and operations officer Naval Polar Oceanography Center. Her meteorological background includes weather forecasting for Naval aircraft as the Officer in Charge of the Naval Oceanography Command Detachment, Oceana Virginia and for Navy vessels as the Naval Eastern Oceanography Center, Norfolk Virginia. Ms. Willis has a background in the collection of oceanographic data onboard the USNS Harkness and USNS Maury survey vessels and in the electronic navigational charting as Deputy Navigator of the Navy. Her other relevant Naval positions are the director of the Strategic Policy Forum (a Congressional and Executive Branch crisis simulation for Members of Congress, senior Executive branch officials, and military leaders) and adjunct professor in the Strategic Leadership Department at the Industrial College for the Armed Forces.

Ms Willis received her Bachelor's Degree in Marine Science from the University of South Carolina. She received a Master's degree in Meteorology and Oceanography from the Naval Postgraduate, and a Master's Degree in National Strategy from the Industrial College of the Armed Forces.

Unmanned Surface Vehicles

By John Haynes

Over the next decade the maritime sector is likely to see one of the largest changes since sail gave way to steam. Unmanned Surface Vehicles (USV) are now being considered for various marine roles and the drivers for rapid development are significant.

Unmanned or autonomous vessels have passed through the trial and evaluation stage and are now being adopted for civilian and military applications. The maritime sector now has the opportunity to shape technology developments from legislative and end-user standpoints.

As the maritime sector is often the last to adopt new technology it is important to identify genuine innovations from other transport sectors. The driverless car is being pioneered by some of the largest companies in the world including Google, and small unmanned aircraft are being considered as a delivery method for global retailers including Amazon. As these innovations pass through rigorous regulatory approval processes there will be wider acceptance from the public when they are adopted.

The military has already learned a lot about Unmanned Aerial Vehicles (UAV) and the systems required to operate

Sea Machines **USV demonstrating Collaborative Following** with Mother Vessel and Planned Survey Tracking by unmanned vessel.

BAE Systems Unmanned RHIB with ASV Technology.

(Photo: BAE Systems)

them. During the war in Afghanistan the U.S. went from a UAV inventory of 100 to 10,000 over a 10 year period. There are several terms in use for unmanned aerial vehicles, including Unmanned Aircraft System (UAS) which has generally been adopted by defence and civil aviation authorities. UAS emphasizes the importance of other elements beyond an aircraft itself including ground control stations, data links and other support equipment.

The maritime sector has the opportunity to gain extensive knowledge from numerous civil aviation uses including aerial surveying of land and crops, search and rescue operations, inspecting power lines and pipelines, monitoring wildlife and delivering medical supplies to remote or otherwise inaccessible regions. Utilizing fixed wing or rotor aircraft, the technology is usually referred to by aviation professionals as an Unmanned Aerial System (UAS) in preference to the military term 'drone'.

Beneath the surface Autonomous Underwater Vehicles (AUV) operate independently of direct human input. Remotely operated underwater vehicles (ROVs) are controlled by a remote human operator and tethered by an armoured umbilical cable that carries electric power, video and data. ROV technology was developed in the 1960's to perform deep sea rescue operations and recover objects from the ocean floor. The offshore oil & gas industry created work-class ROVs to assist in the development of offshore oil fields.

Small Unmanned Surface Vehicles Lead The Way

On the surface the COLREGS (International Regulations for Preventing Collisions at Sea) are a major and ongoing issue as mariners and legislators debate whether unmanned vessels can operate safely in the vicinity of manned vessels. While confidence is building in the wider shipping community a USV platform is required that will do minimum damage to another vessel if a collision should occur. Small, light vessels often with inflatable or foam collars, have tended to be used to prove the unmanned concept.

Creating defined sea and waterway areas where unmanned vessels can operate will enable further evaluation of their capabilities.

The first adopted vessels are mainly in the sub 12 meter (40 feet) range.

The vessel technology is mature in this size range with numerous hull forms to choose from.

The sensor technology is also mature and aviation has proved that it can be fitted into relatively small platforms then deployed over long distances.

These small, lightweight vessels are flexible enough to fulfil a number of roles, plus their size and weight characteristics enable them to be easily transported by road, rail and air. Lightweight advanced materials, including composites, for hull and superstructure are likely to become the norm as this enables the onboard technology or fuel payload to be greater.

Davit and crane lifting specifications plus storage space on mother vessels are important considerations that for now will keep USV dimensions similar to current deployed vessels such as ships boats. Launch and recovery is a challenge for any unmanned platform and this will be important when inte-

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-grating USV activities with larger ships when underway. Launch is the easier part of the process but there is still the issue of releasing the USV and pulling away from the suction effect of the mother vessel. Recovery can result in damage from collision with the mother vessel. Potential solutions range from simple nets to sophisticated high tech capture systems. Civilian roles include surveying, scientific research and pollution response. The likelihood is that the oil and gas sector will lead the adoption of this technology. As this industry is highly regulated and risk adverse this will raise confidence for the wider maritime community. Port security is likely to expand the use of fixed location CCTV and situational awareness technology to mobile unmanned platforms that can patrol specific locations or cover large areas of a harbour on a 24/7 basis in all weathers. Military roles include Intelligence Surveillance & Reconnaissance (ISR), target practice and mine hunting with a growing desire to explore all possibilities to keep personnel out of harm way.

Unmanned Boat Design and Systems Integration

The innovators of first generation USVs tended to use existing floating platforms ranging from plastic kayaks to RHIBs to accommodate bespoke electronics and controls in waterproof housings. Once command, control and communication had been proven the next generation of USV developers required bespoke craft to demonstrate task specific applications. From the naval architect and boat builders perspective there have been opportunities to adapt proven craft and for new designs which have evolved into the USVs that are available today. COTS (Commercial Off The Shelf) procurement is now driving many military and government decisions, therefore the objective will be to create standardised marine platforms that can easily be adapted to carry modular technology payloads as the vessels role changes.

This may include switching vessels from unmanned to manned as the task requires.

As the industries of boat building and autonomous system development are so different, it is proving essential to develop strategic alliances to enable cost effective systems integration. The industry recognises that a key enabler will be getting the systems architecture right from the start. A well designed open architecture will provide a flexible and modular system that can be expanded incrementally.

U.S. based Liquid Robotics has a vision to instrument the ocean with fleets of networked, wave-powered ocean robots. Wave motion is greatest at the water's surface, decreasing rapidly with increasing depth. The Wave Glider's unique two-part architecture exploits this difference in motion to provide forward propulsion. Wave Gliders have spent over 15,000 days at sea with the longest mission covering over 9,000 nautical miles. The Liquid Robotics Open Oceans Partner Program is a global technology program designed to accelerate the creation, integration and deployment of new technologies and applications for unmanned ocean systems. Building upon the Wave Glider, the world's first wave and solar powered ocean robot, this program offers participating partners a comprehensive suite of open integration and development tools. Gary Gysin, President and CEO of Liquid Robotics, said, 'We are bringing the open systems, rapid innovation model of Silicon Valley to a maritime world of special purpose systems. Working with our partners, we will create entirely new solutions for defense, commercial and scientific customers by opening up access to the world of maritime systems.'

Autonomous Vessels and the Ocean Environment

In November 2015 a brand new Marine Robotics Innovation Center was opened in Southampton UK. Run by the National Oceanography Center the center will be will be a hub for businesses and technologists developing autonomous platforms with novel sensors that will be used to cost-effectively capture data from the world's oceans.

One of the first occupants is UK based company ASV (see related story on page 10), a leading provider of unmanned vessels with more than seventy platforms in the field globally and a wide variety of associated payloads. ASV designs, builds and operates a range of platforms for industrial, scientific and military applications worldwide.

The first use of an Autonomous Surface Vehicle (ASV) to perform bathymetry for updating the U.S. nautical charts for NOAA (National Oceanic and Atmospheric Administration Office) occurred in the Alaskan Arctic in the summer of 2015. Surveying alongside TerraSond's mother-vessel, the ASV collected data simultaneously on adjacent survey lines, effectively doubling the production rate. The ASV also surveyed by itself in areas too shallow and dangerous for the larger vessel to work. Tom Newman, President of TerraSond, said, 'This is a force-multiplier for data acquisition. Operated in a semi-autonomous mode, unmanned but supervised, one person can replace the three person crew it would normally take to operate a survey launch. It is definitely the future of seafloor mapping.'

Unmanned Capability Enhances Naval Operations

Unmanned technology with the potential to change the face of naval operations within a decade has successfully been demonstrated for the first time by BAE Systems in partnership with ASV at a site near Portsmouth Naval Base. The new system will allow crews to carry out vital tasks such as high speed reconnaissance and remote surveillance while keeping sailors out of harm's way. The technology is designed to be fitted to the RHIBs already used extensively by the Royal Navy. The modified boat is capable of operating autonomously for up to 12 hours at a time, on either a pre-planned route or via remote control. It can reach speeds in excess of 38 knots, providing unique ship-launched manoeuvrability and enhanced situational awareness to support the decision-making of its operators.

Underpinning the system's ability to operate autonomously is its complex array of sensors, including a navigation radar, 360 degree panoramic infrared camera array and laser range finder. Dan Hook, Managing Director of ASV, said, 'The algorithms that we are developing with BAE Systems allow the boat to perform complex missions and navigate through

waters avoiding collisions. This gives it the flexibility and sophistication to operate in a number of different tactical roles, whether it's patrolling areas of interest, providing surveillance and reconnaissance ahead of manned missions, or protecting larger ships in the fleet.'

Les Gregory, Product and Training Services Director at BAE Systems, said, 'This technology delivers an extremely robust and fast-moving unmanned boat that is able to perform a number of surveillance and reconnaissance roles, even when operating at high speed or in choppy water. While other programmes are primarily designed for larger, slower boats to tackle mine counter-measure scenarios, this system provides an extremely manoeuvrable multi-role vessel.'

In 2015 Atlas Elektronik UK were awarded a contract by the UK Ministry of Defence to supply an autonomous mine-sweeping capability to the Royal Navy. The ARCIMS mission system, based on a specially designed 11 metre (36 feet) vessel, can be operated from shore with the minimum of support or launched and recovered from an RN Hunt Class mine countermeasure vessel. These USVs will create underwater influences to detonate mines in a controlled manner. The system will include autonomous 'Sense & Avoid' capability to enable safe operations at sea. The benefits of these modern unmanned sweeping systems are that they can safely clear sea lanes from mines therefore removing the 'man from the minefield.'

Dull, Dirty and Dangerous Tasks for Workboats

U.S. based company Sea Machines are developing unmanned work boats for a number of applications in the maritime and offshore industries. Sea Machines Autonomous Control Systems (ACS) provide algorithmic supervised autonomous control to enable unmanned operations of a vessel relative to a local base station or mother ship.

The ACS is designed to perform repetitive and quantifiable marine tasks more reliably when compared to direct human control. Michael Gordon Johnson, Sea Machines CEO, likens their new control system to the advances made by Dynamic Positioning (DP), 'A skilled master can keep a vessel in position, but it is much easier for a computer to do it. Sea Machines system is a further advancement beyond DP. The next step is to have unmanned vessels working beyond the line of sight using satellite communications.'

Regarding utilizing unmanned vessels for oil spill operations Johnson added, 'The challenge is that you never know where the spill is going to occur. Typically what happens is that boats of convenience and crews of convenience are used, which is not necessarily the most efficient outcome. Working surrounded by crude oil is absolutely miserable, it is also hazardous and can cause health problems.'

Creating vessels and systems that can perform dull, dirty and dangerous tasks has been a driver for many of the vessels that we have seen introduced to date. With autonomous systems highlighted as one of the most significant technologies for the future, this current crop of small unmanned vessels are only the tip of the iceberg for the maritime sector.

PRM Showing Results Offshore Brazil

By Claudio Paschoa

4D seismic reservoir monitoring has been increasing offshore Brazil and according to Petroleum Geo-services (PGS) it has already become routine in the North Sea. Petrobras and CGGVeritas developed a specific workflow for 4D seismic modeling studies, which was defined and is being applied to the Marlim field in the Campos Basin since 2005. Other Campos Basin oil fields such as Roncador, Albacora Leste, Barracuda e Caratinga have also been subjected to 4D seismic monitoring along the last decade. In turbidite reservoirs such as Marlin, 4D seismic technology allows for optimal reservoir management by establishing the most productive well placement locations, so that this type of reservoir can achieve recovery rates of over 50%.

4D seismic technology is also being used for Permanent Reservoir Monitoring (PRM) of reservoirs. A pioneering deepwater 4D permanent monitoring project is being developed by Petrobras at the post-salt, Jubarte field, in the Parque da Baleias (Whale Park) sector of the Campos Basin which contains both the post-salt and pre-salt reservoirs off the coast

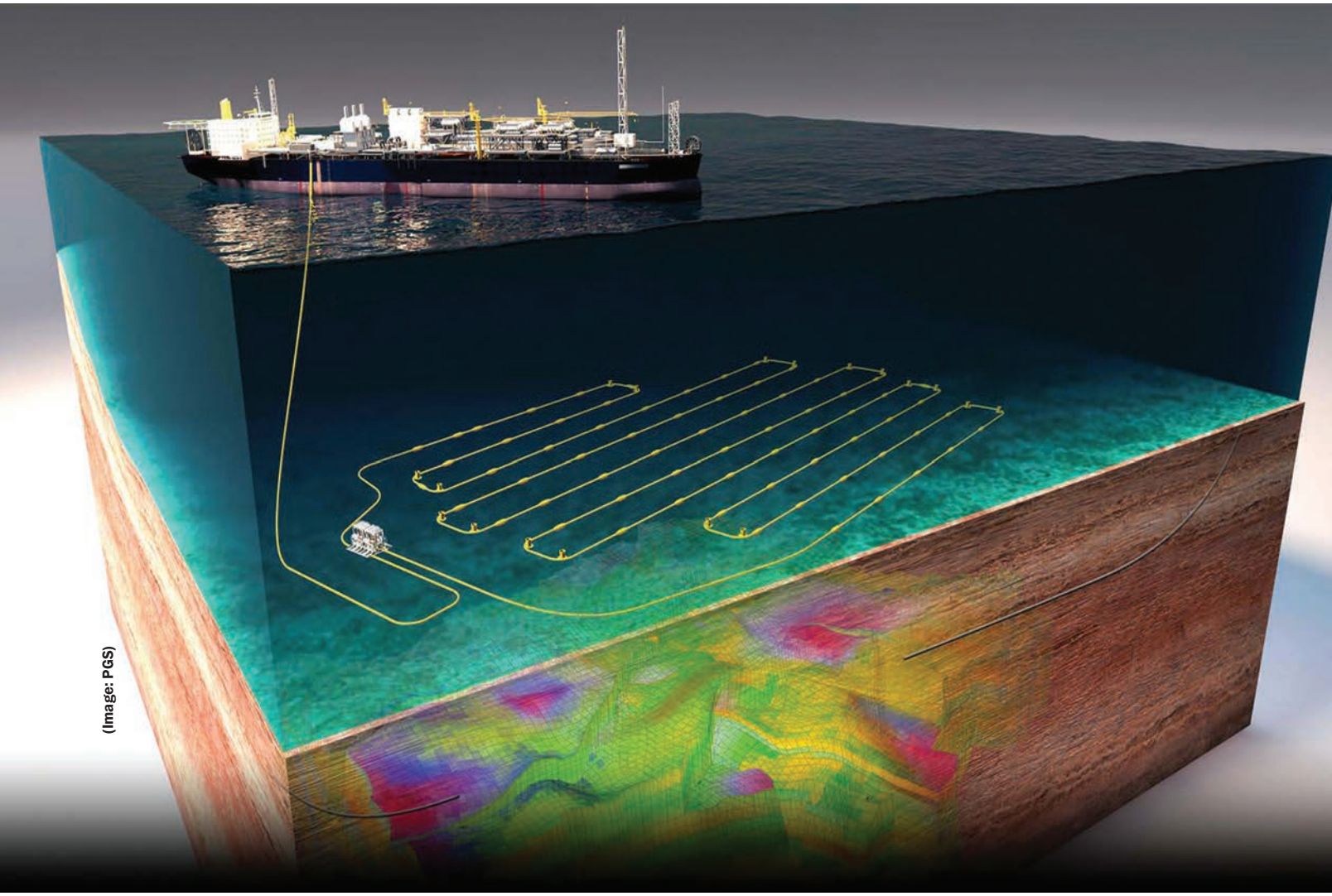
PGS subsea seismic sensors at Jubarte PRM.

(Image: PGS)

A pioneering deepwater 4D permanent monitoring project is being developed by Petrobras at the post-salt, Jubarte field, in the Parque da Baleias (Whale Park) sector of the Campos Basin which contains both the post-salt and pre-salt reservoirs off the coast of the southeast state of Espirito Santo.

of the southeast state of Espirito Santo. Since 2012, Petrobras has been successfully applying permanent reservoir monitoring (PRM), through high-quality 4C4D seismic reservoir surveillance, at depths of as much as 1,350m (4,428 ft.) at the Jubarte field. The Jubarte field, with oil reserves estimated at 600 million barrels of heavy oil (17.1°API), has a total area of 245 square kilometers, and is located in the northern portion of the Campos Basin, 77Km offshore, at a water depths between 1,185m and 1,365m. The PRM has produced as many as 3.8 million sensor traces per square kilometer with four-component sensors at every 50m (164 ft.) along the cables. "There is very high potential for enhanced oil recovery, simply by increasing our knowledge about reservoirs. If we understand them, we can learn to exploit them better," said Paulo Johann Ph.D., Geophysics Manager at Petrobras.

Petrobras' subsea seismic grid is the first PRM project in deep waters in the world, and Petrobras' first objective was to validate the fiber optic sensing technology designed for deepwater deployment, in detecting small impedance changes in the reservoir. The target was to monitor oil and water flows inside the reservoir and pressure changes due to injection and to production. Possible discontinuities, which would impact the flow and that couldn't be identified using regular 3D seismic data, are being revealed by 4D seismic data as an anomaly limit for difference volumes. This pilot project, launched in December of 2012, is composed of 35.6 km of seismic cables, arranged in two seafloor arrays that cover 9 sq. km in the south portion of the Jubarte field. The cables are anchored 300m apart to ensure good coupling, reduce noise and prevent lateral movements due to currents. They have a total of 712 4C4D receiver stations (three-component accelerometers and a hydrophone) at 50m intervals and were



(Image: PGS)

FPSO P 57 linked to deepwater PRM at Jubarte Field

deployed in parallel lines. Jubarte PRM acquisition geometry presents a super density of seismic traces with more than 3,8 million traces by sq. km of multi-azimuth and multi-component data. The seismic survey area comprises 121 square kilometers. The area of cable distribution on the ocean floor represents 9 sq. km. The area of interpretable seismic data for the main reservoir is approximately 35 sq. km. The first acquisition was concluded in February 2013 and has been processed by PGS. Passive monitoring of seismic activity of the reservoir was also acquired during a 4-month period before the second acquisition (first monitor) scheduled for December 2014.

The Jubarte PRM seismic system uses PGS/Optoseis. The system comprises a fully 4C (four-component) fiber-optic sensor array installed on the seabed and an optoelectronics controlling and recording unit installed on the FPSO P-57. Online data QC is carried out aboard the FPSO, the seismic data is then uploaded to PGS's processing center in Rio de Janeiro for further processing by a team of PGS and Petrobras geophysicists. Following the installation of the system in deep waters, Petrobras and PGS began acquiring active seismic data at least once a year using a seismic source vessel and passive or micro-seismic data between them. The PGS OptoSeis system is totally optics and is based on the Michelson interferometer sensing elements. In addition to fiber optic seismic array, the system also contains led-in cables, wet-mate connectors and optoelectronics equipment.

Permanently laid sensor cables are an alternative to other

The Jubarte PRM seismic system uses PGS/Optoseis. The system comprises a fully 4C (four-component) fiber-optic sensor array installed on the seabed and an optoelectronics controlling and recording unit installed on the FPSO P-57.

forms of repeated, or 4D, seismic data acquisition. The processed seismic data and images, allow geophysicists, geologists and reservoir engineers to produce seismic interpretations that help Petrobras optimize reservoirs management of the Jubarte field. "The great advantage of the Permanent Seismic Monitoring project is to enable the optimal management of Jubarte's reservoirs, with huge potential impact on increasing the oil recovery factor," said Johann. The PRM will enable a constant update of the geo-mechanical model of the Jubarte field and deepen the understanding of the value of micro-seismic data in deepwater projects. Data processing is in progress, and images to date have been high quality, achieving reservoir group requirements. Johann explained that, "Basically 4D seismic is attained through PRM by repeating 3D seismic on a regular basis, so we can create a dynamic model or film of the reservoir by adding different images above each other." Currently Petrobras is evaluating the possibility of extension of the permanent seismic array to the north and northwest of Jubarte. Johann's analogy to making a real-time movie of the field, showing changes as they happen, is what 4D seismic is all about and the way to shoot this movie is through PRM.

During the OTC Brazil 2015 conference, Mr. Johann presented some of the early results being obtained by the PRM, including data attained from the newly operational injection wells in order to begin to collect historic data on anomalies produced by water injection in the wells. "In production and injection wells the most common anomaly is related to water replacing oil in the lower part of the oil saturated reservoir, close to the oil-water contact," said Johann. Jubarte's PRM acquired a very high quality 4D data, with high repeatability and high signal-to-noise ratio (S/N), that was processed and interpreted in a fast track way. It was possible to identify different production effects, despite the small impedance changes. Results allowed the team to improve the water front understanding in an integrated (geophysics, geology and engineering) interpretation. The flow model and production strategy of this portion of the field are being updated using this new methodology. The first step in the interpretation process was to establish the limit where the geophysicist could be confident that the anomaly is real, above the noise level. In Jubarte the 4D signal is very complex, associated to saturation, pressure and salinity changes, depending on the position in the field. Four classes of amplitude difference anomalies were identified: increase of water saturation in production wells or above injection wells; change of the water salinity around the injection wells; and seismic noise. The behavior of each class was understood, modeling the wells production changes in a pre-stack gather and checking the amplitude changes for different incidence angles.

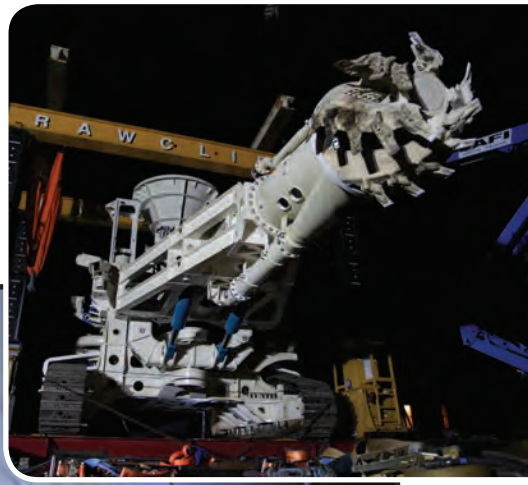
Nautilus takes delivery of SMD's SPT

Nautilus Minerals Inc. said that the Solwara 1 Joint Venture has taken delivery of the three Seafloor Production Tools (SPTs) from Soil Machine Dynamics Limited's (SMD) facility in Newcastle upon Tyne.

The three SPTs were shipped to Oman, where they are scheduled to undergo wet testing at Duqm Port. The company plans to use the SPTs to cut and extract high grade copper and gold from the seafloor at the Solwara 1 Joint Venture's project site in the Bismarck Sea, Papua New Guinea, with seafloor production operations planned to commence in Q1 2018.

"The Solwara 1 Joint Venture partners are delighted to have achieved this major milestone and we are looking forward to undertaking the extensive wet testing program that we have planned," said Mike Johnston, Nautilus' CEO. "I would like to make special mention of SMD. SMD's world leading expertise in the design, operation and maintenance of deep water robotics, cutting and trenching equipment has been instrumental in the development of the SPTs. We look forward to continuing our relationship with SMD during the wet testing program and into the production phase of the Solwara 1 Project."

All Photos Courtesy Mike Smith Photo/Nautilus Minerals Inc.



Battelle's HorizonVue M360 Video System

Camera, now available for sale or lease, gives Remotely Operated Vehicle (ROV) ability to see 360-degrees while performing subsea operations

Image: Battelle

Battelle and Technip recently tested the capabilities of the HorizonVue M360 Video System on a job in the Gulf of Mexico's Green Canyon to inspect subsea oilfield equipment, and found that it helped to provide greater situational awareness in a complex operating environment 2,200 meters below the surface. The system is now available for sale and lease.

"We were able to capture footage of pipeline and other subsea equipment as well as placement of marker buoys in this very deep ocean field," said Battelle research scientist Matt Gusto. "Each time we do a dive, we learn more about what this camera can do and its value to ROV operators and their clients." The camera was tested and operated by Canyon Offshore, Inc., a subsidiary of Helix Energy Solutions Group, Inc., with installation, training and mobilization support provided by Seatronics, an Acteon company. Intended for use by Work Class ROV operators, and subsea oilfield survey engineers, the HorizonVue M360 camera provides enhanced situational awareness in areas where keeping track of multiple objects simultaneously is critical.

The Big Picture

The HorizonVue Video System records all 360 degrees of the scene simultaneously. When the video is played back the user is able to use a digital pan and tilt window to explore the 360 image in an immersive environment to investigate what is missed by the array of cameras normally used.

"The camera delivers information that we don't normally receive in our survey data package" said Iain Miller, Subsea Intervention Manager of Technip, USA. "The depth of information, and interactivity from 360 imaging software, gives us more information when analyzing the integrity of subsea assets."

It is designed to be retrofitted on vehicles currently in use or incorporated into newly built platforms using the COTS connector of choice. Seatronics has played a critical role in ensuring that 360 degree imaging technology can be easily integrated with common ROV equipment.

"This technology enables a new dimension to camera imagery that will play an essential part in subsea operations," said Euan Mackay, Vice President of Sales Seatronics Inc. "The system can be independently configured by the client resulting in various viewing options without affecting ROV operations, which not only results in time efficiencies but also provides a safety aspect with spatial awareness."

Damen Shipyards Galati

First Steel Cut for Bibby WaveMaster

Following the recent contract signing for the first ever Damen Service Operations Vessel (SOV) with walk-to-work capability, the first steel was cut this week at Damen Shipyards Galati, marking the beginning of construction for U.K.-based client Bibby Marine Services.

The new vessel will be named Bibby WaveMaster 1 and deployed in the North Sea to support forthcoming offshore wind construction and O&M projects.

"This is a significant moment for this vessel and for both Damen and Bibby Marine Services," said René Hooijman, Sr. Project Manager Damen. "The beginning of the physical construction process is a cause for celebration after years of planning and development. The SOV is the result of extensive consultation within the offshore wind industry that has led to the design of a completely new concept from the hull up. It is therefore great to see the project come to life today with cutting of the first steel exactly according to planning. Assembly of the hull will start in April and the launch of the vessel is planned for early next year."

The SOV design provides a bespoke solution for operators involved in the transfer and accommodation of offshore wind personnel. In consultation with its partners in the offshore industry, Damen identified demand for a vessel capable of remaining at sea for long periods of time while continuously deploying and retrieving engineers and support workers along with their equipment and components. Keeping the personnel in good shape throughout the mission and the ability to operate in a wide range of weather conditions were also factored into the design as key requirements.

To achieve these goals, the development program established that positioning the accommodation amidships, combined with a shallower draft made the vessel more stable, delivering optimal comfortable living conditions and more efficient dynamic positioning, Damen said.

Primary access to offshore structures is via a motion-compensated gangway. The vessel has been laid out in such a way that workflow is highly efficient, while remaining separated from accommodation areas, according to the builder. To ensure reliability and fuel efficiency, Damen refined the design leading to a reduction in installed power alongside increased redundancy.

The potential of the design was demonstrated at an early stage with a first-of-its-kind DP test at the Netherlands marine research institute MARIN. During these trials, a scale model was pitched against simulated, worst-case scenario North Sea conditions and exceeded all expectations.

Image: Damen

Makai Upgrades Cable Installation Simulation Software

Makai released version 6.0 of MakaiPlan Pro, software for planning and simulating subsea power and telecom cable installations. MakaiPlan Pro includes the tools of MakaiPlan GIS cable route engineering software. In addition, MakaiPlan Pro allows the user to perform powerful and precise 3-D, dynamic simulations of a submarine cable installation. The operator can quickly simulate an entire cable lay in advance from the comfort of the office at up to 50 times faster than real-time. This is useful for developing Ship Installation plans, performing pre-lay and post-lay analysis, and also for operator training. The operator can run advanced simulations for conducting Installation Feasibility Studies and Equipment Selection.

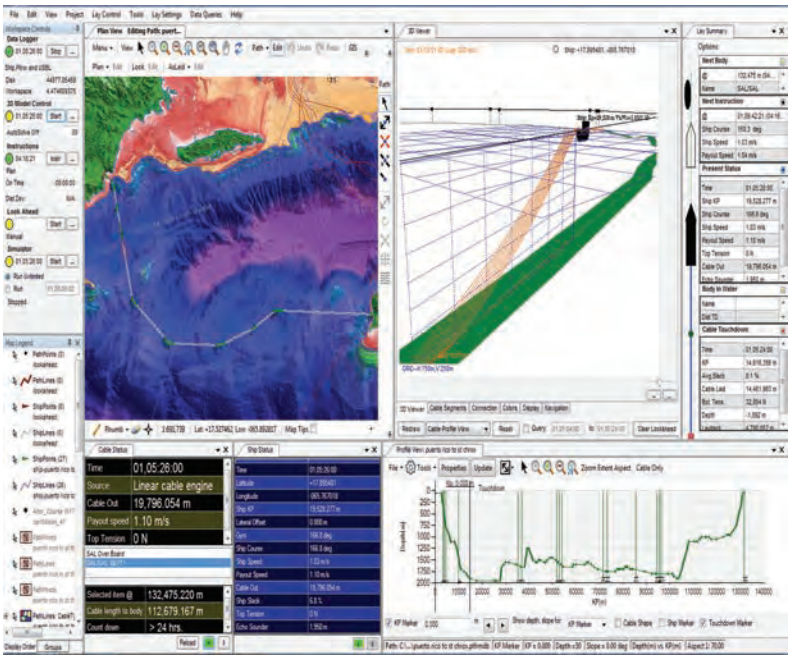


Image: Makai

A detailed simulation aids installers in understanding how to control cable seabed slack/tension during dynamic cable laying situations such as starts and stops, repeater deployments, sharp alter courses, and dealing with irregular seabed. Makai provides tools for each of the three primary phases of a cable project:

- Route Planning and Engineering (MakaiPlan),
- Installation Planning and Simulation (MakaiPlan Pro), and
- Real-time At-sea Cable Installation Control (MakaiLay).

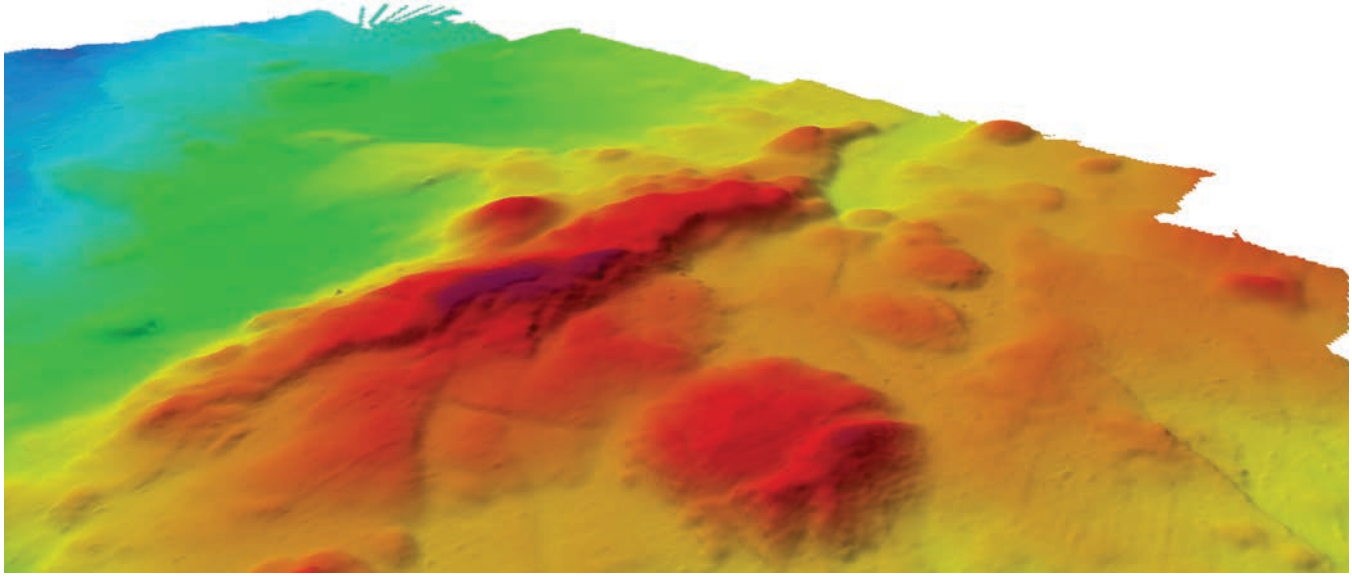
Each tool has been thoroughly validated and used successfully on cable projects for over 16 years, Makai noted. Information flows seamlessly from one product to the next, and cable projects that were planned using MakaiPlan can be directly opened with MakaiPlan Pro, preserving the information richness of the plan (GIS layers, geo-referenced notes, etc.). After planning and simulating the installation, the entire output (including final ship plan, installation notes and more) is passed onto MakaiLay, which is installed on the cable ship. A smooth and hassle-free transition from planning to installation minimizes the chance of errors, by totally eliminating the need to use a host of individual Excel spreadsheets, databases, and simulation tools that were not designed specifically for subsea cable lays.

www.makai.com

Seafloor Rise Named Engineer's Ridge

The newly discovered seafloor rise Engineer's Ridge has been officially documented through the U.S. Board on Geographic Names, Schmidt Ocean Institute said. Less than three months after announcing Falkor Seamount, an underwater mountain discovered and named by the crew aboard Schmidt Ocean Institute's research vessel Falkor, the team has found and named another underwater feature.

The U.S. Board on Geographic Names unanimously approved Engineer's Ridge on January 19, 2016. Named after the "unsung heroes of science at sea," the underwater feature was discovered during a science expedition in the Marianas Trench Marine National Monument in November 2014. Located just south of Guam, the R/V Falkor technicians mapped and measured Engineer's Ridge at 4.5 x 3 km and a maximum depth of 4,100 meters. There are strict conventions and protocols for naming geographic features, and only in very rare events will the name of living persons be used. In this case, Schmidt Ocean Institute's Lead Marine Technician Leighton Rolley argued that collectively, research ships' engineers have "made an outstanding and fundamental contribution to ocean sciences." "Engineers face daily challenges to keep the vessel running," said Leighton. "In addition to supporting vessel maintenance, engineers often assist the science party with fabrication of equipment and address problems that can determine the success of an expedition." According to the official naming proposal, Falkor and its crew ran 393 kilometers of survey lines to define the underwater bluff. It was during an expedition to explore the biology and geology of the Mariana Trench, that the team discovered Engineer's Ridge and obtained footage of the deepest fish known to science. "Without the contribution of the engineering team we would have been unable to continue to explore the deepest parts of the world's oceans, and ultimately discover the deepest fish known to science," said Leighton. There were several issues where the engineer's help was invaluable, "the naming of this feature is a lasting testimony to all the engineers who keep ships and science going."



RV Falkor (right) and its crew ran 393 km of survey lines to define the underwater bluff now dubbed "Engineer's Ridge" (above). A bonus: footage of the ghost fish (left), the deepest fish known to science.

(Images: Schmidt Ocean Institute)

Sound Metrics ARIS Defender

Sound Metrics will launch its latest design of imaging sonars at Oceanology in London. The ARIS Defender diver-held sonar is the company's latest addition for the ARIS (Adaptive Resolution Imaging Sonar) series of high definition and high-resolution imaging sonars. ARIS Defender follows ARIS Explorer and offers a unique set of capabilities. The design of ARIS Defender allows the customer the fully autonomous diver-held sonar based on the track record of the ARIS Explorer sonar. In fact, ARIS Explorer customers can purchase a "Defender Upgrade Kit," converting Explorer to Defender. The ARIS Defender 3000 operating frequencies of 3.0MHz and 1.8MHz are identical to those used in the ARIS Explorer 3000 imaging sonar.

www.soundmetrics.com

Tritech's AquaTrak CVL

Sea and Land Technologies (SALT) purchased the Tritech AquaTrak Correlation Velocity Log (CVL) to enhance its rental pool. AquaTrak CVL offers the benefits of a 300 kHz and the accuracy of a 1200 kHz and is available with the same connector and flange interface as found on most 600 kHz Doppler Velocity Logs (DVLs), making is a drop-in replacement for industry-standard DVLs. The single vertical beam permits installation of the AquaTrak CVL safely above the bottom of the ROV for protection to provide the same high level of performance, irrespective of altitude and with a range of 0.5m to 300m. AquaTrak uses an acoustic cross-correlation technique to calculate the distance moved between two very closely spaced pulses which transmit from a single transmitter. This innovative technique enables AquaTrak to run effectively at low speeds, a common operation when performing subsea operations with a Work Class Remotely Operated Vehicle (wROV).

www.tritech.co.uk

ROCIS: Airborne Mapping

Fugro and technology partner Areté Associates delivered near real-time, synoptic, surface current data to characterize Loop Current and Loop Current eddy conditions in the U.S. Gulf of Mexico during a period of intense current conditions. The new ROCIS (Remote Ocean Current Imaging System) was deployed on its first operational project, in the U.S. Gulf of Mexico. Over the course of the five-month program, Fugro surveyed currents over a distance of more than 125,000 km. ROCIS is the first commercially available system of its kind. Fugro and Areté Associates developed a system that uses a combination of digital camera technology and accurate positioning systems, together with advanced algorithms, to derive surface currents from wave spectra measurements. It can be installed on a suitable survey aircraft, together with an inertial navigation system augmented by Fugro's Starfix satellite positioning system. Current data are reviewed in real-time on board the aircraft, providing continuous assessment of data quality and the location of strong currents. Within an hour of the aircraft landing the system produces a "quick-look" map of the currents over the area while processed data files are available a few hours later. During the program ROCIS data supported day-to-day operational planning and enhanced the accuracy of 3D hydrodynamic current forecast modeling. The key technical benefits of ROCIS are the near synoptic, wide area, high resolution, high integrity surface current measurements that allow sub-mesoscale circulation to be measured and monitored. During a four-hour flight the system can survey ocean currents at 250-m intervals over a track of 900-1,100 km.

AQUAmodem Op1L

Aquatec Group launched the AQUAmodem Op1L, a new lightweight version of its standard optical modem, designed for use by divers and on small ROVs. The optical modem allows short range interrogation, commanding and data download from underwater equipment. The new instrument is three times lighter than the original optical modem, making it ideal for applications in oceanographic, environmental and coastal research, as well as offshore energy industries. The AQUAmodem Op1L is compatible with any instrument with an RS232 serial interface, including Aquatec's AQUAlogger and HYDROlog ranges, and can replace ROV mateable connectors or cables, resulting in economical operations and greater flexibility. The latest version is also interchangeable with Aquatec's original optical modem, and can reduce expenditure costs when combined with existing systems.

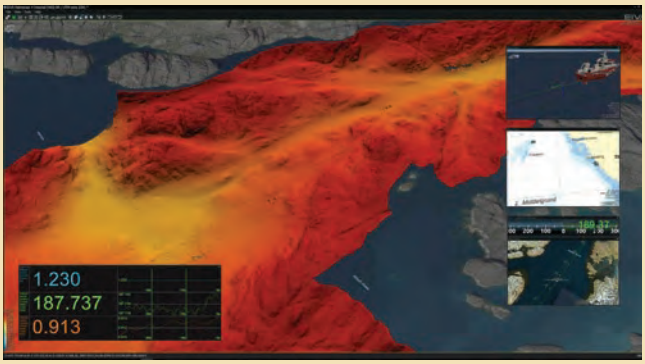
www.aquatecgroup.com

Valeport fastCTD Profiler

Valeport's new fastCTD Profiler is designed to deliver high quality CTD casts at rapid drop rates. Created for coastal and oceanographic profiling, this new profiler is an evolution of Valeport's popular miniCTD instrument. The system incorporates Valeport's world-class technology to allow the fastCTD Profiler to deliver the highest quality profiles in a lightweight and robust package.

The fastCTD Profiler uses a conductivity cell designed for optimum flow-through, a high accuracy, fast response thermistor temperature sensor and a 0.01% pressure sensor synchronously sampling at up to 32Hz to attain the most accurate measurement data. Completely programmable, no data is logged until the programmed trigger depth is reached by the device. The Valeport fastCTD Profiler is also available with an optional integral Fluorometer, from Valeport's new Hyperion range, and an optional Bluetooth communications module for easy data analysis or export. Designed to operate autonomously and powered by a single D-cell battery, this instrument can also be supplied with a traditional SubConn connector for standard RS232/RS485 communication.

www.valeport.co.uk



Next-Gen Survey Navigation & Positioning

The fourth generation of NaviPac, the flagship of the software suite from EIVA, will launch at Oceanology International 2016. NaviPac 4 is the result of a major overhaul of the survey navigation and positioning software developed by EIVA. The new software generation introduces both new and improved features, making for an even more effective tool as part of the NaviSuite software suite for offshore survey and construction operations. "We have increased our investment in product development, as we believe the best way to support our customers during challenging times in the oil industry is by providing them with solutions that will render their operations more efficient both in terms of budget and man-hours in play," said Jeppe Nielsen, CEO, EIVA. NaviPac 4 brings visualization and processing features from EIVA NaviModel, the NaviSuite solution for 4D modelling and visualization.

OI Booth #: D500

EDITORIAL CALENDAR

Month/Edition	Features		Bonus Distribution
January/February Underwater Vehicle Annual: ROV, AUV & UUVs Ad Close: 01/21	Market: Technical: Product: Special Report:	HD Cameras and Sonar for Vehicles Underwater Navigation Scientific Deck Machinery US Navy	
MTR Special Reports: Oceanographic February 2016 Bonus Electronic Edition Publication Date: February 27, 2016			
March Oceanographic Instrumentation: Measurement, Process & Analysis Ad Close: 02/22	Market: Technical: Product:	Subsea Engineering: Complexity of Subsea Field Architecture Oceanology International 2016 Technology Spotlight Sonar Systems & Seafloor Mapping	Oceanology International March 15-17, London Subsea Tieback March 22-24, San Antonio
April Offshore Energy Annual Ad Close: 03/21	Market: Technical: Product:	Seismic Vessels: Streamers & Magnetometers Deepwater Positioning, Mooring & Anchoring Subsea Vehicles and Systems for Pipeline Survey & Inspection	AUVSI May 2-5, Arlington OTC May 2-5, Houston
May Underwater Defense Ad Close: 04/21	Market: Technical: Product:	Offshore Renewable Energy: Wind, Wave & Tide International Naval Technologies Subsea Housings	Sea-Air-Space May 16-18, National Harbor Mast Europe May 24-26, Amsterdam UDT June 1-3, Oslo
June Hydrographic Survey Ad Close: 05/20	Market: Technical: Product:	Comms, Telemetry & Data Processing GPS, Gyro Compasses & MEMS Motion Tracking Interconnect: Underwater Cables & Connectors	
MTR Special Reports: Hydrographic July 2016 Bonus Electronic Edition Publication Date: July 15, 2016			
July/ August **MTR 100** Ad Close: 07/22	The 11th Annual Listing of 100 Leading Subsea Companies Market:	The Norwegian Subsea Market	Offshore North Sea August 29-September 1 Oslo
September Ocean Observation: Gliders, Buoys & Sub-Surface Networks Ad Close: 08/22	Market: Technical: Product:	Research Vessels Seafloor Engineering & Remote Operations Geospatial Software Systems for Hydrography	Oceans 2016 September 18-22, Monterrey
October AUV Operations Ad Close: 09/21	Market: Technical: Product:	Harsh Environment Systems for Arctic Ops ROV Technology: Workclass to Micro Systems Underwater Tools & Manipulators	Arctic Technology Conference October 24-26, St. John's
November/ December Subsea Engineering & Construction Ad Close: 11/23	Market: Technical: Product:	Fresh Water Monitoring & Sensors Offshore Inspection, Maintenance & Repair (IMR) Underwater Imaging: Lights, Cameras & Sonars	Underwater Intervention 2017
MTR Special Reports: Unmanned Marine & Subsea Vehicles November 2016 Bonus Electronic Edition Publication Date: November 7, 2016			

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MTR 100

Haugsdal

Kongsberg

Bolatiwa

InterMoor

Jensen & Grennan

Global Diving & Salvage

Haugsdal Named President of Kongsberg Maritime

Egil Haugsdal follows Geir Håøy as President of Kongsberg Maritime. Haugsdal holds extensive leadership experience from Kongsberg, and currently heads Kongsberg Oil & Gas Technologies. He has previous experience from Kongsberg as Executive Vice President of Business Development and as President of Kongsberg Protech Systems. Haugsdal will assume his new position as President of Kongsberg Maritime after a short period of overlap with Geir Håøy. As previously announced, Geir Håøy will assume the position of CEO of Kongsberg in June 2016.

InterMoor Appoints Bolatiwa

InterMoor, an Acteon company, has appointed Folabi Bolatiwa as general manager in Nigeria. Bolatiwa will be responsible for overseeing the company's continued growth in the region. Bolatiwa joined InterMoor in 2007 as an engineer and has more than 10 years of experience in the offshore oil and gas industry, gained in engineering, operations and management roles. He served as InterMoor's Gulf of Guinea operations manager and helped launch the business in Nigeria. Bolatiwa spent the last eight years working in Africa; in Angola as an engineer and a specialist in the coordination of mobile offshore drilling units (MODU) and FPSO mooring systems installations, repairs, maintenance and recovery, and in Nigeria, Cameroon, Equatorial Guinea and Ghana in an operations capacity. He graduated from Texas A&M University with a bachelor of science degree in marine engineering in 2006.

Global Diving & Salvage Bosses Earn Patriot Award

Global Diving & Salvage President and CEO Devon Grennan and VP of Quality Assurance Jennifer Jensen have received the Patriot Award from the Office of the Secretary of Defense, Employer Support of the National Guard and Reserve in acknowledgement of the company's continued support of Jeff Birchfield, Global's HSE Manager and a Staff Sergeant in the Washington Army National Guard.

Delia Succeeds Schmidt as Ohmsett Program Manager

MAR Inc. has named John Delia the Program manager for Ohmsett – The National Oil Spill Response Research & Renewable Energy Test Facility, succeeding Bill Schmidt who retired in December 2015. Delia was most recently with BAE Systems where he served as a Program Manager responsible for the production and development of systems as well as the logistics for the Low Probability of Altimeter (LPIA), Common Data Link (CDL) and F-22 product lines within the Electronic Systems group. Prior to working at BAE systems he served as a Senior Engineer with Northrop Grumman supporting the Defense Metrological Satellite Program (DMSP) where he performed extensive data analysis and operations of sensors on satellites. Delia has a Master's degree in Management from the Polytechnic University in Brooklyn, N.Y. and a Bachelor's degree in Electrical Engineering with a minor in Mathematics from the City College of New York.

UTEC Appoints McGovern

UTEC Survey appointed Caroline McGovern as its new Head of Finance. Before joining UTEC, McGovern was the CFO for MOL Energy UK where she was a founding director of the business which grew to comprise ownership of 20 North Sea exploration and production licenses. McGovern is a Chartered Accountant with the Scottish Institute (ICAS) and holds a bachelor of science degree in Business Management Studies and a Diploma in Marketing.

Herbert Joins Phoenix Intl

Phoenix International Holdings, Inc. hired Jack Herbert as its Commercial Operations Sales Manager in the Largo, Md., office. His responsibilities include executing Phoenix commercial (AUV, ROV, and Engineering) sales objectives, increasing market share, and leading an

McGovern

UTEC Survey

Herbert

Phoenix

Sloane & Farrell

Resolve Marine Group

aggressive commercial marketing and sales program. Prior to joining Phoenix, Herbert worked as a Business Development Manager for Marine Sonic Technology Ltd., Reson Inc., and IxBlue. Before entering the private sector he served as a NOAA hydrographer aboard NOAA ships RUDE, RAINIER, and on two NOAA Navigation Response Teams based in Norfolk, VA and New York, NY.

Sloane Joins Resolve Marine

Senior Salvage Master Nick Sloane has joined the senior management team at Resolve Marine Group. The news comes just months after Resolve opened its operations in Gibraltar, expanding its emergency response capabilities to Europe, the Middle East and Africa.

"Nick is a force in the industry and now that Resolve has a worldwide footprint, he is a natural fit," said Joe Farrell, President and CEO of Resolve Marine Group. Sloane brings more than 34 years of experience to the organization, having overseen an extensive list of salvage and oil and gas projects across the globe including the Americas, Europe, Russia, Asia, the Middle East and Africa. He was a member of the Lloyds Panel of Special Casualty Representatives and most recently served as the Senior Salvage Master of the Costa Concordia salvage operation off the Island of Giglio, Italy.

Pena Joins DOE

Deep Ocean Engineering, Inc. said that Raul Enrique Pena has joined the company as its Vice President of Sales and Marketing to drive the continued growth of Deep Ocean while expanding its presence internationally. Pena brings an in-depth knowledge of sales, channel management, business development and marketing from his successful career in telecom and tech, having worked in both start-up and established organizations. He has conducted business in Latin America, Asia and Europe in recent years, and will be focused on strengthening our relationships with Deep Ocean clients and sales channels.

Marchetti Joins Hawboldt

Hawboldt Industries said David Marchetti has joined the company in a senior sales role. Marchetti brings to Hawboldt more than 27 years of experience in operations, manufacturing, engineering, project management and aftermarket / customer service, including experience with ROV systems, and subsea oil and gas operations. Marchetti has held various positions with companies such as Schilling Robotics, GE Vetco Gray, and FMC Technologies, and most recently held the position of VP of Operations - Subsea at Forum Energy Technologies. He will be based in Houston where he will lead the sales and service efforts for the Launch and Recovery product lines.

DeMille Joins Edgetech

EdgeTech welcomed John DeMille for sales, service and support in search and recovery (SAR) side scan sonars. John DeMille has joined EdgeTech as Product Line Sales Engineer. DeMille has more than 40 years in the marine industry and is well known by police, fire, public safety dive teams and other dedicated SAR teams at the local and federal level throughout the country, having provided training, service and sales support on side scan sonar systems and other important equipment for the industry. DeMille spent 20 years as a U.S. Navy Sea Bee Deep Sea Diver serving with the U.S. Navy underwater construction teams and then went on to work as a project superintendent installing marine transatlantic communication cables. Most recently, DeMille worked with Marine Sonic Technology where he was heavily involved with the side scan sonar product line.

MacArtney Brings dotOcean to North America

MacArtney continues to expand its business portfolio through a new partnership with dotOcean for North American markets. The agreement consolidates MacArtney's position in key markets and provides customer access to the extensive range of dotOcean sediment and soil measurement products.

MacArtney has via its subsidiary Ma-

Pena

Deep Ocean Engineering

Marchetti

Hawboldt

DeMille

Edgetech

cArtney Inc. signed an agency and sales representative agreement with dotOcean covering the North American continent. dotOcean is a Belgian company specializing in sediment and soil measurement systems and instrumentation. The products included in this partnership include the GraviProbe, a, free-fall impact instrument analyzing soil layers during intrusion; the deep sea GraviProbe, which captures high quality geotechnical profiles of mud and soil layers up to 5500 meter water depths; the DensX, an in-situ, direct measurement mud density method using safe X-ray technology and an automated winch; and the iCone, a manual profiler that analyses underwater soil layers in small waterways and rivers.

Iver3 AUV Sold to Canada

OceanServer Technology received a contract for an Iver3-580 EP system from Canada Public Works and Government Services for delivery to the Defense Research and Development Canada (DRDC). The Iver3 AUV will be used to augment existing autonomous systems and provide a platform to continue R&D development in underwater research at DRDC Atlantic.

OceanServer has sold several systems to DRDC with a wide range of sonar, software and sensors for research into areas such as mine counter measures. DRDC will have access to Iver's mature

Iver 3

Photo: Parks Canada / Thierry Boyer

hardware and software interfaces to further studies in various adaptive behavior "autonomy software" architectures. The Iver's primary system CPU is capable of outputting vehicle position and trajectory information to a separate payload computer. The primary Iver3 CPU in return accepts input of autonomy decisions such as heading, speed and depth following OceanServer's well documented API for remote helm and other behavior applications. The vehicle will be equipped with an INS for very accurate navigation along with the Klein 3500 Side Scan and Bathy system for imaging and mapping the seafloor.

Polarcus Cuts More Jobs

Polarcus announced it will implement further measures to cut costs, including additional headcount reductions and changes to the executive management team. The expanded cost reductions are part of a longer term plan that aims to help Polarcus withstand a prolonged difficult market as well as to take advantage of opportunities in this volatile environment, the company explained. As part of the cost management program implemented at the end of 2014, personnel reductions now total 26 percent. This additional reduction of 15 employees are all office staff and include executive management positions to fit a redefined Polarcus. Cost savings as a result of these recent personnel changes plus additional other overhead cost reductions will total $7 million annually, excluding one-off restructuring costs which will be incurred in Q1 2016.

Chief Financial Officer, Tom Henrik Sundby and Senior Vice President Human Resources, Dr. Paul Hanna made the decision to leave the company. Additionally, Peter Zickerman, Executive Vice President Strategic Investments and company founder, has moved from being an employee to a consultant as strategic advisor to the company. The Executive Vice President Strategic Investments and Senior Vice President Human Resources executive management positions are eliminated as a result of these changes.

Effective March 1, 2016, Hans-Peter Burlid will be promoted to the position of Chief Financial Officer. Burlid currently serves as Vice President Finance

& Investor Relations for Polarcus, an executive management position which will be eliminated. He has 12 years of experience in the seismic industry with key roles in finance, accounting and business development and was instrumental in the start-up of Polarcus. Burlid holds a B.Sc. in Economics and Business Administration from Blekinge Institute of Technology, Sweden.

Mooring Components for Floating Wind Park

Statoil signed a contract with offshore chains and mooring systems supplier Vicinay Marine for the design, manufacture and deliver mooring components for the world's first floating offshore wind park, the Hywind pilot park offshore Scotland. Vicinay Marine will provide the mooring chains and connectors for the Hywind project, to be delivered at place in Scotland with in 2016. The fabrication of the mooring system will take place at Vicinay Marine´s facilities in Sestao and Galdames in Spain. The 30MW pilot project will consist of five 6MW floating turbines operating in waters exceeding 100m of depth. The Pilot Park objectives are to demonstrate cost efficient and low risk solutions for commercial scale parks. Production start is expected in late 2017.

Call for Nominations

The University-National Oceanographic Laboratory System (UNOLS) Marcus Langseth Scientific Oversight Committee (MLSOC) is seeking nominations for two open committee member positions to be filled immediately. The MLSOC, a standing committee of the (UNOLS), is charged with overseeing the scientific operation of the R/V Marcus Langseth research vessel as a National Oceanographic Facility (NOF). The Langseth provides the U.S. academic community with the resources to acquire state-of-the-art, two- and three-dimensional marine seismic-reflection data. First and foremost, MLSOC fulfills an ombudsman role for all scientific groups in need of high-quality geophysical images, with the goals of providing state-of-the-art seismic acquisition capabilities, lowering the threshold of expertise needed to use the facility, and increasing the quality and accessibility of archived data. Second, the MLSOC is charged with monitoring and advising on the Langseth's capabilities for general geophysical and oceanographic research, thereby insuring the most cost-effective operation of this unique asset.

The term of office for committee members is three years, with the possibility of a reappointment for a second term. The MLSOC typically meets in San Francisco prior to AGU and again by teleconference or in person each year. Scientists interested in serving as an MLSOC member should submit a two-page current C.V., a one-page statement of interest that should include his/her vision for Geophysical scientific research over the next decade, as well as a summary of experience using seismic facilities. Copies of these materials should be sent to the UNOLS Office (office@unols.org) by March 18, 2016.

OI 2016

Previews of new technologies and company exhibits planned for Oceanology International 2016 in London.

3D at Depth

3D at Depth provides industry leading subsea LiDAR laser systems (SL) and software to deliver repeatable millimetric measured point clouds and solutions designed to help clients build, maintain, map and monitor underwater assets and resources. 3D at Depth's SL platforms combine integrated hardware sensor technology with 3D software suite to address the challenges of subsea 3D measurement and visualization for offshore oil and gas, commercial and government industries. Based in the technology hub of Boulder Colorado, the company is focused on innovations and best practices to enhanced 3D underwater data collection processes.

Booth #: C301

AML's Base • X_2

The latest generation of AML Oceanographic's Base • X presents the best profiler technology of today in a compact form. Available in 100m and 500m versions, Base • X_2 retains the size of its predecessor while gaining WiFi connectivity and GPS cast geo-referencing. Data is automatically downloaded and processed into desired manufacturer formats, saving valuable time for the operator. With AML's new combined conductivity and temperature sensor, CT • Xchange, Base • X_2 converts from an SVP to a CTD profiler with the switch of a single sensor head.

AML's CT • Xchange

AML Oceanographic's new CT • Xchange provides conductivity and temperature in one sensor head. The combination allows for more sensors on all X • Series instruments. With CT • Xchange, two-port Base • X_2 is a high performance CTD in a compact, cost-effective package, and Minos • X is the smallest combined CTD/SVP on the market. CT • Xchange also features an extended range on both parameters: 0 to 90 mS/cm for conductivity and -5 to 45 °C for temperature.

Booth #: D150

Aquatec AQUAscat 1000LT

It is now even easier to measure suspended sediment concentration with the new AQUAscat 1000LT acoustic profiler. The latest addition to the well-established AQUAscat range combines cutting edge technology with economic design to give the best value solution for scientists and surveyors. The AQUAscat 1000LT observes profiles of suspended sediment concentration of up to 2.5m using multi-frequency acoustics. Profiling allows sediment dynamics such as resuspension and entrainment to be explored, which is not possible with single point measurements. The instrument is supplied with the latest user-friendly post-processing software that allows the mean particle size and concentration to be calculated from the acoustic backscatter output.

Booth #: J300

ASV: C-WORKER 5 ASVs

ASV completed the construction of four C-Worker 5 vehicles. These Autonomous Surface Vehicles (ASVs) will be added to ASV's global lease pool in the second quarter of 2016. While the C-Worker 5 can accommodate a variety of client payloads and applications, it was specifically designed as a hydrographic survey force multiplier. The C-Worker 5 is five meters long and can operate at seven knots for

five days before refueling. This speed/range combination maximizes acquisition effectiveness while minimizing launch and recovery operations. As a force multiplier, it can operate concurrently alongside traditional survey vessels, dramatically increasing survey efficiency.

The C-Worker 5 uses a direct drive marine diesel propulsion system operated via ASV's proven ASView control system. The C-Worker 5 integrates quickly and easily with a wide variety of payloads including hull mounted and towed sensors. The ASView control system enables line plans from a variety of data acquisition systems to be uploaded for efficient data collection. "The C-Worker 5 is an exciting new ASV that will dramatically help our clients' bottom line," said Thomas Chance, ASV's Chairman. "The new vehicle also complements ASV's C-Worker 6 and C-Worker 7 product line which can accommodate larger payloads." The C-Worker 5 will be unveiled publicly for the first time at Oceanology International.

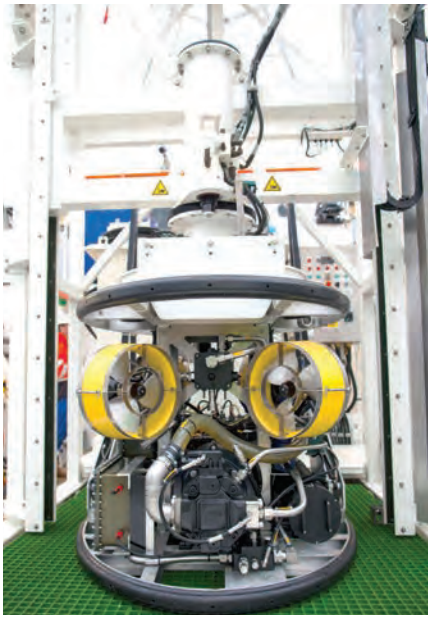
Booth #: G401

Bibby HydroMap

Bibby HydroMap will be presenting a number of interesting developments, including the widely anticipated results of its latest d'ROP survey trials. These will be revealed initially at an exclusive invite-only session on Tuesday, March 15, at 14:30, followed by a public presentation within the Innovation Zone on Thursday, March at 17 14:30. On its exhibition stand visitors are encouraged to take part in the 'd'ROP Challenge,' to be in with a chance to win their own limited edition d'ROP and one of a kind Bibby Athena. To complete the challenge, entrants will build their own d'ROP using colourful interlocking bricks from a popular unnamed toy brand. If they complete the challenge within the specified time, they take home their own d'ROP, and if they score the fastest time of the entire show they are awarded with a replica Bibby Athena.

Booth #: B100

d'ROP



D-2 Marine

D-2 will introduce at Oceanology a newly designed Conductivity, Temperature, and, Depth, (CTD) modular sensor suite that will improve oceanographic data collection on a variety of deployment platforms, especially UUV/ AUV's. The CTD sensors are well suited to platforms which require sensors to be a small and low power. A 'Hybrid' fully internal field conductivity sensor with ideal length to wetted surface area can be used with or with an aspirating pump. This sensor is optimized UUV/AUV/ Drifter platforms which will benefit from much smaller sensor, which consumes less energy less, and does not require a water pump, even at very low platform velocities, hence allowing extended data collection capability in all applications. The new sensor is also well suited to arctic environment deployments as the sensor will not freeze at the air sea interface. The conductivity sensor has a fully contained electric field so can be mounted in close proximity to other equipment. Both static and dynamic accuracy/precision allow for full ocean depth deployment. Designed and built by D-2 Marine Corp., a fully owned subsidiary of D-2 Incorporated an American ISO 9001:2008 certified manufacturer with 25+ years' experience in high precision measurement instruments.

Booth #: P10

BMT Group

BMT Group, an international multi-disciplinary engineering, science and technology consultancy will demonstrate its integrated approach to better understanding the operational complexities of the marine environment. Through a suite of

Photo: BMT

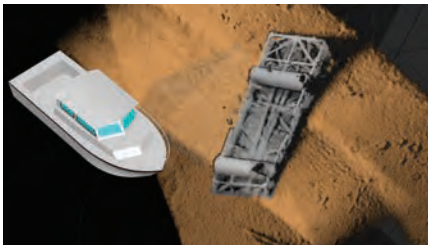
solutions, BMT can forecast, measure and analyze, providing companies with the insight and knowledge to understand the response and operation of structures and vessels in complex environmental conditions. With offices located in Europe, Asia and the Americas, BMT draws upon a wide range of experience and expertise to offer cost effective, safe and reliable products and services across the oil & gas, renewables and coastal maritime industries.

Booth #: N400

Coda Octopus

Coda Octopus continues to develop unique real-time 3D technology and it now has three different levels of sonar system for different customer requirements (Echoscope, Echoscope C500 and Dimension). Coda Octopus have also significantly enhanced its real time 3D solution for breakwater application by further development of its Construction Monitor System (CMS) Software, which includes patented features such as block tracking algorithms to maintain accurate tracking. This solution is a comprehensive workflow management tool for block placements. Coda Octopus have continued to push this unique technology across a range of different market applications across the world. Real-time 3D visualization dominates all other visual markets and underwater is no exception.

Booth #: C100



dotOcean

dotOcean offers innovative measurement instruments, sensor networks and rapid development services to the maritime and offshore industry. The products dotOcean will present at Oceanology International 2016, are being used for sediment analyses, profiling underwater soil layers and determination of the nautical depth. Next to the GraviProbe and DensX, dotOcean will present three new products at Oceanology International 2016: the Deep Sea GraviProbe (operational until a depth of 5500 m), the iCone (for surveys in small waterways and rivers) and an Autonomous Survey Platform.

Booth #: G350

(photo: dotOcean)

Kongsberg Maritime

With focus on 'Integrated solutions for research vessels', KONGSBERG's stand features a MUNIN AUV, the latest generation HiPAP system, cNODE miniS transponders, new EM 712 shallow-to-medium depth multibeam echo sounder, a new portable multibeam (EM 2040 P) and the new EA 440 single beam echo sounder. GeoSwath Plus USV, wide swath bathymetry for unmanned surface vehicles and the PulSAR towed side scan sonar will be on show. The new KONGSBERG Maritime Broadband Radio will transmit live video/data to the stand from the Northern Wind vessel, which has EM 2040 P, EM 2040 and TOPAS PS120 on board. Product demos will be held on Northern Wind throughout Oceanology.

Booth #: D600

EdgeTech

EdgeTech is celebrating "50 Years in Underwater Technology" this year and the company will be exhibiting many of its well-known products and solutions at Oceanology International in March 2016. The company is known worldwide for its high quality products which include: side scan sonars, sub-bottom profilers, bathymetry systems, AUV, USV and ROV-based sonar systems, combined and customized solutions. In addition to the full line of underwater survey products, EdgeTech provides reliable USBL systems, transponder beacons, deep sea acoustic releases, shallow water and long life acoustic releases, and customized underwater acoustic command and control systems.

Booth #: H201

FSI

FSI designs and manufactures precision instrumentation for marine applications:

- Sub-Bottom, Sidescan, Combined, and CHIRP Sonar Imaging Systems
- ACM-PLUS Family of Current, Wave, and Tide Meters
- Pinger/Locators and Recovery Systems
- Acoustic Transducers and Arrays

The CHIRPceiver is a true 24-bit dual frequency CHIRP sub-bottom profiling transceiver; provides CHIRP acoustic pulses in standard LF (1KHz-10KHz), and optional ULF (200Hz-2KHz) or HF (8KHz-23KHz) bands. Bubble Gun portable, low-frequency, seismic systems enable deep

sub-bottom and transition zone surveys from small vessels; minimal footprint, power source, and infrastructure needs; low frequency, wide band energy spectrum; stable and repeatable shot-to-shot wavelet correlation.

Booth #: N10

Imenco

Imenco UK Ltd will be exhibiting at Oceanology International 2016 at ExCel Exhibition and Conference Center in London where it will be sharing stand L150 with its Middle East Agent Indepth International Ltd. Imenco will be highlighting the SubVIS Orca HD over Ethernet subsea camera along with the widest range of SD and HD subsea cameras, LED lights and green line lasers available from a single manufacturer. The range of Imenco electronics provides complete spreads for all classes of ROV, Trenchers, Ploughs, and for diver support. The SubVIS Orca has undergone successful trials in the Northern North Sea over the last six months producing stunning video outputs for environmental research organizations and oil and gas companies alike. Imenco will be showing some of the results on a large video screen on stand. Imenco UK Ltd will have sales and technical support available throughout the exhibition to answer any customer queries on existing and future HD over Ethernet ranges of subsea electronics, of which the SubVIS Orca is the first.

Booth #: L150

JouBeh

Join JouBeh at OI 2016 in London where it will be showcasing the Iridium Pilot. The Iridium Pilot is more reliable than ever, delivering exceptional performance, durability and value for broadband connectivity at sea, everywhere on the planet. Without the burden of long-term commitments, you can still satisfy all your voice and data communications needs at prices that fit your budget. As the best Iridium cost-per-byte option, Pilot can easily be integrated into your existing data acquisition system.

Key features and benefits

- Pole-to-pole global coverage
- Reliable high-speed data (32 kbps, 64 kbps, 128 kbps)
- 3 independent voice line capability
- Durable construction
- Performs in any conditions
- Easy to install
- Global Service Program
- 5-year limited warranty

Booth: Atlantic Canada Pavilion

Marine Electronics Ltd.: New Dolphin 2D Sonar

Marine Electronics Ltd. is presenting its new Dolphin 2D sonar at Oceanology where designers of small AUVs and ROVs are expected to be impressed by its performance and compact size. The new sonar was first shown to the industry in prototype form a year ago. Since then further design, development and testing has been completed and Marine Electronics is now able to demonstrate this impressive new product to potential customers who have been waiting eagerly since its preview.
The new Dolphin 2D is a 720 kHz system that has evolved from the company's existing Dolphin 3001 model while introducing several new key benefits. Its compact size and light weight now make it an ideal choice for use on small ROVs and AUVs as well as for other applications on surface craft. Its versatility and ease of use is also improved by an Ethernet connection to the underwater unit.
A one-piece composite ceramic unit with 96 elements gives the new Dolphin 192 acoustic beams that create a 120 degree horizontal display. With a low power consumption of less than 15 watts the sonar can provide clear images at 30 frames per second for very close range work at less than 1-metre, or for long range imagery up to 100 metres at 7.5 frames per second. It is able to provide the clearest imagery at most ranges but if customers need a 2D sonar for targets at a specific distance the basic model can be adapted to meet their needs. The new sonar also contains a nine-axis MEMS motion sensor and requires no surface image processing. This means that what leaves the unit via its Ethernet connection is the image that the user sees.

Booth #: E200

Marine Research Ltd.

Marine Research Ltd. is a hydrography and oceanography service company, specialized in shallow and extremely shallow waters, from 0 to 100 m deep. It can provide multibeam bathymetry, side-scan sonar imaging, water quality monitoring and various other related services. At its Oceanology International stand, visitors can find out more about the company's survey services and take part in live demonstrations on its Underwater Mass Spectrometer. Visitors will be able to see how easy measurements can be performed and find out more about the advantages of this revolutionary method.

Booth #: B551

National Oceanography Center

The National Oceanography Centre (NOC) will be demonstrating sensors and showcasing its science and marine autonomous systems capability at Oceanology International. The NOC's marine autonomous program will be taking place in room nine over the morning of the 16th of March, and will include a talk on the new Marine Robotics Innovation Centre as well as one on the use of sensors and AUV's in Carbon Capture and Storage. The Oceans of tomorrow stand will also be hosting demonstrations of pH and nutrient sensors developed at the NOC.

Booth #s: A235, A315

Nautilus Marine Service

Nautilus Marine Service, the provider of VITROVEX glass housings capable of operating in the most extreme regions of the Earth, has increased its product range: both a 13-in. diameter glass sphere that can withstand full ocean pressure and a 20-in. diameter glass spheres with and more than 40 kg uplift, are available immediately. Various high optical grade spheres up to 7.5-om/ diameter complement the deep water product range of VITROVEX enclosures for applications featuring camera, video and lights. VITROVEX glass enclosures offer the dual advantage of buoyancy and pressure proof housings - a perfect combination for small and autonomous underwater instrumentation packages.

Booth #: F200

Oceaneering

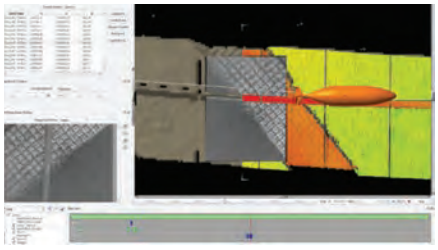
As the trusted subsea connection specialist, Oceaneering solves beyond the status quo for subsea surveys and deepwater seafloor mapping. We connect reliable AUV technology to pipeline inspection and offer cost-effective, innovative solutions with accurate, high-resolution pipeline inspection information.

Pushing the frontiers of marine science and ocean technology using new leading-edge technologies, Oceaneering is connecting what's needed with what's next as the world's largest ROV operator. Our services include but are not limited to Survey Services; C-Nav Precise Point Positioning solutions; Subsea Asset Integrity; Subsea Connections; and Service, Technology and Rental.

Booth #: J301

QPS

Pictured below: C&C Technologies' Hugin AUV conducting pipeline inspection operations in the Gulf of Mexico – pipeline inspection data processing and visualization in QPS Fledermaus.



Acquire-Process-Visualize-Share: Be sure to visit QPS where it will showcase its industry leading software (QINSy, Qimera, Fledermaus and Qarto) for collection, post processing and visualization of maritime geomatic data. Latest features on display will include new tools in QINSy for cablelay and rockdumping projects; some great new tools for data cleaning and processing in Qimera; powerful new pipe/cable visualization tools in Fledermaus; and Qarto our brand new ENC production toolkit.

Booth #: H200

RTsys

The COMET AUV will be displayed for the first time at Oceanology International 2016.

RTsys, a specialist in underwater acoustics, revealed the results of a four years development combining acoustics and underwater robotics. The company developed a next generation of AUV meeting the needs of current demand in offshore companies such as weight and size, working capabilities (speed and autonomy), positioning and recovery and re-deployment. The first achievement is to offer a compact system with high speed and autonomy which is quickly reconfigurable and deployable. COMET AUV weighs less than 35 kg and can speed up to 15 knots. It is able to cover a 200 km distance at 3

(photo: RTsys)

Outland Technology

Outland Technology introduces a new underwater CP probe, model CP-100. The CP-100 features dual cell technology to provide accurate and reliable CP readings as well as a hardened stainless tip to stand up to abuse from the environment. It is suited to both contact and proximity readints. It is available with both Diver-held and ROV mounts and multiple connector options.

Booth #: H700

knots on a single deployment thanks to its rechargeable batteries. Moreover COMET AUV is used as collaborative underwater drones or operate in “swarm” mode.
In July 2015 COMET AUVs realized a world premier by operating in swarm mode scouting in front of a vessel. COMET AUVs are able through swarm mode development and using its underwater acoustic capabilities to collaborate on various 3D geometrical that will improve their positioning accuracy. These AUVs can operate from several meters to 1500 meters from each other and are able to accomplish a various type of missions and communicate in broadband. A wide range of sensors load can be embedded on COMET AUVs which are now ready to provide their cutting edge capabilities to many applications.

Booth #L550

SEACON

SEACON (part of TE Connectivity) are world leaders in underwater connector technology and provide an extensive and diverse range of electrical, optical and hybrid connector assemblies, submersible switches and cable system solutions for many applications within the Oceanographic, Oil & Gas, Defense and Environmental markets. Also exhibiting on SEACON’s booth will be DEUTSCH, TE Connectivity, Rochester Wire & Cable, Raychem and Tyco Electronics.

Booth #: C650

Seafloor Systems

Dockside Demo

Seafloor Systems launched a line of Autonomous Surface Vehicles developed for hydrographic survey applications. The EchoBoat-ASV is a multi-payload, remotely and autonomously controlled survey boat, featuring portability, improved thrust and large payload capacity. The HyDrone-ASV is a remotely and autonomously controlled singlebeam survey catamaran platform for bathymetric surveying. Seafloor’s

VectorNav

VectorNav introduces the VN-360 GPS-Compass, an OEM heading and position sensor that provides a low-cost alternative to digital magnetometers and larger, more expensive GPS-compass/Satellite-compass systems. By connecting two GPS/GNSS antennas mounted with a clear view of the sky, the VN-360 provides a reliable, fast-acquisition position and heading solution for a wide range of applications. With a footprint the size of a postage stamp and a user-configurable antenna baseline, the VN-360 offers maximum flexibility for integration into existing systems and enables new applications previously constrained by size, weight, and power requirements. The VN-360 is the follow-on product to VectorNav’s recently released VN-300 Dual Antenna GPS/INS. In addition to GPS-Compass capability, the VN-300 includes an onboard inertial navigation system (INS), which provides highly accurate position, velocity, and attitude estimates under the most demanding dynamic conditions.

Booth #: C661

range of ASVs combine workhorse utility and capability with modern, advanced microelectronics making owning and operating an ASV affordable to all in the Hydrographic Community.
The survey vehicles can be monitored while underway, in both Auto and Manual modes, while within line-of-sight range. The mission planner application runs on a base station laptop, connected through a radio telemetry link, and displays the vehicle's graphical positioning and progress against a background map of the survey area. Battery voltage, current, and capacity remaining may be monitored via this link. Switching from autonomous to remote control is easy using a high-power remote control system that offers up to 2km range, with a survey endurance of over eight miles on a single battery pack Both survey vehicles will be shown at Oceanology International 2016 in London. There will be a live demonstration of the EchoBoat-ASV on the ExCeL dockside on 15th and 17th March at 10:30 and 15:30.

Booth #: B601

Sonardyne

Subsea technology company Sonardyne International, will be presenting technical advances in surface and subsea positioning, navigation, imaging, communications and monitoring. New additions to the company's Lodestar AHRS and SPRINT inertial product lines mean that there is now a model to suit all ROV/AUV applications and budgets. As all versions use the same small and lightweight subsea housing, users can switch capability without having to fit different vehicle hardware. Sonardyne will also be presenting its expanded line-up of Syrinx DVLs, acoustic and optical modems, NOAS obstacle avoidance sonar and SMART, an instrument designed for asset monitoring and analysis.

(photo: Sonardyne)

Booth #: F300

SubC 4K Suite

SubC releases its 4K Ultra High Definition (UHD) suite at Oceanology. Featuring 4K video, digital stills, LED Light/Strobe and a 4K DVR Overlay system, the 4K suite is the latest in SubC's high resolution video/digital stills packages and is the first commercially available 4K system on the market. With four times resolution of HD, the 4K suite provides the highest quality underwater footage with incredible detail for the inspection of subsea assets and ocean science research. The 4K suite and its components are designed for easy integration with almost any platform including ROVs, AUVs, Towed Video and Drop Camera systems. The camera and light can also be combined with a battery for a completely autonomous monitoring solution as the camera can be programmed to carry out a series of operations at custom intervals when direct control is not available.

Booth #: E400

SubCtech: Li-Ion Subsea Power – The Subsea Socket

SubCtech, Kiel's answer to the increasing demand for greater autonomy and long-term deployments underwater is a safe and highly-reliable family of Li-Ion batteries, the PowerPack. A high energy density of 210WH/kg on battery level makes SubCtech's Li-Ion batteries with pressure housing made of titanium more efficient than comparable pressure-neutral Li-ion batteries. Long-term deployments and high currents are no longer problematic, thanks to the system design and the low

TECNADYNE™
THE LEADER IN SUBSEA PROPULSION

Tecnadyne

Since 1985, Tecnadyne has been a leader in the worldwide subsea robotics industry, manufacturing the most reliable and longest lasting thrusters on the market. A large portion of Tecnadyne's manufacturing activity involves the design, fabrication and development of customized subsea systems to satisfy the unique requirements of our customers, including propulsion systems, rotary & linear actuators, hydraulic power units (HPU's), intelligent hydraulic valve packs, subsea and harsh environment controllers, subsea position sensors, and subsea pressure compensators for use on Remotely Operated Vehicles (ROV's), Autonomous Underwater Vehicles (AUV's), manned submersibles and other subsea platforms. Tecnadyne is introducing a specialized product line of AUV brushless DC thrusters. As with all of Tecnadyne's thrusters, they will have capability for integrated electronics, option for full ocean depth and magnetically coupled propellers to eliminate shaft seals for optimum reliability.

Booth #: M120

40kWh Li-Ion AUV battery, ready to be installed.

self-discharge. PowerPacks are available from 100+ Wh to 100+ kWh. The BMS controls all safety functions and communicates via simple ASCII NMEA-0183 commands or via MODBUS.

Being qualified according to ISO 13628:6, MIL-STD 810G, the Li-Ion batteries are used for Subsea Oil+Gas. Standardized COTS (commercial off the shelf) batteries benefit from the high quality level that comes with production in accordance with IPC-A-600/610 class 3. As a result, highly-reliable batteries with top capacities are available at a reasonable price, even for condition- or environmental-monitoring-systems. UN T38.3 transport certificates are available for some battery types, e.g. 14.4V @167Ah.

Booth #: M250

Proserv

Proserv offers an enhanced portfolio of field-proven technologies, in-depth engineering expertise and world-class services to clients in the drilling, production, subsea & decommissioning market sectors while also providing offshore survey services. Proserv will demonstrate the following products and services:

- NASNet positioning systems
- NASDive diver communications
- Survey Services

Booth #: C101

Teledyne Marine's 'One Team' at Oceanology International

Teledyne Marine's newly formed One Team will be out in full force at OI London, spanning four booths (F100, G100, J100 and D10) and 23 brands. The Teledyne Marine companies provide a vast array of technology solutions ranging from tiny hydrophones and connectors to one-of-a-kind turn-key systems. Teledyne Marine will be launching several new products, conducting dock-side and on-water demos, and hosting a Learning Center with presentations spanning new product innovations, customer applications, and tips to better utilize Teledyne Marine's products, software and services. "The essence of our One Team approach is that, from first point of contact, customers will be aligned with an individual, or team of individuals, who will expertly address all aspects of their current application. With technologies broken into 5 core segments; Imaging, Instruments, Interconnect, Seismic and Vehicles, our Teledyne Marine sales staff is now able to address not only brand level solution, but turn-key systems and capabilities by leveraging our full range of technology solutions. Our goal is to provide a one-stop shopping experience including 24/7 customer support world-wide," says Mike Read, President of Teledyne Marine.

Booth #s: F100, G100, J100 & D10

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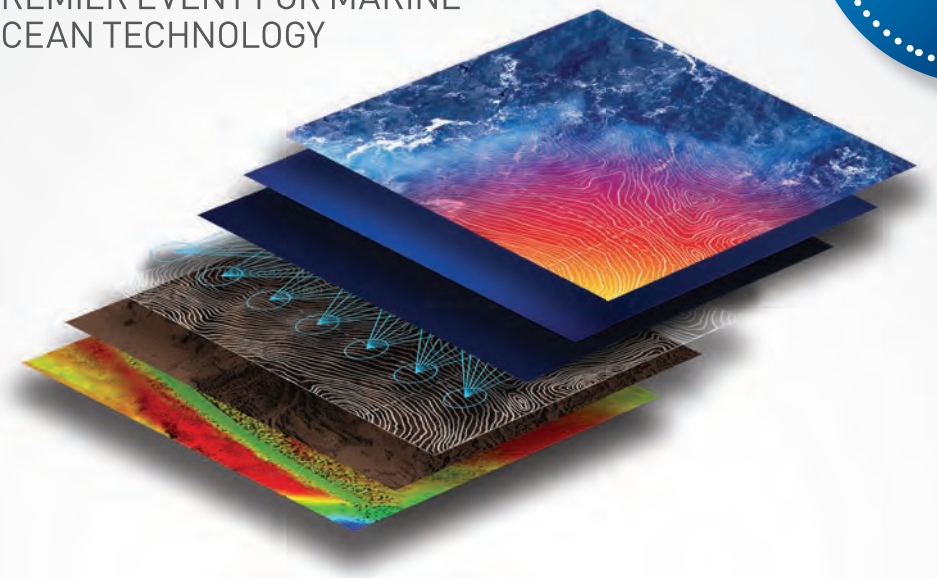

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