Hydro INTERNATIONAL

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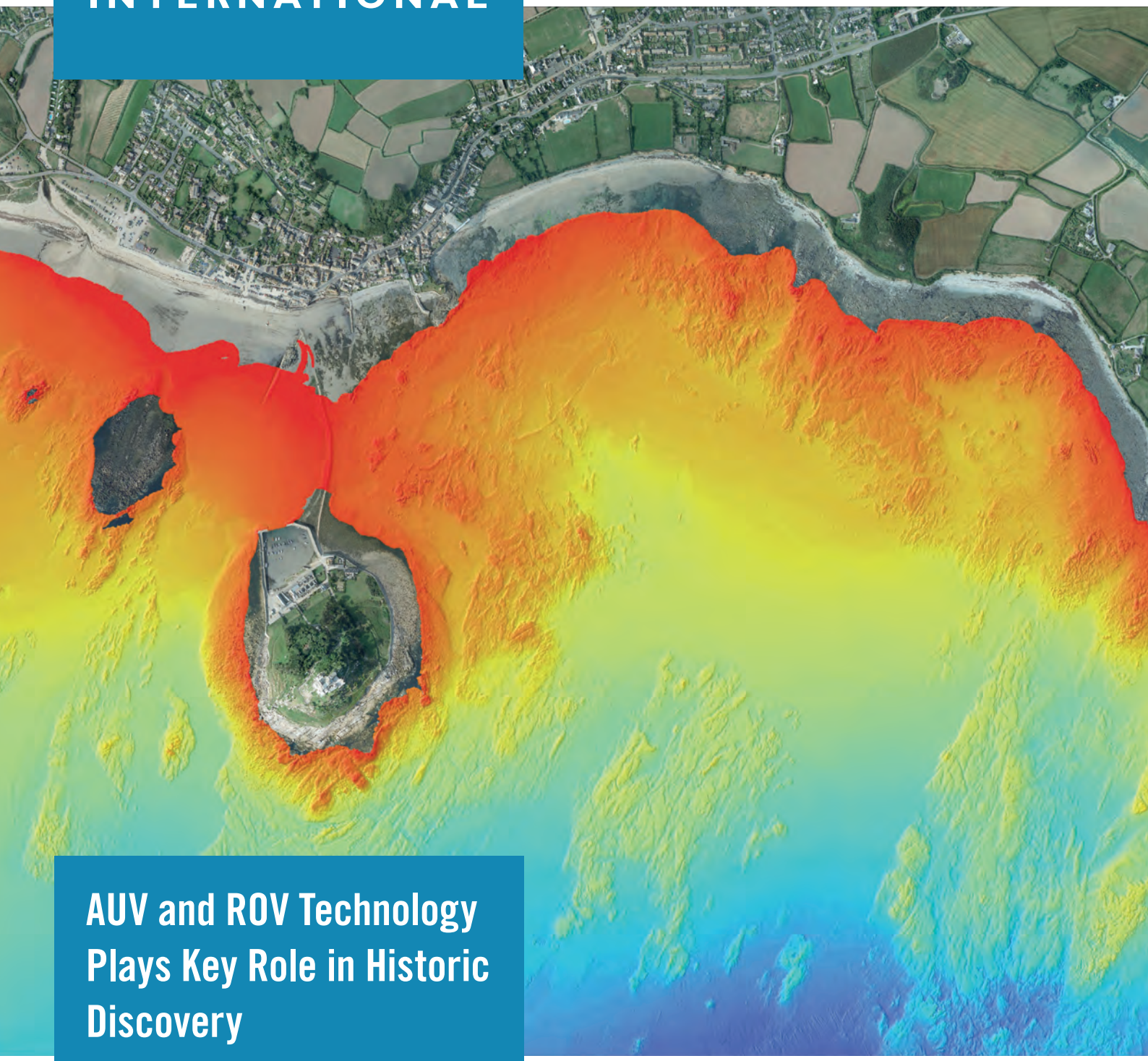


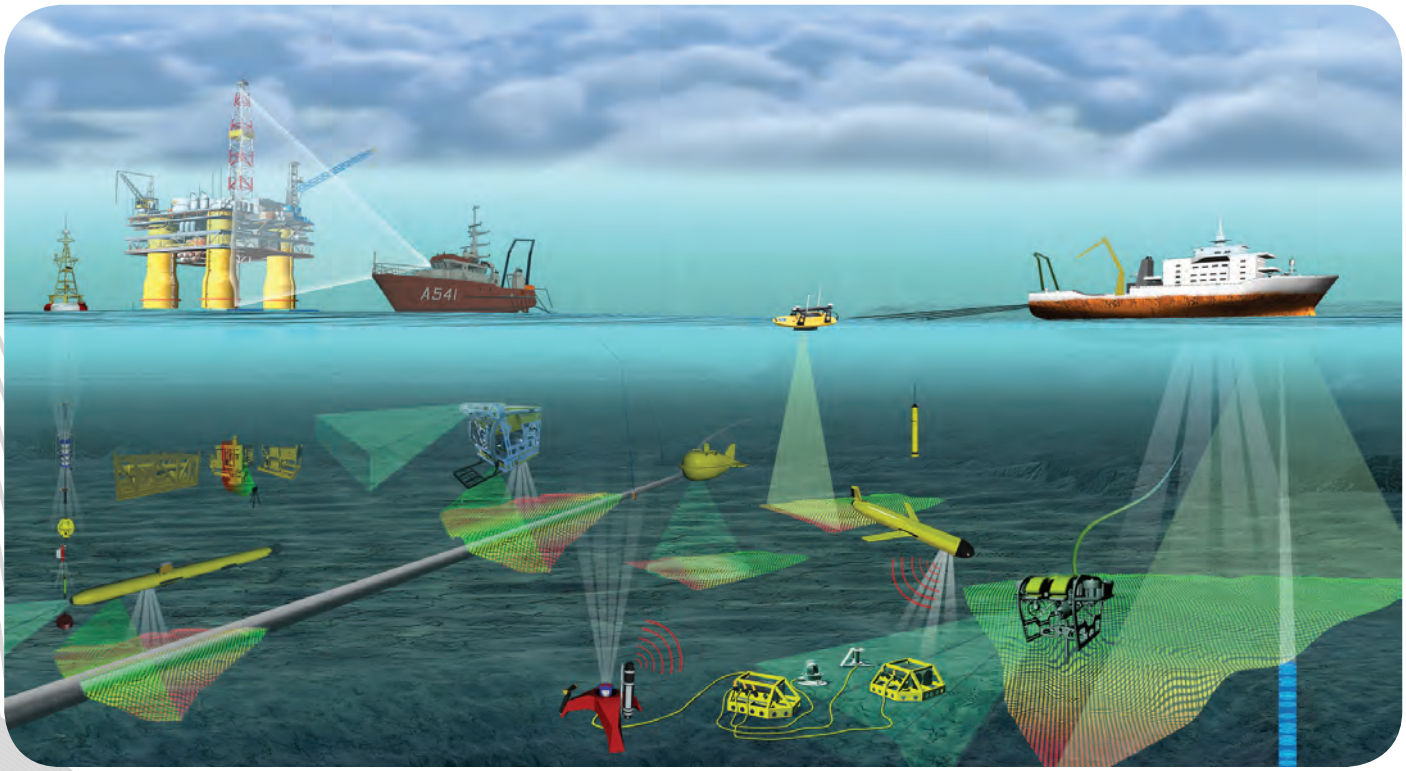
AUV and ROV Technology Plays Key Role in Historic Discovery

Optimizing a Low-cost Multi Sensor System for Hydrographic Depth Determination

Ocean Business 2019 Preview

From the seafloor to the surface…

Teledyne Marine delivers solutions



Teledyne Marine is a group of leading-edge undersea technology companies that have been assembled by Teledyne Technologies Incorporated. Through acquisitions and collaboration, over the past 14 years Teledyne Marine has evolved into an industry powerhouse, bringing the best of the best together under a single umbrella. Each Teledyne Marine company is a leader in its respective field, with a shared commitment to providing premium products backed by unparalleled service and support.

See all our solutions at Ocean Business 2019 in Southampton.

Meet us in Booth T5 and U12

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Hydro INTERNATIONAL

Hydro International is an independent international magazine published 6 times a year by Geomares. The magazine and related e-newsletter inform worldwide professional, industrial and governmental readers of the latest news and developments in the hydrographic, surveying, marine cartographic and geomatics world. Hydro International encompasses all aspects, activities and equipment related to the acquisition, processing, presentation, control and management of hydrographic and surveying-related activities.

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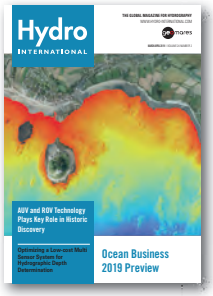
Front cover

An example of multi-beam bathymetry around St. Michael's Mount, Cornwall, UK. The bathymetric survey was carried out and supplied by Halcrow Group.



Challenge

▲ *Durk Haarsma.*

The most challenging factor for market growth in hydrography is a lack of well-trained people. That is the outcome of this years' Hydro International business survey (see page 17). We surveyed our readership again on the state of hydrography and 226 respondents were on the same page as they were last year: growth will be very small, if there will be growth at all, and there are some persistent factors playing into that. The decline in oil and gas would be my number one, if I had to choose without knowing the outcomes of the survey. It appears to be second just before the efficient data management that comes in as number three, but number one is the lack of well-trained staff. Overwhelmingly given as the most important factor holding back growth, there are simply not enough skilled surveyors to help grow hydrography in a steady way. Not enough young people are choosing hydrography as the field they want to work in. This problem has been going on now for years and plays into effect big time now. Hydrography simply doesn't seem to appeal to enough youngsters. The majority of students are not in favour of technology studies anymore, marketing and communication are way more popular. And for those who have chosen hydrography as a field to work in, the desire to go to sea disappears quite soon after the start of their career. The young professional wants a regular life without weeks at sea, not being able to interact with family and friends. The biggest survey companies in the world recognized this a few years ago and as a response, tried to modernize their vessels with lots of facilities onboard that were not possible before (e.g. internet, gyms and film theatres). It would be worthwhile asking them if they saw any effect, but I doubt it. It is not enough to offer the same facilities, when the fact of being physically away from home, apparently weighs in quite heavily. Hydrography is not an easy study, basics of geodesy, acoustics and positioning are quite heavy subjects to start with, and that is only the beginning. With not enough new people to fill in vacancies, even after extensive searches, companies have to invest heavily in training people on the job – sometimes finding less or otherwise skilled people and training them to learn hydrography. They have to offer a higher salary in a highly competitive market and offer more perks to their employees, to make it more attractive for them to choose to work for a particular company. That all sounds good for the individual surveyor, but only solves the problem short term. The overall conclusion of the survey was that the market is barely growing and respondents are very cautious about their expectations, even in a bullish economic environment as we see today in many parts of the world. That has been the feeling for a few years now. While technology is quickly moving forward everywhere, and maybe only a little less so in hydrography, often there's no room to deploy those techniques. That is not a very healthy situation!

The friction between this needs to be solved to return to a situation that holds enough potential for the future, with a sufficient number of skilled and highly professional staff to deploy the most promising technology in many applications that are in dire need of hydrography: offshore renewables and coastal zone management to name a few. My advise would be to address the topic of staff shortage and its consequences at a high level and to exchange ideas to solve the problem!

Durk Haarsma,
director strategy & business development
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p.s. The Hydro International team will be at Ocean Business in Southampton, UK from 8-10 April 2019. We are more than happy to discuss and receive feedback on our platforms Hydro International and Geo-matching.com and to exchange ideas on how to grow your company. Come and find us at stand number R4. See you there!

HYDRO ALPHABETICAL LIST OF ADVERTISERS

NF/GEBCO Training Programme
Alumni Helping to Map Gaps in Our Understanding of the Ocean Floor

In March 2019, a groundbreaking partnership was agreed between The Nippon Foundation-GEBCO Seabed 2030 project, which aims to map the entirety of the world's ocean floor by 2030, and the Five Deeps expedition. This lays the groundwork for previously unexplored areas of the seafloor to be mapped and the data to be made available for public use. In keeping with Seabed 2030's core principle of building capacity and fostering international scientific collaboration, the partnership also provides an unparalleled opportunity for students and alumni of The Nippon Foundation-GEBCO (NF/GEBCO) postgraduate training programme, at the Center for Coastal and Ocean Mapping (CCOM) of the USA's University of New Hampshire (UNH), to play a part in this pioneering expedition.

Ahead of its dives to the deepest points in each of the five oceans, Five Deeps must produce detailed bathymetric maps of each location to ensure the safety of its operations. It is also leaving its sonar systems on during transit between dives, during which bathymetric data will be collected. The data will be donated for inclusion in the grid of the General Bathymetric Chart of the Oceans (GEBCO), the only organization with a mandate to map the entire ocean floor. This represents a significant contribution to Seabed 2030's efforts to crowdsource all available data into the definitive and freely available GEBCO grid. In return, Seabed 2030 has agreed to enlist and fund experts to operate the onboard sonar systems to collect the transit data.

▲ *From left to right: NF/GEBCO alumni Seeboruth Sattiabaruth, Aileen Bohan, Jaya Roperez and Azmi Rosedee in front of the DSSV Pressure Drop. Aileen, Jaya and Azmi bid farewell to the ship ahead of the expedition to the Java Trench. [Courtesy: Cassie Bongiovanni]*

Cassie Bongiovanni, who recently finished her master's degree in Earth science - ocean mapping at UNH, joined the expedition for the first dive to the Puerto Rico Trench, the deepest point in the Atlantic Ocean. Since joining the crew, she has been hired as a full-time mapping coordinator for the Five Deeps expedition. When Cassie asked for assistance on the second leg of the expedition, which was to the South Sandwich Trench in the Southern Atlantic Ocean, she was joined on the DSSV Pressure Drop by Aileen Bohan, an alumnus of the NF/GEBCO training programme class of 2017-2018 who is now a marine geoscientist with the Geological Survey of Ireland.

Data gathering in transit

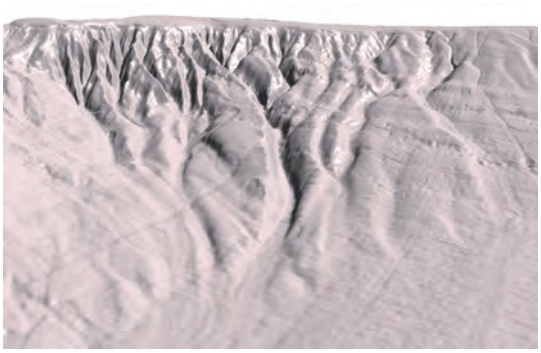
The Nippon Foundation/GEBCO alumni contingent was further boosted for the data-gathering transit leg of the expedition from Cape Town to Freemantle by the arrival of two fellow alumni: Jaya Roperez (2014-2015), a former commissioned officer of the National Mapping and Resource Information Authority of the Philippines currently pursuing her master's degree in ocean engineering at UNH, and Azmi Rosedee (2015-2016), a lieutenant commander in the Royal Malaysian Navy who took part in Ocean Infinity's search for Malaysian Airlines flight MH370.

Speaking about her time aboard the DSSV Pressure Drop, Jaya said that it was "such a privilege to be that person who can make people appreciate the seafloor and realize the importance of mapping it. We have the GEBCO 2014 grid as a base surface, and it helped us explain the whole point of collecting transit data." She added: "I had been working in the hydrographic office for five years when I got into the NF/GEBCO training programme, but acquiring technical knowledge and first-hand experience from CCOM – which has the best of the best professionals in ocean mapping – definitely prepared me for this."

XPRIZE finalists

Additionally, Seeboruth Sattiabaruth, a surveyor at the Hydrographic Unit of the Ministry of Housing and Lands in Mauritius, is accompanying Cassie on the expedition to the Java Trench in the Indian Ocean, taking place in April. Their contribution to the Five Deeps expedition is just one of the ways in which alumni of the NF/GEBCO training programme are playing an active role in efforts to further the global understanding of the world's ocean floor. All four alumni are members of the GEBCO-NF Alumni Team that qualified for the final round of the Shell Ocean Discovery XPRIZE with a concept utilizing both unmanned surface vehicle (USV) and autonomous underwater vehicle (AUV) technologies for safe, efficient and cost-effective seafloor mapping. ◀

Most Complete Submarine Cartography of the INBIS Channel Published



A scientific study describes for the first time the submarine cartography of a high-latitude system in the INBIS channel, which covers tens of kilometres in the northern western area of the Barents Sea, in the Arctic Ocean. This channel is one of the few submarine valleys in polar latitudes that kept its geological architecture during the Last Glacial Maximum (LGM), according to the new study published in the journal Arktos – The Journal of Arctic Geosciences, in which the lecturer José Luis Casamor, member of the Consolidated Research Group on Marine Geosciences of the Faculty of Earth Sciencesof the University of Barcelona takes part.

Other participants in the research study are experts from the Trieste National Institute of Oceanography and Experimental Geophysics (OGS, Italy) and the University of Tromsø (Norway), among other institutions.

Many unknown landscapes in our planet are under oceanic waters. Nowadays, sea floors and polar regions build up two big frontiers for research in the field of Earth Sciences. In this context, the application of advanced technologies in scientific campaigns – differential GPS, high resolution multibeam bathymetry, 2D and 3D reflection seismic imaging, remotely operated underwater vehicle (ROV) – was a methodological revolution that broadened the precision of bathymetry maps in sea floors.

▸ *https://bit.ly/2TWjnis*

SBG Systems Releases Horizon IMU for Navsight Marine Solution

SBG Systems has released the Horizon IMU, a FOG-based high-performance inertial measurement unit (IMU) designed for large hydrographic vessels surveying harsh environments.

Navsight Marine Solution consists in a powerful and ready-to-use IMU dedicated to hydrographers. It is available at different levels of accuracy to meet the various application requirements and can be connected to various external equipment such as Echo-sounders, Lidar, etc.

Navsight Marine Solution already offers two levels of performance with the Ekinox and Apogee IMUs. These MEMS-based IMUs address most hydrographic markets whether shallow or deep water. The Horizon IMU allows customers to bring Navsight technology to the most demanding environments such as surveying highly dense areas (bridges, buildings, etc) as well as applications where only a single antenna can be used. Horizon IMU's based on closed-loop FOG technology which enables ultra-low bias and noise levels. This technology allows robust and consistent performance even in low dynamics survey.

▸ *https://bit.ly/2UWvbh3*

Next-generation USV to Launch at Ocean Business 2019

Unmanned Survey Solutions (USS) has designed and built the next-generation Accession Class Unmanned Survey Vessel (USV) for use in nearshore and offshore hydrographic surveys. The device will launch at Ocean Business in April 2019.

The unique modular design of the USV allows the vessel to increase its base design length of 3.5m to a maximum of 5m for additional payload equipment and/or power for extended endurance depending on operational requirements.

James Williams, director at USS, said "We wanted to build a USV that was truly versatile, reliable and robust enough to withstand operating in offshore conditions while keeping it simple and easy to use for surveyors. I'm delighted with our solution and extremely excited to be launching the Accession Class USV at Ocean Business in April."

▸ *https://bit.ly/2UdKTHm*

Seabed 2030 and Five Deeps Sign Agreement

Seabed 2030 and the Five Deeps Expedition have signed an agreement which lays the groundwork for previously unexplored areas of the seafloor to be mapped and the resulting data made available for public use. Seabed 2030 is the collaborative project of The Nippon Foundation and GEBCO aspiring the complete seabed mapping by 2030.

In this cooperation with the Five Deeps Expedition, the world's first manned expedition to the deepest point in each of the five oceans, the Seabed project is ensured of data contributions in areas which would not have been collected otherwise. In addition to data gathered at trench sites, the Five Deeps Expedition has agreed to leave its sonar systems switched on while in transit in order to provide additional bathymetric data collected between these areas.

The Memorandum of Understanding between the two organizations was signed at the International Hydrographic Bureau in Monaco between Dr Graham Allen of Seabed 2030 and Victor Vescovo of The Five Deeps Expedition in the presence of Mathias Jonas, secretary general of the International Hydrographic Organization.

▸ *https://bit.ly/2FBeum3*

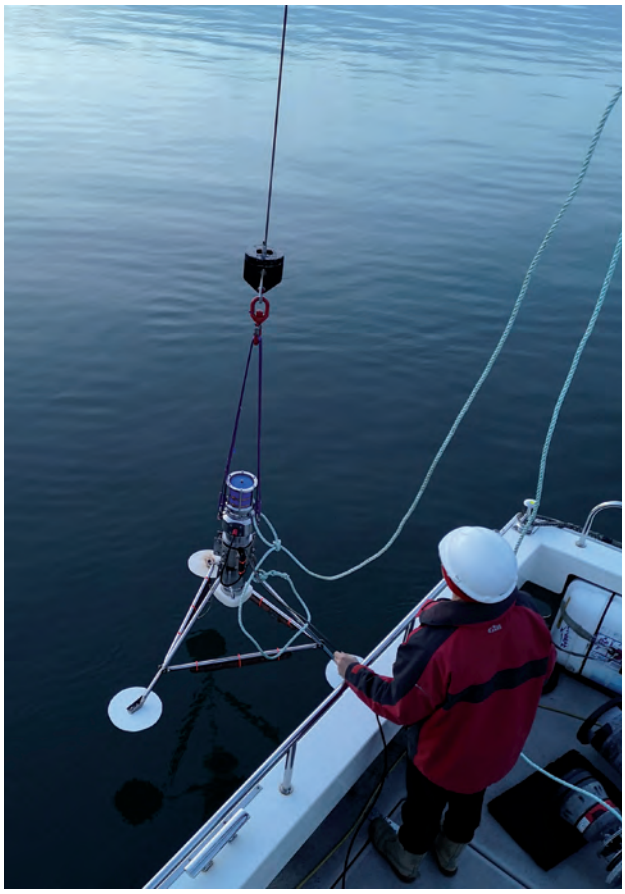
Seafloor Based Seismic Cable Permanent Reservoir Monitoring with Sonardyne Sensors

Norwegian energy firm Equinor is to deploy cabled subsea instrumentation from Sonardyne International to help increase the accuracy of time-lapse seismic data at the giant Johan Sverdrup oil field. From the first production of the development, Equinor plans to use seafloor based seismic cable permanent reservoir monitoring (PRM) technology to observe what is happening in the reservoir over time to help maximize recovery rates.

While PRM technologies increase the amount and data quality that operators have about their reservoirs, processing it can sometimes be complicated by changing environmental conditions, such as water velocity and tidal height, at the time each survey is conducted. If those conditions are known, their impact can be readily removed.

To solve this challenge, Equinor has engaged subsea services contractor Subsea 7 to install a Sonardyne Pressure Inverted Echo Sounder (PIES) at 110-120-metre water depth at Johan Sverdrup. PIES instruments continuously measure the two-way travel time of sound waves propagated through the water column from the seabed to the sea surface as well as the pressure (depth) at the seabed. This data is then used to calculate a continuous time history of average water velocity and tidal variation throughout the whole water column.

▸ *https://bit.ly/2WnPJ27*



Danish Geodata Agency Partners with Esri to Chart the Waters of Denmark and Greenland

Esri, a location intelligence company, has announced that it has partnered with the Danish Geodata Agency (GST) to implement a modern workflow to more efficiently create and maintain nautical charts of Danish and Greenlandic waters. Esri will assist with the installation of, and training for, the new enterprise production system. Because maritime traffic is increasing significantly and new routes are opening due to melting ice, it is crucial to have accurate charts in support of safe navigation and environmental protection. GST turned to Esri for a solution when the organization needed to convert the production of navigational charts from a file-based system to a database and to combine cross-agency chart production into one inclusive system. By partnering with Esri and Geoinfo A/S (Esri's Danish distributor) to implement this new chart production system, GST expects to reduce the time it takes staff to produce charts of all Danish waters and enable them to share information across departments and multiple agencies.

The Danish Geodata Agency recently created nautical charts for Greenlandic waters using Esri's ArcGIS for Maritime: Charting solution and found that it was able to automate up to 70% of the paper chart production work. "We are very much looking forward to this collaboration with Geoinfo and Esri, who support the Geodata Agency's vision of being the driving force in the digital development in the marine area," said Pia Dahl Højgaard, GST director.

▸ *https://bit.ly/2FAhM93*

AML Oceanographic's MVP200 Selected for Swedish Research Vessel

AML Oceanographic has announced that a Moving Vessel Profiler is being installed on one of the most modern research vessels in the world, the Swedish vessel 'RV Svea'. The newbuild Swedish vessel, owned by the Swedish University of Agricultural Sciences (SLU), will be used by the university and the Swedish Meteorological and Hydrological Institute (SMHI) for a wide variety of environmental surveys, from monitoring ocean acidification to assessing fish stock.

By including a Moving Vessel Profiler (MVP), the scientists expect to gain a clearer understanding of the oceanographic dynamics encountered in the Baltic Sea, such as strong halocline layers and anoxic waters. Furthermore, the high data density that MVP can provide will improve the data quality from the many hydroacoustic measurements conducted on RV Svea and make SMHI's oceanographic models substantially more accurate. The MVP200 will collect CTD, Dissolved Oxygen, Chlorophyll A data continuously and in real-time while the vessel travels at 10-11 knots, making it the sole solution capable of providing an accurate characterization of such a complex environment.

▸ *https://bit.ly/2Wvhh63*

IMCA Publishes Guidelines on the Shared Use of ROV Sensors

The International Marine Contractors Association's (IMCA) has published 'Guidelines for the Shared Use of Sensors for ROV and Survey Purposes' (IMCA S 025 / R 022), which is available on the association's website. The document provides technical guidance and an overview of some of the factors to consider when sharing ROV-mounted positioning, surveying and imaging sensors that may be used for more than one specific purpose.

While the sharing of sensors may be desirable to improve efficiency and reduce costs, there are certain technical factors that need to be managed in order to maintain the quality of data.

Nick Hough, IMCA's technical advisor – Offshore Survey, said "Provided a risk assessment is undertaken, and measures are in place to mitigate them, the shared use of sensors for ROV positioning and for surveying applications need not present any operational issues and can offer a cost saving."

▸ *https://bit.ly/2FyNjbm*

MacArtney Provides AHC Winch Solution for Planned Subsea Offshore Operations

MacArtney's MERMAC R40 AHC Winch, aboard the ASN Ile de Class vessel, will be facilitating the effective laying of seismic cables on the seabed of the Johan Castberg oilfield in the Barents Sea for Equinor's new Permanent Reservoir Monitoring system.

The MacArtney Group has been developing and supplying winch systems for the offshore Oil & Gas market for four decades. With the experience of delivering over 400 winch systems within this industry, MacArtney has always been dedicated to supplying smarter solutions. From this experience has grown the development of MacArtney Active Heave Compensated winch systems designed to reduce dynamic effect during the launch, recovery and operation of submarine equipment.

This MERMAC R40 AHC winch, engineered for offshore work in weather conditions of minimum Hs (Significant Wave Height) of three metres during launch, recovery and operations is of compact design and fitted with a right angle level wind. The MERMAC R40 AHC winch is supplied with a Moog Focal combined Electro Optical Slip Ring. The winch is umbilical compatible and fitted with slip ring and joint box suitable for single mode fibre optics.

▸ *https://bit.ly/2HUOKmm*

Teledyne Marine Technology Workshop in San Diego Calls for Speakers

Teledyne Marine has announced a call for speakers to present at the Technology Workshop in San Diego, California on 6-9 October 2019.

Teledyne are looking for speakers for all three-days of the user conference and are wanting users to present at the event as well. Teledyne users are encouraged to submit an abstract sharing their experience utilizing Teledyne products in offshore energy, oceanographic research, hydrography/navigation, defence/security, aquaculture/fisheries, civil engineering and river monitoring.

▸ *https://bit.ly/2HJBKQW*

Fugro to Apply Specialist Geodata Services for Dutch Wind Farm Zone

Fugro has been awarded a further substantial marine site characterisation project off the Dutch coast. This is the largest geotechnical site characterisation programme tendered by the Netherlands Enterprise Agency (RVO.nl, part of the Ministry of Economic Affairs and Climate Policy) and will be performed in the Hollandse Kust (west) Wind Farm Zone. Other contracts executed by Fugro in the same region since 2015 include geophysical and geotechnical data acquisition and metocean monitoring.

With project preparations underway and a target start date in April, contract finalization is expected soon. The geotechnical programme will continue until September and comprises a seabed investigation and borehole drilling. Fugro will also deliver standard and advanced laboratory testing and an integrated geological/geotechnical soil model which will be used by future developers of the wind farm to prepare their bids.

The fieldwork will utilise Fugro vessels including geotechnical drilling vessel, Fugro Scout. Deployment of Fugro's innovative SEACALF MkIV system for seabed cone penetration testing will enhance operational safety as its coiled rod requires no manual handling. The system is also much less weather sensitive than conventional systems, increasing productivity by avoiding downtime.

▸ *https://bit.ly/2Uflptc*

Teledyne CARIS Software Selected to Enable Major Government Project in Africa

Teledyne CARIS has announced they will be delivering a full software solution to the South African Navy Hydrographic Office. The solution, provided through Teledyne CARIS' official distributor Unique Group, includes software that will be implemented as part of a larger project to be executed by Southern African Shipyards (SAS) where a new hydrographic survey vessel is being built.

Three additional survey motor boats are also slated for manufacture, all of which will be equipped with HIPS and SIPS to process acquired hydrographic data.

During the project, the shore based South African Navy Hydrographic Office will be refurbished and Bathy DataBASE (BDB) and Hydrographic Production Database (HPD) will be implemented to manage hydrographic data and produce nautical products like paper charts, ENCs and other digital products.

The implementation phase is set to commence shortly, and will begin with the installation of the software and a number of training sessions.

Charles de Jongh, account manager at Teledyne CARIS, commented: "We are pleased to deliver an integrated software solution to manage the hydrographic and charting information at the South African Navy. For us, this is an important new client on the African continent and we very much look forward to building a strong, long-term relationship."

▸ *https://bit.ly/2FD9BZM*

SeaRobotics Corporation Launches SR-ENDURANCE ASV

SeaRobotics Corporation (SeaRobotics), has announced the successful completion of its factory acceptance testing of its entry into the Autonomous Surface Vehicle (ASV) Workboat market with the SR-Endurance 7.0 metre system. The system is optimized for sonar research through the utilization of an optionally manned helm configuration and a serial diesel-electric propulsion system. Outfitted with an instrumented launch and recovery system (LARS), and supporting hydrographic winch system, the SR-ENDURANCE 7.0 can deploy towed sonar/instrument systems, dipping sonar/systems, or ROV systems.

"Having built numerous ASVs in the 6-11-metre range, we are now offering a commercial workboat for the research and survey markets," said Geoff Douglass, SeaRobotics ASV development manager. "In many operational scenarios the advantages derived from a variable depth sensor such as a multi-beam or side scan sonar, sub-bottom profiler, or magnetometer, as well as the surface motion mitigation, make towed systems valuable in autonomous operations."

With an endurance of up to six days at survey speed, and up to ten hours between automatic battery recharge, the 80 HP, SR-ENDURANCE 7.0's quiet platform for sonar/sensor research belies its 80 HP strength.

▸ *https://bit.ly/2FyhxKA*

Hydro International interview with Admiral Garcez

Hydrography in South America

Hydro International sat down with Director Vice-Admiral Antonio Fernando Garcez Faria, a Senior Naval Officer of the Brazilian Navy, who has now taken up the role as Hydrographer of Brazil. Hydro International thanked Garcez for his time and congratulated him on his assignment.

Can you summarize your biography?
I was sworn in as Director of Hydrography and Navigation (DHN) on 19 April 2018. Most recently, from 2016 to 2018, I was the Brazilian Navy Director of Education. I also served as Director of the Naval War College, from 2014 to 2016; Deputy Chief of the Office of the Commander of the Navy, in 2011; Director of the Navy Hydrographic Center, from 2007 to 2010; and Commanding Officer of the Brazilian Navy Oceanographic Ship 'Antares', from 2004 to 2006. I graduated from Naval Academy, in 1983. Upon graduation, I joined the course of Hydrography for Officers (International Hydrographic Organization Cat A Course). Later on, I earned my Masters in 'Operational Oceanography' in 1995, and Doctorate in 'Physical Oceanography' in 1997, both from the Naval Postgraduate School, Monterey, California, USA.

▲ *Director Vice-Admiral Antonio Fernando Garcez Faria.*

In particular, why did you decided to become a naval officer and specialist in hydrography? Was this a dream that you wanted to make reality?
I was born in a small town in the mountains, about two hours drive from Rio de Janeiro, and I was 10 years old when I first saw the sea. It was love at first sight and from that moment on I decided that I would like to not only become a sailor, but to study and unveil the mysteries of the ocean.

Therefore, joining the Navy was the logical way to make my dream come true. At the Naval Academy, I had an opportunity to participate in a short oceanographic cruise and decided to become a Hydrographer. After graduating and completing my training cruise, my decision was to serve at DHN and, in August 1984, I was assigned to the Hydrograhic Ship 'Canopus'.

Your government put you in charge of one of the most powerful hydrographic services in the world. How did you feel on the day of your appointment?
After 35 years of service in DHN, I have to admit that it was a very emotional moment for me. I was pretty aware of the responsibility of being the Hydrographer and the Oceanographer of the Brazilian Navy, but at the same time I felt confident that I could get the job done with what I had learnt from my predecessors and especially because I knew that I could count on a very professional and dedicated crew as well as the support of the Directorate-General of Navigation.

Having the opportunity to lead this fabulous and passionate team was well worth all the effort I put in throughout my professional life in the Navy.

A peculiarity of Brazilian hydrography is surveying and charting the Amazonian basin. How much of the Directorate's resources are devoted to this? Do you have a personal experience in this endeavor?
Yes, Brazil has a strong concern with the safety of navigation in the Brazilian waterways including the Paraguay-Parana waterway and the Tiete-Parana waterway, besides the Amazonian basin. To meet the challenge of surveying and charting those regions, for more than 50 years, DHN decided to establish local hydrographic branches with its own vessels, two in the northern region and another in the western region. Each northern local hydrographic branch is equipped with one mid-size hydrographic ship (530 tons) and two smaller hydrographic ships (140 tons). The western local hydrographic branch is equipped with a small hydrographic ship and smaller boats. All local hydrographic branches have personnel with experience in hydrography and nautical cartography, and all hydrographic ships and boats are operated by at least two hydrographic surveyors.

I did not have the opportunity to serve in one of our riverine hydrographic ships, but as the Head of the Navy Hydrographic Center, I had the opportunity to visit all our hydrographic branches in the Amazon and Paraguay-Parana basins when we were reviewing our Nautical Cartographic Plan.

Years ago, the DHN and Petrobras cooperated to define the extension of the Brazilian Continental Shelf as indicated in article 76 of UNCLOS. Was that work completed, revised by the UN and transformed into a national law?
In accordance with UNCLOS (United Nations Convention on the Law of the Sea), DHN survey

activities over the Brazilian Continental Shelf, in a project known as LEPLAC, began in June 1987.

Under the coordination of the Interministerial Commission for Marine Resources (CIRM), these activities were jointly developed by DHN, the Brazilian energy company Petrobras and the Brazilian scientific community.

The proposal for the Outer Limit of the Brazilian Continental Shelf was then forwarded to the Commission on the Limits of the Continental Shelf of UN-DOALOS (CLCS) in May 2004. Brazil claimed an area of 960,000km2 in addition to the two hundred nautical miles, distributed offshore on the Brazilian coast, mainly in the north (Amazonas Cone region and Northern Brazilian Ridge), in the southeast (Vitoria-Trindade Ridge and Sao Paulo Plateau) and in the south (Santa Catarina Plateau and Rio Grande Cone).

After CLCS completed the analysis of the proposal in 2007, recommendations were sent to the Brazilian Government and Brazil has been working since then on the elaboration of the revised proposal, dividing the Brazilian continental margin into three distinct areas.

The South Region proposal was submitted and presented to the UN in 2015 and is currently under CLCS analysis.

The proposal for the Equatorial Margin was sent and presented to the UN in March 2018. And finally, the proposal for the Eastern and Meridional Margins was forwarded to the UN in December 2018.

Brazil has borders with many South American countries. Some borders are maritime, others are terrestrial and may include rivers. In which case, does the DHN participate in the border definition? Does DHN intend to adopt S-121, the new IHO standard for Maritime Limits and Boundaries?
DHN participates in the definition of the maritime borders in the southern, eastern and northern limits as was detailed in the previous question. In the case of the terrestrial borders, including those defined by rivers, the Army Corps of Engineers and the Institute of Geography and Statistics are involved with its definition. Nevertheless, when hydrographic data is necessary, DHN will support these Institutions with existing data or, if needed, with new hydrographic surveys.

▲ *Oceanographic research ship named ''Rio Solimões H14''.*

Regarding the adoption of the S-121 format, DHN is preparing to deposit its maritime borders and limits coordinates in such format, as defined by IHO and UN-DOALOS, as soon as CLCS finalizes the analysis of the Revised Proposal for the Outer Limit of Brazilian Continental Shelf.

In general, how many Brazilian Ministries need the DHN's support?
The Brazilian Navy is a Member of CIRM, and also has the responsibility of acting as the Executive Secretary to this commission. CIRM is constituted by the Ministries of Foreign Affairs, Science, Technology and Communications, Environment, Mining and Energy, Agriculture, Education, and Health, among others.

DHN coordinates and operates metocean and hydrographic systems, as well as eight hydrographic and oceanographic ships and reports its situation and developments to CIRM and makes the data available to all these ministries, universities and research institutes. Futhermore, DHN operates two polar ships in support of the Brazilian Antarctic Program (PROANTAR), which is coordinated by CIRM with the involvement of some ministries.

Brazil is one of the IHO founders. Two IHB Directors were Brazilian and at present Captain Alberto Costa Neves is Assistant Director in the IHO Secretariat. The cooperation of DHN with IHO has been always effective. How do you intend to continue it?
I intend to lead DHN to not only continue, but to enhance the collaborative work with IHO, which we have been doing for the last century. In order to achieve this goal, DHN is working closely with IHO subsidiary organs and participating in all its Working Groups. A very important part of this endeavor is to work closely with the countries of the Regional Hydrographic Commission (RHC) that Brazil is a member (SWAtHC, MACHC and HCA) or observer (SAIHC). Bilaterally, DHN will continue to interact with Hydrographic Offices of other continents, especially with Africa, and to share its technical expertise in order to develop the hydrographic capacity of those countries who have not yet established a hydrographic service.

Brazil produces Electronic Navigational Charts (ENCs) along the IHO standards. Are these easily readable on the ECDIS machines? Are the ENCs promptly distributed to the mariners?
DHN is a member of IC-ENC, and Brazilian ENCs are distributed through RENC Value Added Resellers and Distributors, reaching, in a timely manner, mariners all around the world. Even before we send our ENC S-57 files to IC-ENC, where their integrity in an ECDIS is tested according to S-58 'ENC Validation Checks' standards, we submit them internally to an ISO 9001/2015 certified process to check any problems that could happen with the charts

▲ *Oceanographic research ship named "Rio Tocantins H12"*

in an ECDIS. All these procedures guarantee that Brazilian ENCs will reach the mariners in a quick but reliable way, fulfilling their needs for the hydrographic information and ensuring the safety of navigation.

Some private industries distribute the ENCs produced by the HOs using the services of PRIMAR and IC-ENC organizations. These industries also produce digital charts for other types of navigation. To do this they need to establish derivation agreements with the IHO. Is DHN favourable to those agreements? In other terms, how do you see the presence of the private industry in the nautical charting activity?

Yes, DHN has no objections to those agreements respecting national laws and regulations. DHN has bilateral agreements with HOs that operate RENCs and a few with VAR, and believes the WEND principles are well defined. DHN recognizes the importance of the private industry in the nautical charting activity especially for leisure navigation, non-SOLAS waterways, customized and thematic products. Anyway, Brazilian official nautical charts are produced and issued by DHN in accordance with Brazilian law.

The only concern on this matter is to ensure the end-user will receive the full service that comprises the product (chart/document) and all updates during the period in a proper and timely manner.

As member of the IHO, what advantages do you see in the substantial change of the IHO Convention which started at the end of 2016? Do you have a suggestion to improve IHO effectiveness?

When the IHO Convention started, IHO structure had been adjusted with the establishment of a Council and a Secretariat that was pretty successful in other organizations. With this new structure, it was possible to speed up decisions within IHO and boost the activity of the subsidiary organs, and nowadays there is no need to wait for the next Assembly to make an important decision which will impact all RHCs and HOs.

I think it is too early to have a perception about the need for any improvement. We shall wait a few more years.

DHN is member of IOC and UNESCO, which is also a member of UN-DOALOS, IALA and IMO. What support do you provide to these institutions?

Yes, DHN also represents Brazil in IOC/UNESCO, IALA and the Commission on the Limits of the Continental Shelf of the UN-DOALOS.

Nowadays, DHN has a seat on the IHO Council, IOC Executive Council and IALA Council, having Admiral (Ret) Palmer elected as the IHO Council Vice-Chair and Admiral (Ret) Marcos Almeida elected as the IALA Vice-President.

Since DHN operates the Brazilian Marine Meteorological Service and is the METAREA V Coordinator as part of the Worldwide Met-Ocean Information and Warning Service (WWMIWS), it follows resolutions of the WMO and JCOMM.

Brazil is represented in IMO by the Brazilian Permanent Representation to IMO below the Naval Staff. The Chief of Naval Staff is the Brazilian Coordinator to the IMO affairs and the Director of Ports and Coasts acts as the Brazilian Executive Secretary to the IMO affairs. Meanwhile, DHN provides support regarding technical matters concerning GMDSS, MSI and e-navigation.

The DHN was established in 1876. Is it possible that in its archives are stored the nautical documents published before that date? If yes, how far back do these records go?

The DHN Technical Archives have nautical cartographic documents dating back to the middle of the 19th century. Before the hydrographic service, the lighthouse authority service and the marine meteorological service came together to form the DHN. Some of them are of great historical value with the Collection of Brazilian Nautical Charts (1864-1870) being used in French navy officer and cartographer Ernest Amédée Barthélemy Mouchez's Book and the 'Hydrographic Compendium' written by the Brazilian Admiral Antônio Luiz Von Hoonholtz in 1864.

This is really fortunate as DHN receives requests from many students and scientific researchers for access to these materials and we are very glad to grant it hoping that, buy doing this, we can not only stimulate knowledge of the history, but also spread the importance of hydrography to a broader community.

Additionally, DHN's most modern research vessel 'Vital de Oliveira' shelters the first Brazilian Sailing Directions, covering the northern coastal region from the state of Paraiba to the state of Ceara, issued in 1868 and written by Commander Manuel Antônio Vital de Oliveira, considered the patron of Brazilian Hydrography.

Do you have any advice for young people who want a hydrographic/oceanographic career?

After visiting aquariums or oceanographic museums, young people should experience being a trainee as part of a survey onboard of a research vessel. Obviously, it is more exciting when you are actively involved with the operation of hydrographic and oceanographic systems and with the results of the surveys. The feeling of unveiling the mysteries of the sea or matching the measurements and observations with the behaviour of the sea is amazing.

And never give up if you feel sea sick on your first cruise! This passes very fast and it´s a small token to enjoy life at sea! ◀

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Findings from the *Hydro International* Business Survey

Cautiously Expectant

The outcome of this year's annual survey amongst the readership of *Hydro International* can be characterized as slightly more pessimistic or, to put it another way, slightly less optimistic than last year. Maybe the best conclusion is that our readers are still very cautious about the outlook in the hydrographic market. All in all, however, the outcomes are largely aligned with last year's survey results. Read on for more details of the findings.

This year's *Hydro International* business survey was held in March so that the findings could be included in this issue of the magazine in time for Ocean Business in April 2019. We were keen to be able to make a one-on-one comparison against last year's survey in order to be able to spot trends amongst our readers' responses. Having now analysed those responses, we can conclude that the most striking outcome is that very little has changed since last year. Our readers' expectations in terms of growth, readiness to invest and problems preventing the sector from growing have all remained at the same level as in 2018.

Today's professionals have a very reserved outlook on the business

Close reflection of industry profile

Over the course of two weeks, 226 respondents completed the survey. This figure is slightly down on last year, although this could be due to the fact that just two reminders were sent out this year compared to three reminders last year. Most of the respondents are working in hydrography (42.67%), mapping (6.22%), electronic charting/GIS (4%) and cartography (3.11%), which amounts to 56% of the respondents working in 'traditional' hydrographic surveying areas. Offshore construction is the largest 'non-traditional' category, accounting for 7.11% of respondents. The other categories, including engineering surveying, environmental research, remote sensing and ROV deployment, are all relatively small with a similar number of respondents. Needless to say, apart from a few very small variations that could be due to the time of year or other coincidental factors, the breakdown of respondents closely reflects the profile of the *Hydro International* target group.

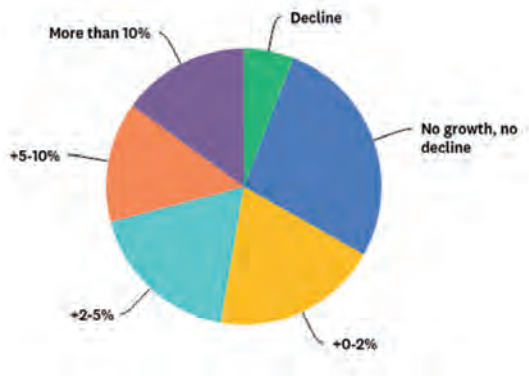
In terms of company size, almost two out of every five respondents are working in a company with between 1 and 50 employees, one in every five in a company with between 50 and 200 employees, another one in every five in a company with between 200 and 1,000 employees and another one in every five in a company employing more than 1,000 people. We analysed the responses from this varied group of hydrographic professionals to assess their expectations about the future growth of their company and, in conjunction with that, their willingness to buy new equipment or make other investments.

One year on

A year ago we discovered that 52.5% of respondents thought their company would grow by up to 10%, and we categorized this finding as 'optimistic'. This year, a slightly smaller number of respondents expect up to 10% growth (51.82%) so we could class this as equally 'optimistic'. However, the percentage of respondents that expect their company to decline rather than grow has risen from 4.29% to 5.91%. Stability (neither growth nor decline) is expected by 27.27% of the respondents compared to last year's 27.70%. Therefore, this narrow majority of just over 50% expecting a slight growth combined with more than 27% expecting stability implies that today's professionals have a very reserved outlook on the business. We classed this outcome as 'optimistic' last year. However, we believe that receiving almost exactly the same answers to the question about growth in two consecutive surveys, plus the fact that the numbers are actually slightly down on last year, means that this should now be interpreted as 'cautiousness'.

Promises

Crowdsourced surveying is widely portrayed as one of the next big things for the field of surveying as a way of helping us to map those immense chunks of uncharted waters. It is therefore notable that not many respondents in this year's *Hydro International* survey (only 11.06%) regard crowdsourced surveying or crowdsourced bathymetry as a key market trend. Perhaps this is due to the fact that we have surveyed professionals from the hydrographic industry, whereas much of the crowdsourcing ability and capacity will come from the maritime and cruise industry. Much less surprisingly, unmanned systems emerge from our survey as the main market trend: 67.26% believe that unmanned systems are



▲ *Figure 1: What growth rate do you expect for your company between 2019 and 2021?*

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shaping the future of the field. Two other key trends are multi-use of survey data and real-time processing, both scoring more than 40%. Not far behind is satellite bathymetry, with just over 30% of the respondents seeing this as a major trend, while big data scores just under 30%. At 15.49%, even telemetry/onshore processing scores slightly higher than crowdsourced surveying.

▲ *Figure 2: Word cloud of answers to the question 'Which technological advancements do you expect to become key for your organisation in the (near) future?'*

Challenges

In answer to the question 'What could withhold further growth of the sector?', the most striking ongoing concern appears to be the lack of suitably trained staff. 45.7% of the respondents express their fear of not being able to hire enough skilled professionals to do the job. This is followed at some distance by efficient data management (32.58%), market demands with respect to data accuracy (29.86%) and the effects of an ever-declining oil and gas sector (28.96%). Open data is regarded as a factor that could restrict further growth by just 20.81% of the professionals who completed our survey. Since the availability of skilled people is clearly the biggest concern among professionals, it is a topic that should be urgently addressed by policymakers in hydrography.

The most striking concern appears to be the lack of suitably trained staff

Investment in 2019

A little over 40% of the respondents hope to invest in hardware such as sonar, echosounders and underwater positioning equipment this year. This still seems like a very healthy replacement rate for equipment in a business that is still regarded as being in recovery. The investment readiness in hydrographic software is just a few percentage points lower, with 35.96% expecting to invest in new software in 2019. More than 30% indicate they have plans to invest in unmanned survey vessels, while the 'traditional' survey vessel is still generating interest among 18%. Training is also an investment that can contribute to further growth. Over 30% of our professionals are planning on training their staff, both in surveying itself as well as in data processing. Could this be an indication that companies are training new staff themselves to compensate for the shortage of skilled people in the talent pool?

Best advice

Just like last year, we once again asked respondents to share with *Hydro International* their best advice for colleagues or professionals who are new to the field. This open-ended question generated quite a few heartfelt, well-meant pieces of advice that highlight the biggest challenges facing this industry. Perhaps unsurprisingly, the common thread running through many of the responses is the lack of well-trained staff, with recommendations ranging from 'Keep up with new technology' and 'Stay up to date with possibilities to use modern hydrographic survey equipment' to 'Good education, stressing the fundamentals' and 'Keep up to date with new survey techniques'. On a positive note, this can be seen as a sign that the pressing need for new, well-trained people is now being recognized within the field. The respondents in our survey clearly feel a responsibility to warn that the lack of employees with the right skill set is a factor of great concern for an industry that deserves to achieve steady growth over the next few years. The advice to *Hydro International* itself was to 'Keep up the good work'. In this case, if that means emphasizing the warning about the talent shortage then we are happy to do just that. Furthermore, we will continue to contribute to educating professionals as much as possible by providing interesting and relevant feature articles on the newest technology to help all our readers to stay up to date with the latest developments. ◀

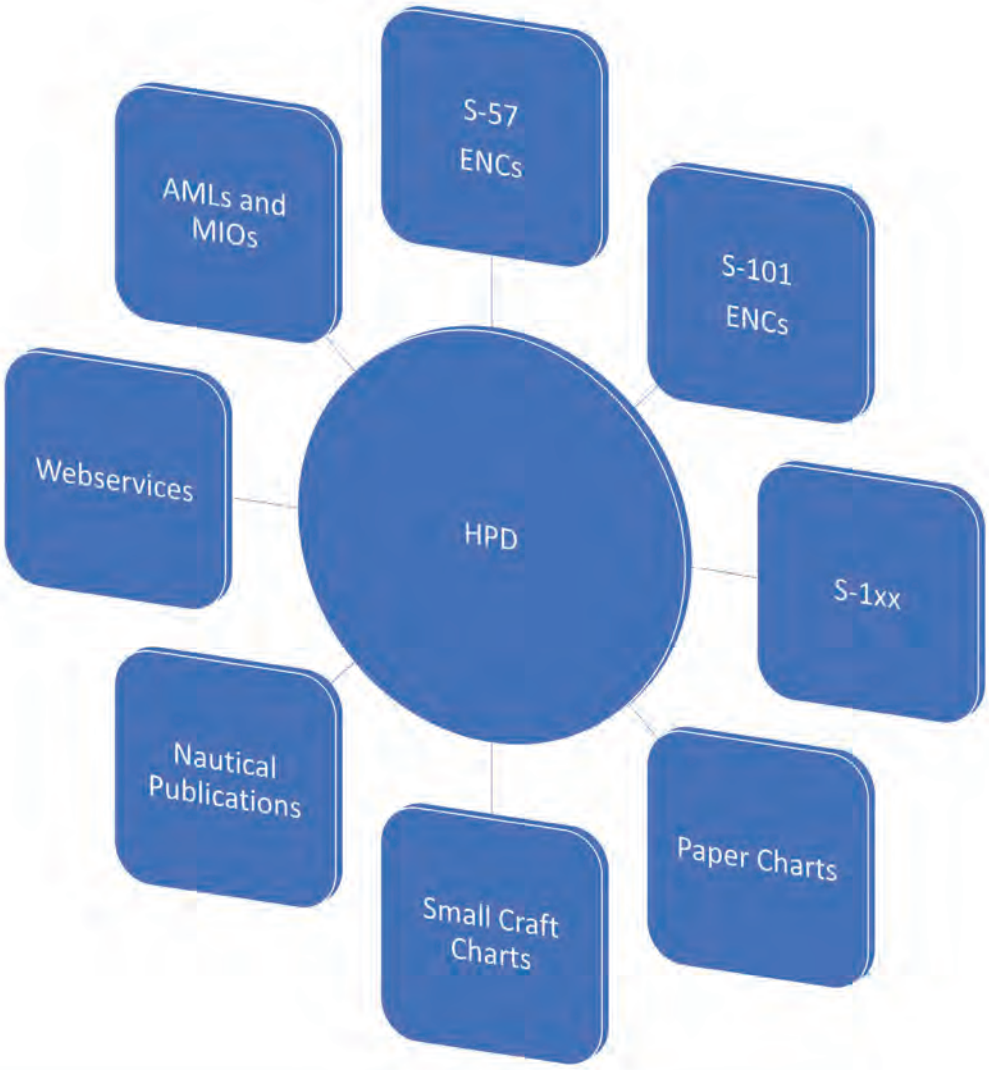
▲ *Figure 3: Data processing by students (photo Teledyne Caris).*

▲ *Figure 4: Students inspecting an LBL transponder (photo Teledyne Caris).*

New Products, New Ideas, Less Work

Cartography at the Source

For two decades, CARIS' hydrographic production database solution has enabled geospatial data to be managed in a data centric manner, while allowing various types of products to be created and updated from this one data centric source. A large user base of hydrographic offices worldwide has utilized this capability to produce and maintain a large percentage of the world's paper charts and ENCs. Over time, the advantages of deriving products from one source has led to the introduction of more product types being produced by the system. Expanding from paper charts and digital chart products (such as ENCs and AMLs) to include raster products and nautical publications, such as List or Lights and Notice to Mariners. Autonomous shipping, autonomous survey operations, and IHO's S-100 and its many product specifications are among the initiatives that will continue the evolution of data processing and resulting services.



▲ *Figure 1: Data centric source used in many products and services of various types.*

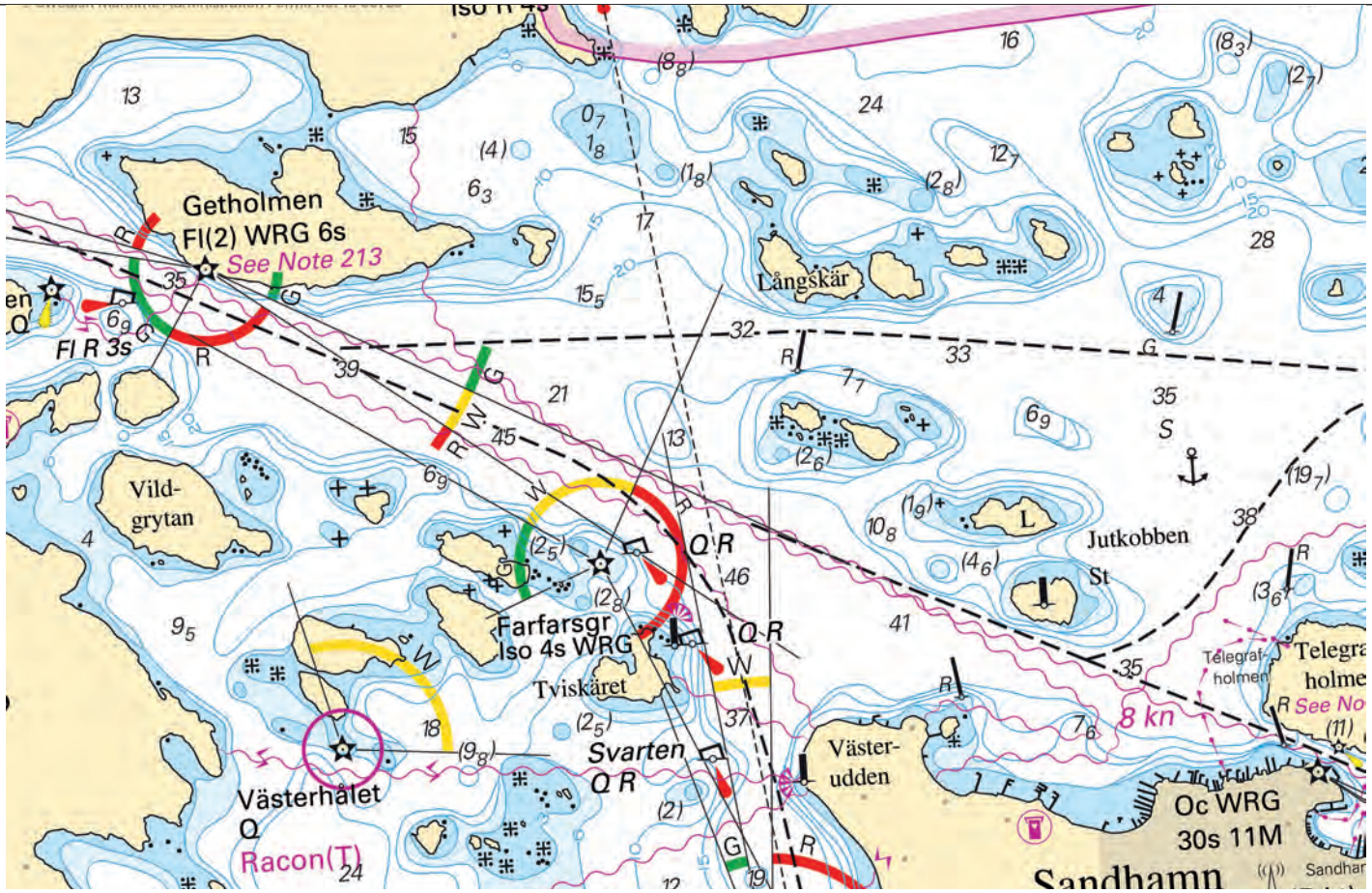
The challenge is that as the demand and expectations for new data services and products continue to rise, the hydrographic industry is also witnessing the need for production efficiencies.

Make the Most out of the Resources

Modern chart compilation software does allow some cartographic portrayal to be generated automatically and paper charts are produced and updated with increasing ease. However, cartographic efforts remain relatively labour intensive, making this an area where high gains in efficiency can potentially be achieved.

While there may not (yet) be commonly accepted algorithms and rules for all cartographic decisions, why not utilize the cases where humans are making a decision that an algorithm cannot make, or is not allowed to make, more efficient? One example is text placement. While text, such as light characteristics, can be generated automatically, this is an example of where no commonly accepted automation is ensuring the right placement in all situations. Is the automated position not ideal for navigational concerns in relation to a nearby fairway, or possibly obscuring something significant? When a cartographer makes the decision to override the automated position, that decision should be utilized for applicable products and services.

The IHO's S-101 ENC product specification recognizes the need for cases where humans



▲ *Figure 2: Swedish Maritime Administration's homepage with source data using INT1 portrayal - http://sjofartsverket.se/sv/Snabblankar/Kartviewers/Felanmalda-sjosakerhetsanordningar/ (© Swedish Maritime Administration Permit no. 19-00796).*

(still) need to determine the position of the text and allow encoding of textual positions. This is not possible for S-57 ENCs, but something that most believed was needed for paper charts only. If the human decision-making for position of textual labels is also of use for S-101 ENCs, this should be utilized rather than repeating the process. Such cartographic decisions are already employed by the possibility of applying cartographic decisions from one chart to another overlapping chart. However, while CARIS' Hydrographic Production Database™ (HPD) allows cartography to be stored with paper chart products, it also allows cartography to be generated and stored with its data centric source. Generated and stored once, data centric, enriching the source data, is used by many products and product types. So, when source data is used for a new product or service, or to update an existing one, the cartography associated with it can be used too.

Can Products and their Updates be Automatically Published?

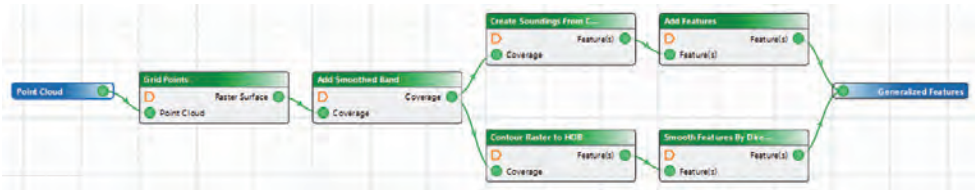
There may (still) be a need for human decisions and for overrides of automatic decisions, but by centralizing such work, less work is needed during production. Human hands and eyes will likely continue to play a role in tasks such as validation. However, with the right mixture of automation results and validation tools to confirm those results (to catch the increasing few cases where this is not the case), the cartographic process will rely more and more on automation.

Products being published without at least some involvement, and validation, by humans is not (yet) accepted for navigational products. However, the same source data is being made available through web services utilizing the same cartography and the same IHO INT1 portrayal as used for navigational Safety of Life at Sea (SOLAS) charts. Automatically extracting updated source data ensures the services are providing the latest changes.

Figure 2 is an example of web services utilizing the cartography-in-source option. The data is extracted using CARIS HPD Raster Tile Product functionality that automatically generates the raster tiles used by the service from the source data.

Automatic Generalized Features from Bathymetry

Of course, this type of work often involves receiving and preparing data for product use. This may, for instance include topographic data from other agencies, or bathymetry from private survey contractors or the Hydrographic Offices' own survey department. Preparing bathymetric data for nautical charts is notoriously time consuming when done manually. Receiving bathymetry occurs frequently and accuracy is of highest importance for safe navigation, while the generalization typically will be needed for multiple chart scales. Traditionally, automatic contouring has not been widely accepted, and taking a manual or semi-manual approach to compilation has for many been the norm.



▲ *Figure 3: Automatic process generating cartographically generalized contours, plus selecting soundings, for one or more scale levels using CARIS Process Designer.*

Sophisticated algorithms for surface smoothing, such as the Rolling Coin algorithm developed in conjunction with the Finnish Transport and Communications Agency (Traficom) and provided in CARIS BASE Editor™ software, are producing results that are appropriate and accepted for use in charts.

If one considers the bathymetry compilation process in context of emerging products such as high-density bathymetric (bENCs) and S-102 Bathymetric Surface overlays, the results from automated algorithms and methods is the only option. Acceptance of these results for other chart products is inevitable.

Cloud Distribution

PRIMAR, one of the world's Regional ENC Coordinating Centres (RENCs) providers, the Canadian Hydrographic Service (CHS), and Teledyne CARIS™ are currently executing a pilot project aimed at leveraging cloud distribution for geospatial products. The project is demonstrating the ability to serve S-102 Bathymetric Surface products. S-102 is just one of the S-100 product types, but one that holds enormous potential for many purposes. Other S-100 products, e.g. S-101 ENCs, are natural candidates to follow.

The cloud project is demonstrating how a service can be established from source, providing continuously updated data. The distribution of S-102 products is also an example of utilizing data for multiple purposes as it is applying the same bathymetric data that ends up being used to derive the contours and soundings in ENCs and paper charts.

What is Coming Next?

Artificial intelligence (AI) is not yet a mainstream part of the chart production process. In its survey processing tools, Teledyne CARIS is implementing a deep learning noise classifier for removing noise automatically rather than manually. The full potential for application in cartographic purposes is still being determined, however, this type of capability is encouraging in terms of continued automation.

Conclusion

The adoption of CARIS HPD by agencies throughout the world has long proven the benefit of a data centric production environment that reduces redundancy by continuously seeking new and innovative ways to optimize production. Through increased automation and optimized interactive tools, more data is being utilized more efficiently for more products. There has been a shift from product-oriented-processes, to data-oriented processes, while still retaining human oversight and some interaction in the process. Cartography in source is allowing more data centric management and processes with the possibility of automatically providing data through web services utilizing the latest cloud-based approaches.

Automatically generalizing contours according to the high standards of nautical charts and utilizing AI to clean survey data, are examples of automation possibilities that have the potential to further streamline the cartographic process.

Peter Schwarzberg has extensive experience in the field of nautical cartography having previously worked at the Danish Hydrographic Office. His expertise in charting has contributed to IHO standardization work and continues to play a role in his career with Teledyne CARIS, where he focuses his knowledge of system and data migration on the development of new solution initiatives and implementation with private and government agencies.

Satellite-derived Bathymetry

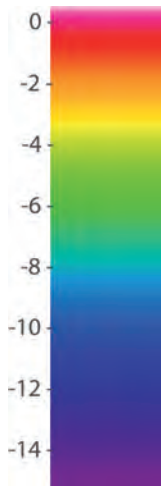
An **Established Surveying** Tool for Seafloor Mapping?

It is only two years since the first hydrographical office started using Satellite-derived Bathymetry (SDB) as a tool to provide high-resolution bathymetry measurements for charting, even independent of other survey methods. These were requested for the recent remote mappings for the LINZ PRNI project (Figure 1). This is a short time period considering it has been over 20 years since the development of the first physics-based approaches, for independent mapping capabilities.

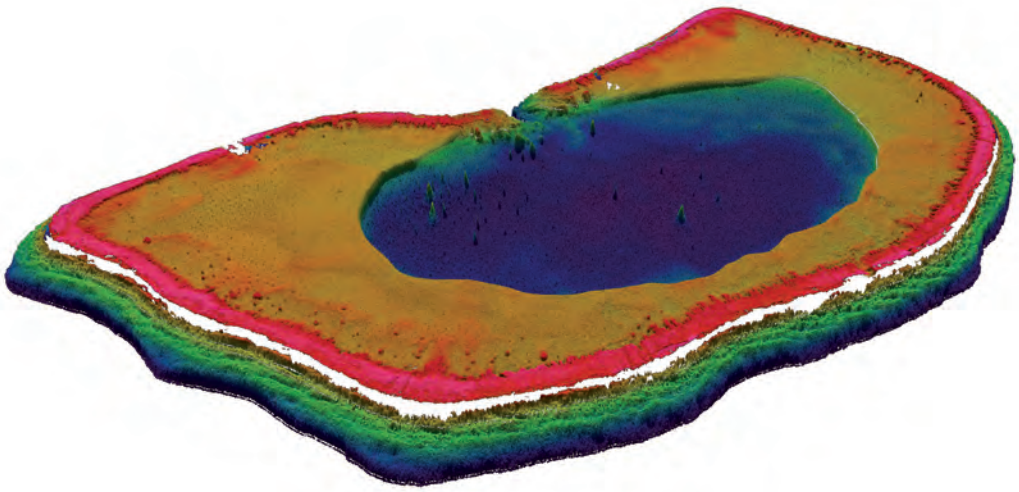
At Hydro 2018 in Sydney, several delegates expressed the change in the across-market uptake: SDB now having an established place in the toolset of surveyors and hydrographers, as a valuable and affordable tool for remote or extended shallow water areas or to increase navigation safety. Marine industries, such as oil/gas and engineering companies have explored these aspects in individual pilot and benchmark exercises for more than a decade now, and pragmatically implement SDB as a survey tool for mapping shallow waters (e.g. Shell 2014(1)). This market demand on the one hand and the lack of scientific information exchange on the other hand, initiated a series of conferences and workshops, such as the first International Satellite-derived Bathymetry Conference (Figure 2) in Germany, followed by the Hydrographic Remote Sensing Workshop HRS in Canada and the upcoming 2nd International Satellite-derived Bathymetry Conference in Australia in 2019.

But is SDB already really understood, in terms of best practices, requirements, quality assurance processes, limitations and uncertainties for all the variety of conditions that the world's shallow waters offer? It seems we have challenging tasks still in front of us to provide hydrographers and experts in this field with the toolkit to understand SDB methods, define standards and define requirements.

For surveyors, it is well known which echo sounding equipment, strategy and processes are fit for purpose in order to achieve a given set of quality standards. Extensive education and internationally recognized qualification programs already provide a solid base for these technologies. However, similar or at least minimal training does not exist for SBD tools. This is of particular importance because under the umbrella term of SDB we have a wide range of data acquisition techniques, even just in the shallow water domain: photogrammetric methods allowing to triangulate identifiable matching points under different viewing angles, measuring wave patterns and their movement, relating these to large-scale morphologic changes, or multi- and hyperspectral measurements, in combination with various spectral analytics and data processing

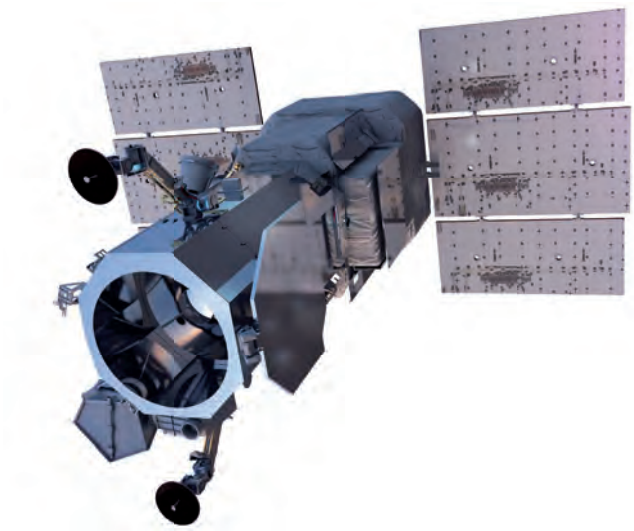


▲ *Depth gauge for the Beveridge Reef survey.*



▲ *Figure 1: Independent Satellite-derived Bathymety of the Beveridge Reef at 2m horizontal resolution.*

▲ *Figure 2: Participants at the First International SDB conference near Munich, Germany, June 2018.*



▲ *Figure 3: Worldview-3 satellite of DigitalGlobe, providing high-resolution multispectral input data for the SDB data analytics. (c) 2019, DigitalGlobe.*

approaches. These methods specify the vertical resolutions (from 50cm to hundreds of metres), the ability to identify obstructions, maximum mapping depth and uncertainties. The capabilities of these SDB methods have been the subject of several projects, amongst others on international (EU project BASE-platform) and national level.

For a number of technical reasons, the multispectral data provides the highest data density, resolution and accuracies, as provided, for example, by Sentinel-2 in 10m, and Worldview 2- and 3 up to 1m resolution (Figure 3). It is therefore the one which has highest potential to fulfil the market demand of high quality and high-resolution shallow water bathymetry. Simply described, this method is based on the reflected light intensity in different wavelengths, which are recorded at a satellite's sensor and includes, amongst others, the information on water depth. Using complex model inversion methods, it is possible to calculate this information from the satellite's data. The multispectral sensors specifications define the theoretical achievable spatial resolutions and data densities, while the specific elements of the signal processing approach determine the actual achievable results, including if water depth or uncertainties can be retrieved independent of ground-truth measurements.

So how can engineers and surveyors, trained for precision and craftsmanship, use the most suitable SDB data for their application, and how can organizations foster innovations to further improve performance and accuracies?

If quality drivers can be stipulated into requirements, and its fulfilments actively required in RFQs, then SDB providers and researchers could be tempted to continue their investments in technologies providing further improved data products and better remote sensing instruments. Ongoing efforts to improve vertical accuracies and reduce uncertainties would seem valuable, as the costs of SDB are a magnitude lower than those of traditional survey technologies. To be sure, much more can be explored and improved, within the multiple levels of required signal corrections such as light scattering from land, accurate atmospheric and water column corrections, parallel multi-image data processing approaches and the interplay between sensor specifications and data analysis technologies.

From the outset, such research activities - aiming to push the current limits of SDB – have been a focus of EOMAP. We believe in core principles which will enhance this technology, market uptake and continuous improvement. These include (a) the physical understanding of the light interaction along its path from the sun to the surface to the sensor, (b) fully transparent and traceable data production procedures, (c) standardized and documented workflows, and last but not least, (d) skilled SDB experts, taking care of the processes and QA/QC procedures. However, these activities need to go hand-in-hand with awareness and capacity building programs and even certification. The understanding of hydrographers and surveyors is mandatory to define requirements and create or implement such data in best practices. Lectures at international meetings, the upcoming SDB Day conference in Australia, and in-house training to hydrographical institutions and the headquarters in castle Seefeld, are all part of our efforts to foster this knowledge to enable SDB users to make best use of this technology.

Thinking further ahead and beyond SDB or related aerial solutions, new flexible standards such as S100 are ready to foster the uptake of other digital data for various purposes. Satellite and remote sensing-based information streams also have more to offer, such as seafloor habitat maps, water quality and sea state data. The journey along the helix of learning, innovation and application development continues. ◀

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(1) www.onepetro.org/conference-paper/IPTC-17346-MS Siermann, J., Harvey, C., Morgan, G., Heege, T. 2014: Satellite derived Bathymetry and Digital Elevation Models (DEM). IPTC OnePetro Journal

Thomas Heege, founder of EOMAP, has more than 25 years of experience in aquatic remote sensing and technical consultancy in manifold projects worldwide. Prior to founding EOMAP in 2006, he has worked as a scientist and project manager at the German Aerospace Center DLR (1996-2006), and at Limnological Institutes in Munich and Constance. Thomas graduated as Physicist in 1993 at the University of Konstanz. He received the PhD in space sciences and remote sensing in 2000 at the Free University of Berlin.

Ocean Business, more than just a static exhibition

The bi-annual event Ocean Business is coming to the NOC, Southampton, UK, from 9-11 April 2019. Three days of ocean technology engineering and science, knowledge sharing, hands-on training, demos, and networking. The exhibition space is completely sold out, including more than 330 exhibitors. A selection of the businesses represented give a taster of their innovations in this preview. Better still, of course, is to come and experience the event for yourself!

Ocean Business is unique. Not only can visitors meet face to face with 330+ exhibitors from across the globe, they can also see the latest products and services first hand with over 180 hours of free to attend live demonstrations held onboard vessels, in dockside waters, in a test tank and in classrooms. Visitors can also attend the Offshore Survey conference and a variety of free to attend co-located meetings held by leading organizations in the industry. For additional information and free registration, go to *www.oceanbusiness.com*.

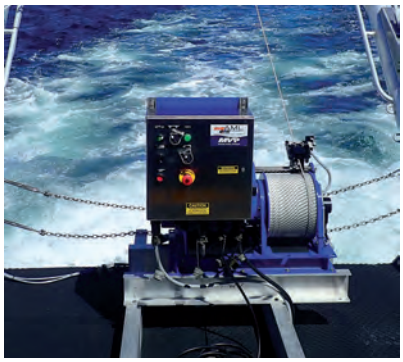
AML Oceanograpic

Remove Technical and Financial Unpredictability from Your Survey Operations

AML Oceanographic helps organizations around the world remove technical and financial unpredictability from their hydrographic, environmental monitoring and scientific research operations. Moving Vessel Profiler (MVP), the world's only automated, real-time underway profiling system is backed by 20 years of experience and thousands of successful surveys. Organizations across the oceanographic community use MVP to reliably collect the data they need efficiently and safely. With 45 years of experience manufacturing ocean sensing solutions that reduce data collection costs while improving data quality, AML is committed to helping its customers succeed. Headquartered in Sidney, British Columbia, the past few years have seen AML add footholds in Dartmouth, Nova Scotia, and Aberdeen in the UK.

Are you looking to increase your survey productivity or do you need more data for your research? Go to the Ray Beverton Room 044/11 at 15:00 on Wednesday 10 April at Ocean Business or visit stand K8.

Booth K8 - *www.amloceanographic.com*



Applanix

Applanix Products and Solutions for Hydrographic Survey & Marine Applications … Maximize Your Productivity!

Applanix designs, builds, delivers and supports products and solutions designed for the hydrographic survey industry. Even in the harshest environments, its solutions provide robust, reliable and repeatable positioning and motion compensation solutions from moving vessels. Marine-based mobile mapping and positioning with Applanix technology not only cuts costs associated with marine surveys, it also delivers improved data quality – fast.

Applanix POS MV

POS MV blends GNSS data with angular rate and acceleration data from an IMU and heading from GNSS Azimuth Measurement System (GAMS) to produce a robust and accurate full six degrees of freedom position and orientation solution. POS MV is designed for use with multibeam sonar systems, enabling adherence to IHO standards on sonar swath widths of greater than ± 75 degrees under all dynamic conditions.

Booth H300 - *www.applanix.com*

Bibby HydroMap

Proven Track Record in Quality Survey Solutions

Bibby HydroMap is specialized in the acquisition, interpretation and reporting of highly accurate seabed survey data. With an experience level among the highest in Europe, Bibby HydroMap has a proven track record in providing quality survey solutions to satisfy even the most challenging requirements. The team are experienced in a range of disciplines including seabed mapping and marine geophysics, UXO survey, cable and pipeline tracking, ROV inspection, benthic sampling and oceanography.

Combining over 20 years of expertise with a focus on innovation, Bibby HydroMap works closely with its clients to develop bespoke

services to suit individual project requirements. During 2018, the company acquired over 26,000-line km of survey data over 38 sites throughout the UK and Northern Europe.
Visit the team at Ocean Business to have a chat and find out more about the services Bibby HydroMap can offer to help your business.
Booth Q8 - *www.bibbyhydromap.com*

CHCNAV

P2 Elite GNSS Sensor for Advanced Positioning and Heading

CHCNAV's P2 Elite GNSS sensor is a dual-antenna high-precision receiver designed to deliver reliable and precise heading and positioning solutions to demanding applications. Truly versatile with embedded 4G and radio modems, the P2 Elite GNSS sensor provides high connectivity integration to achieve accurate positioning in any conditions, using NTRIP/TCP corrections from RTK networks or from radio modem broadcast on construction sites. Integrating the latest GNSS technology in an extremely rugged IP67 and lightweight enclosure, the P2 Elite GNSS sensor is built to match the toughest protection standards to ensure uninterrupted performances. It outputs up to 50Hz precise positioning and heading data (0.15° accuracy with 1m antenna baseline). CHCNAV's P2 Elite GNSS is a highly cost-effective solution for many positioning and navigation applications: marine, unmanned navigation, industrial automation, robotics, machine control, harbor automation, etc.
Booth W76 - *www.chcnav.com*

EdgeTech

High-resolution Sonar Imaging and Underwater Technology

EdgeTech, the leader in high-resolution sonar imaging systems and underwater technology, will be showcasing a number of recently introduced products at Ocean Business 2019. The company will be conducting on-water demonstrations with the new 6205s combined bathymetry & sidescan sonar system. Additionally, at the booth the company will be highlighting the new 4205 sidescan sonar, new 3400 sub-bottom profiler and new rugged acoustic release.
Booth B9 - *www.edgetech.com*

EvoLogics

Next-generation 'Tiny' Modems

At Ocean Business 2019, EvoLogics GmbH (Berlin, Germany) will introduce the company's latest addition to its range of underwater acoustic modems: the new-generation S2C T modems. The light and ultra-compact design represents a size reduction of almost 20% compared to EvoLogics' M-series mini-modems at only 25cm standard height and 1,200g weight. The new model features a fully-fledged S2C engine with no compromises in acoustic performance. It is a great fit for small AUVs and ROVs where size and weight are critical. Perfect as transponders for positioning, the S2C T is capable of simultaneous tracking and reliable bi-directional data transmissions with advanced networking. The S2C T series form factor will be available for EvoLogics' high-frequency models, catering to various applications with four frequency range/directivity options.
Booth E6 - *www.evologics.de*

Fugro Marinestar

Marinestar GNSS

Marinestar high-performance positioning products and services delivered to you by Fugro Satellite Positioning are able to meet a varied range of applications in dredging & marine construction, wind farm installation, cable lay, naval and hydrographic/oceanographic surveys. Marinestar GNSS delivers up to 6cm (vertical, sigma 2) accuracy in high availability, using seven overlapping L-band satellite beams. Via NTRIP the corrections could be delivered over the internet, as an extra path over for instance the fleet's broadband or even Iridium link.
With GPS, GLONASS, Beidou and Galileo constellations, redundancies as well as precision gains are made available. One of the company's most recent developments is the fixing of ambiguities of the GPS constellation leading to the G2+ or G4+ L-band service.
At Ocean Business, the company will be demonstrating another latest development: the 'Satguard' GNSS navigation message authentication feature which protects clients against spoofing risks. Redundant infrastructure and unrivalled 24x7 global customer support makes this precise positioning service the exact tool you need! When positioning counts... you can count on Marinestar!
Booth V23 - *www.fugro.com/marinestar*

MARINESTAR

INNOMAR

Leading Manufacturer of Parametric Sub-bottom Profilers

During Ocean Business 2019 INNOMAR will present its new 'SES-2000 smart' parametric sub-bottom profiler, operating on the DotOcean 'Calypso' autonomous USV. An overview of this new product and possible applications will be given on Tuesday (14:00) in Room 344/44. Live demos are shown on Wednesday (12:00) and Thursday (13:30) at Dockside 2. Another INNOMAR presentation (Wednesday, 13:30, Room 064/03) will focus on using a parametric 3D SBP for offshore site explorations.
INNOMAR is the leading manufacturer of parametric sub-bottom profilers (SBPs) with more than 400 sold units. The 'INNOMAR SES-2000' SBPs are perfectly suited for high-resolution sub-seabed visualization in water depths between less than one metre and more than 11,000

metres. Applications include the geophysical imaging of sediments and sub-seabed structures for dredging purposes, for route and offshore site surveys and to map buried pipelines/cables.
Booth L1 - *www.innomar.com*

iXblue

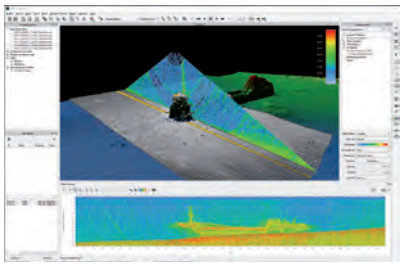
New Partners for iXblue to Offer a New INS/DVL Tight Coupling Solution

iXblue has partnered with DVL manufacturers Nortek and Teledyne RD Instruments to offer a new INS/DVL tight coupling solution. Benefitting from iXblue's field-proven expertise in Fiber-Optic Gyroscopes (FOG), that have revolutionized navigation in the past decade, and from the latest DVL developments that Nortek and Teledyne RD Instruments have been working on, this new solution combines the best navigation technologies available today and offers a plug & play and scalable solution which performance and characteristics can best be suited to the user's need.
Offering modularity and flexibility, this new solution covers the full range of altitudes and depths that users can request by enabling them to choose the INS and DVL combination that most adapts to their operation in terms of accuracy, volume, weight and altitude, with no compromise on the ease-of-use.
Want to know more?
Booth H9 - *www.ixblue.com*

QPS

New Techniques for 3D Visualization of the Underwater Environment

Quality Positioning Services BV (QPS), headquartered in Zeist, the Netherlands, is an independent software design company founded in 1986. QPS subsidiary offices are located in Canada, the USA and the UK.
QPS provides turnkey software solutions for the hydrographic and maritime industry. QPS solutions are used for applications such as hydrographic surveys, sea-floor mapping, offshore and near-shore construction of ports, wind farms and oil and gas, portable pilot units and Electronic Navigation Charts (ENC) production. QPS is seen as a market leader in these fields.
The key technology of QPS is based on precise navigation, the collection and presentation of large volumes of navigation and depth data. This also includes new techniques for 3D visualization of the underwater environment. QPS navigation and positioning software is used onboard offshore construction vessels, pipe-lay barges, drilling rigs, seismic research vessels and hydrographic survey vessels. QPS has a fast-growing market share in the offshore oil and gas industry, offshore wind farms, dredging industry and port communities.
Booth U1- *www.qps.nl*



RIEGL

New Topo-hydrographic UAV Laser Scanner RIEGL VQ-840-G

RIEGL presents its latest solution for combined topo-hydrographic surveying applications: the VQ-840-G. This is a lightweight airborne laser scanner for small to mid-scale coastline and shallow-water surveying from various platforms including UAVs. The VQ-840-G carries out laser range measurements for high-resolution surveying of underwater topography with a narrow, visible green laser beam offering up to 1.5 Secchi depth water penetration. A measurement rate of up to 200kHz and a scanning speed of up to 100 scans/sec are the keys for fast acquisition of dense and feature-rich surveying data. The system is offered with an integrated GNSS/IMU system and can be complemented with an optional camera or IR rangefinder.
Meet the RIEGL experts at Ocean Business and get more detailed information on the company's portfolio of airborne laser scanners and systems for surveying of coastlines, shallow waters and river beds using manned or unmanned aircraft.
Booth W34 - *www.riegl.com*

SBG Systems

First European Unveiling of Horizon IMU

During Ocean Business, SBG Systems, a manufacturer of MRU and INS, will be unveiling for the first time in Europe its brand-new Horizon IMU. Horizon is a FOG-based high-performance inertial measurement unit (IMU) designed for large hydrographic vessels surveying harsh environments. Horizon IMU is now added to Navsight Marine Solution, a powerful and ready-to-use inertial navigation solution dedicated to hydrographers.
Navsight Marine Solution already offered two levels of performance with the Ekinox and Apogee IMUs. These MEMS-based IMUs address most hydrographics markets, whether shallow or deep water. The new Horizon IMU allows customers to bring the Navsight technology to the most demanding environments such as surveying in highly dense areas as well as applications where only a single antenna can be used. Horizon IMU is based on closed-loop FOG technology which enables ultra-low bias and noise levels. This technology allows robust and consistent performance even in low-dynamics survey.
Booth E4 - *www.sbg-systems.com*

SubCtech GmbH

New UPS Subsea Battery Product Line

SubCtech GmbH is a market leader in cost-effective, high-performance, highly reliable and safe Li-Ion batteries for subsea oil and gas platforms, vehicles (AUV, ROV) or other instrumentation, and autonomous underway systems (e.g. FerryBox) combined with high-precision pCO2 gas analyser. At Ocean Business, the company will present its new UPS subsea battery product line.

The proven Li-Ion UPS technology, already certified for offshore applications (API17f, TRL 6, 25 years), is available for a variety of applications such as 'all electric', subsea actuator or any control units. Just like the well-known Li-ion batteries, the UPS systems are modular and can be customized for a wide range of applications. SubCtech's Gosubsea3000 products provide a glimpse of tomorrow. Furthermore, the company is introducing its new mobile and modular FerryBox flow-through underway system. The OceanPackCUBE embodies the latest unattended monitoring technology developed for the Volvo Ocean Race round-the-world sailing competition.

Booth Q2 - *www.subCtech.com*

Teledyne CARIS

Leading Developer of Marine Mapping Software

For 40 years, Teledyne CARIS has been the leading developer of marine mapping software. Teledyne CARIS offers a highly effective solution for near real-time processing and robust quality control of sonar data and the creation and distribution of maps, charts and digital datasets. The Ping-To-Chart portfolio is designed to deliver an integrated and seamless solution for the entire workflow of hydrographic information. The latest addition to the Ping-to-Chart portfolio is Onboard, providing near real-time and autonomous data processing for underwater AUV and USV surveys bringing significant efficiencies and cost savings to the product creation pipeline.

CARIS software offers a comprehensive level of support with training sessions, consulting and a series of courses as well as technical support via online services, multilingual telephone support and email.

Booth N9 & N10 - *www.teledynecaris.com*

Trimble

Flexible, High-performance Positioning Systems from Trimble

It's all about location, location, location. With Trimble marine construction systems, you'll never have to worry about yours. Trimble offers flexible, high-performance positioning systems to meet the unique needs of marine construction on both simple and complex projects. Solutions include both hardware and software, and can be easily integrated into third-party systems. The portfolio includes marine information systems, GNSS receivers, antennas, radios, and inertial positioning systems.

Booth M4 - *www.trimble.com/marine*

Valeport

Unveiling New Optical Sensors

The leading UK designer and manufacturer of innovative marine instruments will launch a suite of new Valeport optical sensors at Ocean Business. Hyperion Turbidity is the industry's first standalone turbidity sensor with such a small footprint to combine Nephelometer and OBS readings in the same instrument. Delivering a minimum detection level of just 0.03NTU (nephelometer) and able to measure turbidity up to 6,000NTU (OBS), this sensor can be placed in situ for extended periods with easy access to highly accurate data.

The SWiFTplus Fluorometer is a new range of probes that combine the power of the SWiFT SVP and a fluorometer for the high-performance measurement of Chlorophyll a, Fluorescein, Rhodamine or Phycocyanin. Ideal for shallow-water bathymetric and environmental survey, the savvy sensors provide all you need to carry out survey-grade Sound Velocity, Salinity, Density, CTD and optical profiles up to 200 metres, in a single instrument.

Booth M1 - *www.valeport.co.uk*

ECA GROUP

ECA GROUP to Exhibit at Ocean Business 2019

ECA Group offers a comprehensive operational system: a wide range of drone systems including Unmanned Surface Vehicles (USVs), Autonomous Underwater Vehicles (AUVs), Remotely Operated Vehicles (ROVs) and associated tooling, such as LARS (Launch and Recovery Systems) or electric manipulator arms for ROVs, as well as a complete software suite for mission planning, real-time mission monitoring data post processing and report generation. Visit our booth for more information!

Booth E8 - *www.ecagroup.com*

Optimizing a Low-cost Multi Sensor System for **Hydrographic Depth Determination**

With shallow water surveys not required to be performed with the accuracy and precision of industrial projects, surveying devices with lower costs are being welcomed by hobbyists eager to determine water depth. With this low-cost demand rising, the investigative development of these products has become a scientific research issue. The department of Geodesy and Geomatics at HafenCity University (HCU) in Hamburg has been working on cost-efficient solutions in recent years.

The Old Openseamap Project

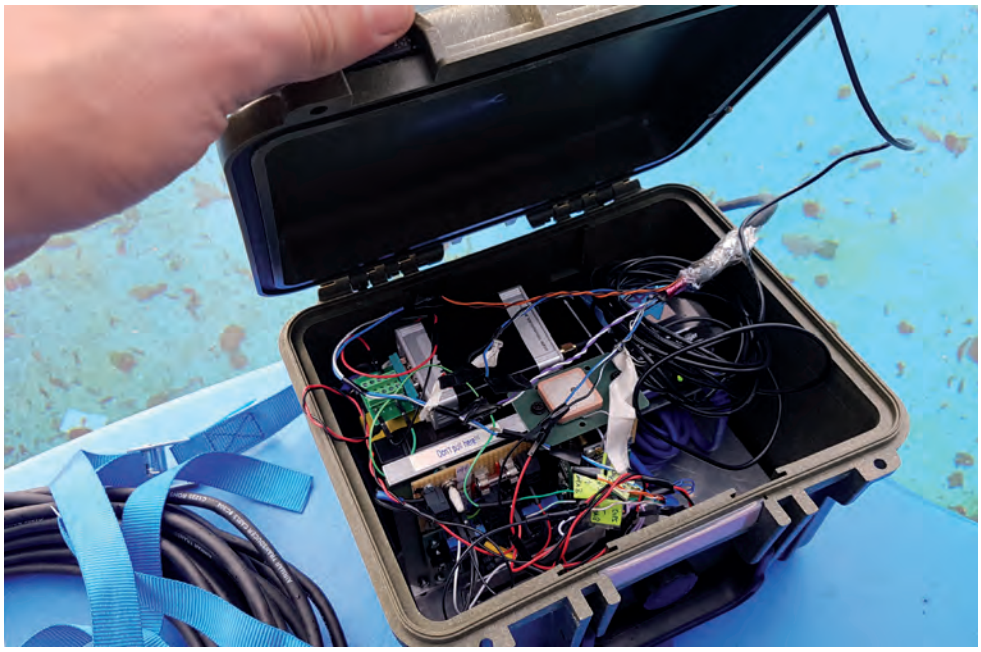
During a project with openseamap.org, a Multi Sensor System (MSS) including an echosounder, GPS and inertial measurement unit (IMU) was built up and tested. Despite having successfully created a working set-up that determined water depths and summoned costs less than €300, the quality of the survey data was yet to be sufficient for sea floor mapping. Secondly, the gathered data could not be processed by the user and had to be uploaded to an external server owned by openseamap.org where the data could be corrected and processed. A new project took place to increase measurement quality of this low-cost MSS and create independence from external data correction services.

The first developed MSS contained a MEMS IMU, a GPS module and a fish finder inside a waterproof box including the necessary electronics for power supply.

Optimizing a Low-cost MSS

Changes were applied to optimize the MSS hardware and software. Hardware changes involved exchanging the GPS receiver and the echo sounder. The old device (regular fish finder) for collecting echo data was exchanged with a SBES – increasing the overall cost. However, the accuracy and integrity of the gathered data showed large improvement. Secondly, the GPS receiver was replaced with an evaluation kit, making it easier to store data in the desired format. A small cost-efficient MEMS sensor was already installed as an IMU. The data from these three components were collected on a data logger that came from openseamap.org. As an advantageable outcome of the hardware adjustments, there was no longer a need for an onboard microcontroller since all the data from the devices came formatted for NMEA-0183. The data logger, IMU and the GPS receiver were placed inside a waterproof box (Figure 1) which can be strapped onto a regular bodyboard, while the echo sounder is adjusted at the downside of the bodyboard (Figure 2) and connected to the data logger inside the waterproof box via an RS232 connection.

For further improvement of the hardware, the IMU was calibrated thoroughly in the HCU's



▲ *Figure 1: GPS and IMU in the waterproofed box.*

Geomatic department's laboratory. By doing so, deviances and shifts of the gyro's axes could be discovered and eliminated. It was later found that this calibration improved the depth accuracy up to 18%.

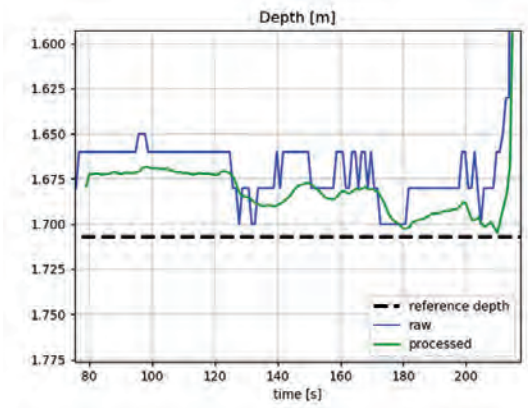
Post-processing of Position and Depth in a Kalman Filter

Instead of depending on external work for post processing, a Python code was written which can be easily executed by any user without a surveying background. All necessary steps for data correction and processing were included: By combining the information from the IMU, echo sounder and GPS, the measured point's position underwater must be corrected according to roll/pitch and the measured depth. Furthermore, an extended Kalman Filter (EKF) was used to improve the quality of the data series. The critical issue during the filtering process was found to be the prediction of state values' variances after setting up the system model for the MSS. The EKF system model describes the development of all state variables (e.g. position, depth, turning rates, etc.) over time. For performing an iterative loop over each time step, the variance (or expected error) of each state variable must be indicated by the user. In fact, those state variable's variances have to be carefully adjusted in order to describe a moving system (the low-cost MSS) in the best possible way.

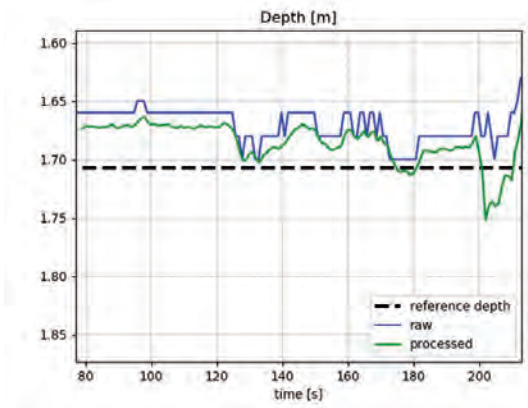
First Test Runs

After calibrating the IMU and attaching the sensors to the bodyboard, the first test surveys were performed in a pool with known water depths. The goal was to obtain a quantitative idea about the system's measurement accuracy. The results after performing a reference survey showed an accuracy of 98.17% meaning that the deviation of the measured depth from the reference depth averaged at ±1.83%. After implementing the Kalman Filter, processing the deviation was reduced to ±1.11%.

However, this survey was carried out in an environment with a constant depth (Figure 3). As those values happen to vary during a usual hydrographic survey, the chosen settings on the EKF's system model had to be confirmed by testing the MSS in less predictable open waters. After an open water test run, the EKF's system model variances were adjusted according to the open survey's results. The adjusted values of the system model were then confirmed by processing the reference run, this time using the new variance parameters (Figure 4). Using the filter's final parameters, the deviation from



▲ *Figure 3: Old EKF parameters before open water test run.*



▲ *Figure 4: New EKF parameters after open water test run.*

the reference depth was ±1.22%. This result was therefore less accurate than the parameters developed for constant water depth only. Still, it shows a significant improvement from the measured depth without any computational processing. As an example, the developed MSS is able to fulfil the IHO's requirements regarding the survey of shallow waters up to a depth of 25.98m, while without the implemented processing the required accuracy is not reached with only a 15m depth. Considering those results, it can be stated that the hardware and software improvements of the first low-cost system was a success.

The overall cost of the device is €1,031, which is more than three times higher than the previous system. After assembling an echo sounder specified for hydrographic surveys however, this increase in budget was in fact unavoidable. Still, these costs can be decreased by choosing a small and cheap GPS module instead of an evaluation kit which performs equally accurately but takes away a lot of space on the system.

Outlook

After assembling an accurate depth sensor and developing a post-processing programme, the largest field left to be developed is the GPS/GNSS. To improve the positioning data, it is possible to collect raw data from satellites and upload it into the extended Kalman Filter. This will probably require an Arduino onboard the MSS for converting the raw data in NMEA 0183.

Consideration is being given to adding further sensors to the MSS in order to gain more measurement variables like a barometer for precise height measurement and a magnetometer for determining the heading of the MSS. A barometer can especially determine information about the heave – which is useful if the system is used in wavy conditions.

The next step is to develop a ROS (Robot-Operation-System)-based low-cost open-source localization system for hydrographic surveys which could later be integrated into a low-cost ASV. It will include improved GNSS, an attitude sensor, a camera and the Airmar EchoRange singlebeam echosounder as it was implemented and described above. The camera will be used to support the GNSS position through the use of visual odometry. The developed filtering and post-processing programmes have the potential to be developed even further. For additional sensors and more state variables, the functions in Python can be adjusted and changed if needed. ◀

▲ *Figure 2: Installation of the SBES under the bodyboard.*

Markus Kraft did his Geodetic and Geoinformatics Masters at HafenCity University in 2019.
✉ markus.kraft@hcu-hamburg.de

Prof Dr-Ing Harald Sternberg studied surveying at the University of Armed Forces in Munich and did his doctorate on mobile mapping in 2001. He has been lecturing Engineering Geodesy at the HafenCity University since then. Since 2009, he became Vice President for Studies and Teaching, and since November 2017, professor for Hydrography and Geodesy.
✉ harald.sternberg@hcu-hamburg.de

Fusion 2 – An Evolution in Offshore Survey Operations

Complex set-up operations, multiple topside systems and interfaces, and arduous workflows; these are all now in the past. Sonardyne's Fusion 2 survey software combines intuitive workflows with faster, more flexible INS, LBL and Sparse LBL aided INS operations - all from a single system.

Since surveyors and subsea construction operatives took their first steps into the US Gulf of Mexico, followed by the harsh waters of the North Sea and beyond, the industry has been on a learning curve. From taut wire through to today's digital signalling architectures, systems and methodologies, the industry has evolved. Developments in signalling technology have driven significant advances – Wideband digital signal technology brought survey and construction operations out of the "tone age" and enabled true life-of-field navigation across a whole field of developments. A manageable number of acoustic transponders with digital signals could now offer both long (several kilometres) and highly accurate (millimetric) ranges. The development of Sparse LBL techniques, thanks to the use of inertial navigation systems (INS) like our SPRINT, introduced the concept of deploying fewer transponders on the seafloor, reducing survey times.

These evolutions have made operations faster and more accurate, but often also more complex; INS-aiding brings cost saving advantages but requires the need to interface INS and LBL software and hardware systems. Switching between the two, or making them work together, can be time-consuming.

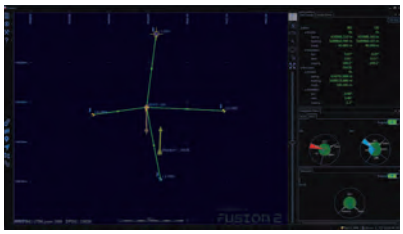
Sonardyne has been providing LBL acoustic positioning software, supported by generations of our trusted Compatt transponder, for 40 years since the first unit was sold in the late 1970s. Since 2006, we've also been developing INS solutions. Taking the learnings and experience built up in both technologies over this time, and through listening to our customers, our software engineers have written, from the ground up, a new, single, powerful, multi-user capable system. From it, surveyors and construction personnel can do all their LBL and INS operations in any combination they want, faster, easier, and with less hardware and fewer interfaces – it's called Fusion 2.

WIDEBAND 3

A key enabler for Fusion 2 is the latest evolution of our Wideband signal architecture – Wideband 3 – which not only offers faster tracking updates, at 1Hz LBL tracking, but also provides combined telemetry and position updates in the same signal. This means tracking is no longer interrupted when sensor data (attitude, heading, depth, etc.) is required. By combining ranging and telemetry data, Wideband 3 accelerates update rates by a factor of 10. Combined with our 6+ hardware, further capabilities are unlocked. When Compatt 6+ ranges are received by an ROV mounted ROVNav 6+ transceiver, Fusion 2 starts calculating its position immediately, instead of waiting for all the array ranges to come in before sending the data to Fusion and on for processing. This means operators know the position of their ROV faster.

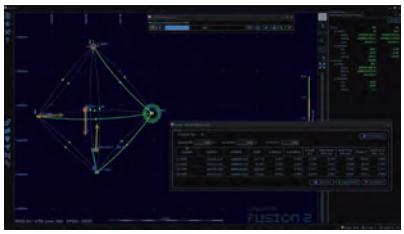
REAL-TIME SLAM

In Sparse LBL, the SPRINT INS on an ROV can take ranges from a single transponder and, because it knows its own movement, can calculate its position relative to the transponder. The key is knowing where in the real world that transponder is. Unlike full LBL transponder arrays, a single transponder cannot be quickly LBL baseline calibrated and, to date, has required to be individually boxed-in by expensive vessels. Fusion 2 removes this box-in requirement through the addition of real-time SLAM calibration. To enable real-time SLAM, our software engineers developed a set of algorithms to run in the SPRINT INS. This means, using raw ranges from Compatt 6+



▲ *Structure tracking system set up in Fusion 2 is easier than ever.*

▲ *All your operations from one screen with a simpler set up, fewer interfaces and less hardware.*



▲ *Quick results and an easy interface showing you your baseline results.*

transponders, Fusion 2 can compute their position without needing to box-in or baseline calibrate. Fusion 2 manages the whole process in real time so, as soon as you achieve the navigational accuracy you need for your project, you can stop calibrating, start tracking and get to work. Fusion 2 can also SLAM calibrate, initialize and start tracking with ranges from just a single seabed reference beacon, making operational start-up faster and simpler.

FULL LBL

For full LBL array operations, the faster ranging and telemetry updates brought by Wideband 3 de-stresses and de-risks mobile Compatt tracking. With sensor data embedded with the range data, you get fast uninterrupted tracking. Sound velocity data can also be accessed without interrupting tracking, further improving confidence in the reliability of position updates.

The previous lengthy workflows, which involved selecting, adding and then giving transponder locations, have been replaced by a simple process in an intuitive and adaptable user interface (UI). Fusion 2 now separates locations and transponders – this enables you to have multiple transponders in a single location, such as a multi bucketed tripod, and swap and change transponders in and out of locations, as does happen over field life-cycles. Then, during an operation, surveyors can dynamically select and change seabed acoustic transponder references during navigation, instead of having to stop and reconfigure them. Once tracking, surveyors can also easily track if they're within their set positional accuracy limits through the UI.

Fusion 2 has also been built to use Earth-centred Earth-fixed (ECEF) coordinates for positioning and calibrations, which means grid scale factors are not an issue. With the Sonardyne's iWand, Compatts being readied on the back deck can also be given their locations prior to deployment – they're simply loaded into an iWand wirelessly from Fusion 2, then sent to the transponders wirelessly on deck – so you know their status before they even hit the water. This all makes Compatt inventory management easier and from one place. Furthermore, acoustic LBL and INS surveys can be

▲ *Edward Moller.*

configured 'in the office' before mobilisation.

FLEXIBILITY

Because of the way the system has been designed, users have complete flexibility in how they want to operate; they can let the system do the work for them, or tailor their operations how they want. A user can run everything from USBL INS operations to full LBL surveys and everything in between.

Multiple computations can be run easily, to compare different set-ups, to see which one is best suited for a particular operation. Then, when using the UI, as well as being able to easily select and place the windows you want to see for any particular operation (and save these for future reference), operators can chose modes suited to their own environment (i.e. night time or day time screens to make viewing easier in a dark cabin or in full daylight). Fusion 2 also has a remote interface for monitoring position data, and in future, more processes and workflows will be automated, and we will be looking to enable smarter integration with survey systems.

Fusion 2 also supports use of our SPRINT 300 for LBL INS, which means lower start-up costs. And with Compatt 6+ able to support five users at the same time, simultaneous operations are less challenging on resources.

ONE SYSTEM, ONE HUB

To further reduce hardware requirements, Fusion 2 was developed so that it works through our Navigation Sensor Hub (NSH). This is the same hub used for our Ranger 2 USBL system, so operators need fewer systems (just one PC, one sensor hub and one cable between them) and fewer systems in their inventory.

▲ *Combined with our 6+ hardware, including Compatt 6+, Fusion 2 unlocks new capabilities.*

▲ *When Compatt 6+ ranges are received by an ROV mounted ROVNav 6+ transceiver, Fusion 2 starts calculating its position immediately.*

The full Fusion 2 package will be launched at Ocean Business, Southampton, UK, in April 2019. There, we'll be showing off its capabilities during live, daily demonstrations. If you're unable to attend the show, get in touch with us through social media, our website or your local office to find out more about our 2019 experience events. ◀

▲ *Sonardyne's Fusion 2 tour took in Houston, where customer demonstrations were held on Lake Conroe.*

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AUV and ROV Technology Plays Key Role in **Historic Discovery**

WWII Wreck Located in South Pacific

An underwater research and exploration vessel has played a key role in locating a major US aircraft carrier lost during World War Two. The R/V *Petrel*, owned and operated by philanthropist Paul Allen, discovered the remains of the USS *Hornet* on the seabed, 5,330 metres below the surface of the South Pacific Ocean near the Solomon Islands, in late January 2019. This article looks more closely at the importance of underwater technology in enabling this historic find.

▲ *The USS* Hornet *under attack during the Battle of the Santa Cruz Islands in 1942. [Courtesy: US Navy.]*

The R/V *Petrel* is an expedition ship belonging to Vulcan Inc., a company founded by explorer and philanthropist Paul G. Allen, co-founder of Microsoft who died in October 2018. It was first used in August 2017 to locate the wreckage of the USS *Indianapolis*, another ship that sank during WWII after being struck by Japanese torpedoes. Having been lost in July 1945, Indianapolis was located at a depth of 5,500 metres in the Philippine Sea. Since then, the team has been dedicated to finding and documenting historic shipwrecks with a focus on World War Two. In another success, R/V *Petrel* located the aircraft carrier USS *Lexington* found at 2023 metres in the Coral Sea in March 2018.

Pivotal role in history

The crew of the 250-foot R/V *Petrel* were keen to locate the USS *Hornet* (CV-8) to honour the memory of Paul Allen, who was particularly interested in aircraft carriers, but also because of the *Hornet*'s involvement in many pivotal moments in naval battles. For example, the *Hornet* is well-known for launching the important Doolittle Raid – the first airborne attack of Japanese homeland targets including Tokyo – in April 1942 and for its role in winning the Battle of Midway in June 1942. Ultimately, the *Hornet* became irreparably damaged by enemy torpedo and dive bombers in the Solomon Islands campaign, during the Battle of the Santa Cruz Islands on 26 October 1942. Faced with an approaching Japanese surface force, the *Hornet* was abandoned, but not before 140 sailors from the crew of nearly 2,200

▲ *The* Hornet *was discovered on the first dive mission of the* Petrel*'s AUV, and the ROV provided live video footage so that the find could be confirmed. [Courtesy: www.paulallen.com]*

▲ *5-inch anti-aircraft guns of the USS* Hornet. *[Courtesy: www.paulallen.com]*

had lost their lives. The vessel was later torpedoed and sunk by approaching Japanese destroyers.

Now, over 75 years after vanishing beneath the waves, USS *Hornet* has been relocated at a depth of almost 5,400 metres below the surface. The ten-person expedition team on R/V *Petrel* started on their mission by analysing data from national and naval archives, including official deck logs and action reports from other ships engaged in the final battle. They arrived at a starting point for their search by plotting positions and sightings from nine other US warships in the area at the time.

Depth-rated to 6,000 metres

R/V *Petrel* is currently the only privately owned vessel equipped to explore down to depths of 6,000 metres. It is fitted with ultra-high-tech underwater equipment including an autonomous underwater vehicle (AUV) – the Remus 6000 – and an echosounder package consisting of one Kongsberg EM710 hull-mounted multibeam system, one Kongsberg EA600 hull-mounted singlebeam system, one ROV-mounted BlueView M450 2D multibeam imaging sonar and one EdgeTech 2205 AUV-mounted sidescan array (75/230kHz with interometric bathymetry). The ROV is an Argus 6000, which recently had an R2Sonic MBES added to it and is outfitted with a full inertial navigation system (INS) including doppler velocity log (DVL), an ultra-short baseline (USBL) tracking system from Kongsberg and a heading reference system. There are a total of nine video cameras on the ROV: six standard-definition cameras used for manoeuvring and three high-definition (HD) TV cameras for presentation and broadcasting purposes.

Former gunner

The *Hornet* was discovered on the first dive mission of the *Petrel*'s AUV, and the ROV provided live video footage so that the find could be confirmed. As part of its coverage of the discovery, American TV channel CBS News spoke to former crew member Richard Nowatzki, who is now 95 years old and lives in California. He was an 18-year-old gunner on the aircraft carrier in World War Two. As he watched the live images of the Hornet being beamed back from the ROV, he joked to the researchers, "If you go down to my locker, there's 40 bucks in it, you can have it!" Although the locker might not be found, the high-definition video images captured by the ROV clearly show torpedo damage to the hull of the USS *Hornet* as well as details such as a five-inch anti-aircraft gun and even an International Harvester aircraft tug. The exact location of the *Hornet* is being kept secret to protect the final resting place of the wreck and her crew.

Read more at: https://www.paulallen.com/the-hunt-for-the-uss-hornet/#LcLy9TADP6OPfFLx.99 ◀

▲ *Damage to the USS* Hornet*'s hull. [Courtesy: www.paulallen.com]*

▲ *The remains of an International Harvester aircraft tug are still clearly visible. [Courtesy: www.paulallen.com]*

A18D in Business for AUV Survey Services

ECA Group demonstrates the high-performance of its mid-size AUV during deep survey missions

As announced in early 2018, ECA Group signed a cooperation agreement for subsea robotic services to Oil & Gas companies with a leasing offer on its latest generation A18D AUV creating a new dimension for its AUV services activity.

Throughout 2018, ECA Group conducted several successful deep survey missions. The next generation AUV demonstrated its capabilities to perform multi-sensor surveys during deep sea operations (around 2,500m water depth) in the Mediterranean Sea.

A COMPREHENSIVE SURVEY SOLUTION

The A18D is the most compact multi-sensor AUV on the market for long-endurance deep water surveys (up to 3,000m). The AUV can capture up to 40km^2 of high-resolution imagery per mission.

Thanks to its complete solution package, the A18D underwater drone generated mosaics of high-resolution sonar imagery, bathymetry, sub-bottom profiling and video in record time using dedicated post-mission analysis software.

With unique 3D navigation accuracy, high-resolution data (MBES, SAS, SBP) was gathered in a single survey at a depth over 2,500m, with a perfect bottom altitude tracking at 25m. In the same survey, multi-sensors were used to obtain the best data possible.

MBES (Multi-beam Echo Sounders) were used for the bathymetry and Synthetic Aperture Sonar (SAS) for the high-resolution imagery.

With its highly accurate inertial navigation, the A18D provides centimetric XY resolutions of the bathymetry data. Unlike deep sea surveys with a boat, the measurement is much more accurate and less sensitive to the effects of sound velocity profiles (e.g. no effect of surface thermocline).

With a SAS (Synthetic Aperture Sonar), the resolution stays constant at 3cm*3cm – no decimetric object can be missed.

The very high quality data, especially on shadows, allows objects to be quickly recognized.

Environmental data, in particular sound velocity, was acquired throughout the mission (descent/survey/reassembly) in order to be taken into account during the post mission analysis with the best accuracy possible.

Thanks to internal synchronization features, all the sensors work together to provide localized bathymetry and imagery data of the same objects.

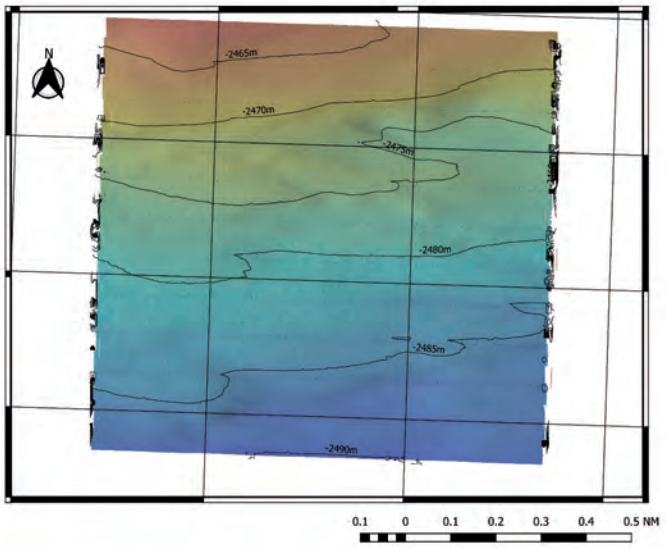
▲ *AUV A18D.*

EASY TO USE, LAUNCH & RECOVER

The recovery phase is critical because this is when human safety and material integrity can be exposed.

Because of this, the ECA Group developed a dedicated LARS (Launch and Recovery System) for its AUV A18D. This simple and robust system enables the operator to control the AUV safely and easily, even in harsh conditions.

Without moving parts or hydraulics, the LARS for the A18D is particularly reliable and easy to maintain or repair, and requires no complex preventive maintenance.



▲ *Global Digital Terrain Modelling of a 1Nm2 survey between 2,450m and 2,500m.*

▲ *Simple and safe LARS solution being used on the A18D.*

The A18D can also be recovered very simply even when it is switched off thanks to an internal emergency rope, offering the operators a contingency plan – reducing risks.

A COMPLETE SYSTEM – FROM TOOLBOX TO FINAL REPORT

Beyond the unmanned vehicle, ECA Group developed a complete operational system including the LARS and a comprehensive software suite for mission planning, real-time mission monitoring, data post-processing and report generation.

To comply with standard requests, this map-oriented software suite can read or generate formats such as XYF, SEG, SEGY or TRA to maximize the data collected throughout the mission.

To get the best from its unmanned vehicles, ECA Group developed various pieces of software managing all steps of the mission from the initial planning up to the final report generation. All the different software have now been merged into a comprehensive and homogeneous map-oriented software suite.

SUPERSEDING OFFSHORE SURVEY REQUIREMENTS

The A18D is a multi-operational AUV able to perform missions for the scientific and offshore market. The AUV is the perfect platform to perform specific missions such as:

- High-resolution imagery and bathymetry
- Sub-bottom profiling
- High-resolution pipeline inspection
- Leakage detection (Methane)
- Acoustic detection and localization (FDR/VDR)

MISSION DRIVEN DESIGN

Compact, reliable and extremely stable, the A18D offers the best platform for deep water surveying enhancing the data quality while reducing integration and expenditure costs.

Measuring 5m in length and weighing 500kg, the A18D can easily be operated from different kinds of vessels – from 18m multitask catamarans to 75m+ offshore supply ships.

Reliable, endurant (more than 20 hours at depth) and stable (roll and pitch <0,15°/s), the A18D is the perfect platform to collect high-resolution data from very performant sensors such as Synthetic Aperture Sonars and Multi-beam Echo Sounders.

Its unique design and advanced navigation features guarantee a high-level of stability and positioning to produce the best quality data possible. Along with its own central navigation system, the AUV is linked to a surface control station and through dedicated acoustic means, it can be regularly repositioned to achieve unsurpassed positioning accuracy.

Its smart Altitude Following Mode (AFM) allows the vehicle to keep gathering high-quality data even on rough seabed bottoms.

The A18D is fitted as standard with a Side Scan Sonar (SAS in option), Multi-beam Echo Sounder, Sub-bottom Profiler, and Physical and Acoustic sensors.

ECA Group offers the A18D vehicle with a sensor suite based on the best products available on the market. This suite can be configured according to a customers' specific requirements.

The vehicle design provides the AUV with a high-level of reliability. Like a ROV, the A18D AUV has a modular design composed of several removable parts with quick access to electronic modules, which is a significant asset for day-to-day operations and maintenance as well as for repairs onboard a mothership during operations.

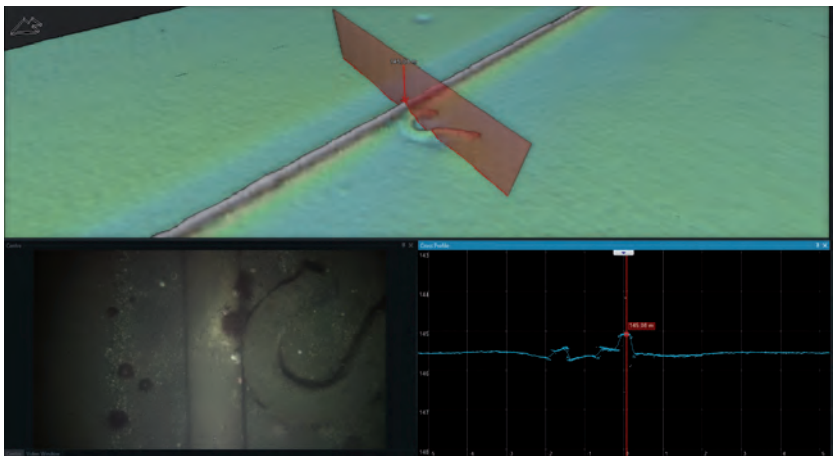
In addition to the LARS, the A18D is equipped with a patented underwater catching system securing the AUV recovery in the harshest conditions. This unique solution enables the operator to recover the AUV in safer conditions before surfacing, reducing the safety risk to personnel and the asset. ◀

The Benefits and Challenges of the Technological Revolution in the Pipeline Survey Industry

Advances in High-speed Underwater Remote Vehicles for **Subsea Pipeline Inspection**

The pipeline survey industry has undergone a technological revolution in the past couple of years, and the consequential benefits and challenges are only just beginning to be fully realized. Cost efficiency of subsea operations has become been one of the key focus areas of the offshore energy industry in recent years. This focus, combined with increased growth in the amount of subsea infrastructure now in-situ on the seafloor, has seen a rising need for innovative approaches to subsea asset inspection. These solutions need to be cost-efficient, maintain data quality, and be able to provide a platform that supports future technologies.

Fast remotely operated vehicles (ROVs) and the use of spatially referenced high-resolution video and still imagery are at the heart of the transition from old methods (towed sidescan/traditional ROV GVI) to future requirements. While cost efficiency has been the key driver, reduced vessel days also limit health, safety and environment (HSE) exposure and carbon footprint, both of which are high focus areas for the operators. Fast ROV survey is a solution that meets the demands for cost-saving and at the same time provides a platform for current and future digital technologies. Fast ROVs have significantly improved survey acquisition speed, which in turn has reduced offshore acquisition time by nearly half. There have also been technological advances, such as UHD still cameras and lasers, which have revolutionized the data that can be collected for pipeline surveys. These technologies have in turn given us access to new data, such as level of detail (LoD) mesh, orthorectified mosaics and high-density 3D point cloud models, for example. This has supported the development of FDI surveys which are starting to revolutionize how pipeline integrity can be managed, pushing back the boundaries of automatic image classification, georeferencing multibeam echosounder (MBES) processing and automatic eventing.



▲ *Figure 1: Synchronized DTM, UHD still image and cross profile.*

Past, present and future

Traditional methods of pipeline inspection used to include acoustic survey, performed with sidescan sonar (SSS) mounted on a towed platform such as an ROTV followed by ROV spot dives at locations of interest. Another method was ROV general visual inspection (GVI) which utilized video cameras, MBES and, commonly, pipetracker and contact CP. Today, modern methodologies such as fast general visual inspection (FGVI) and – most recently – fast digital imaging (FDI) have replaced the traditional pipeline surveys in many cases. FGVI

▲ *Figure 2: Fast ROV.*

is similar to GVI but performed at increased speeds, made possible by the latest technology i.e. HD cameras, improved MBES and fast ROVs. FDI surveys are the latest methodology employed to inspect pipelines, using UHD cameras, laser and fast ROVs to provide photogrammetric deliverables, as well as full MBE coverage and field gradient CP – all performed at comparable speeds to historical acoustic surveys.

DeepOcean performed the first FDI survey in 2017 and since then the introduction of fast ROVs has substantially increased the average speed of pipeline inspection. In 2018, FGVI was performed at an average speed of 4km/h, almost double the speed of FGVI performed with work-class ROVs (WROVs) and four times the speed of traditional GVI. The average speed of FDI survey was even higher, at an average of 5km/h in 2018.

A new breed of ROV

A fast ROV can transition between multiple survey methodologies with only minor adjustments to sensor configuration, making it a one-vehicle solution. This transition can be as simple as lowering the boom camera arms and reducing altitude to change between FDI mode and FGVI or, if pipetracker is a requirement, this is a simple recovery, bolt on, plug and play operation. With combined SSS and sub-bottom profiler (SBP) mounted, a fast ROV can seamlessly switch from pipeline inspection mode, be it FDI or FGVI, into acoustic route/grid survey mode.

Fast ROVs utilize the latest in automatic station keeping to provide a platform with advanced stability for all forms of survey. A true hybrid, the fast ROV (given the right platform to operate from) can perform surveys with the speed of an autonomous underwater vehicle (AUV) but with the added functionality that having a human crew provides, such as CP contact readings or impromptu target investigations. With the current sophistication of autonomous programming, human pilots still provide the safest option for operations around sensitive subsea assets.

A case for change

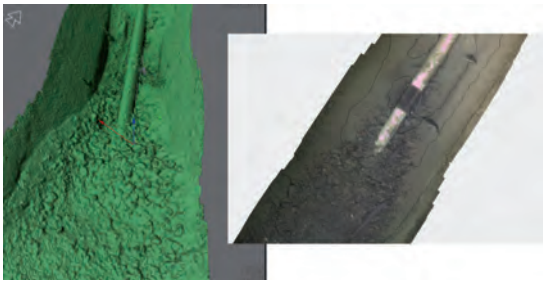
Historical acoustic survey campaigns, followed by a separate campaign with ROV spot dives, were time-consuming with limited results. It was common to dive on a location and find nothing of interest due to misinterpretation of SSS data. With FDI, if an area of interest is identified online then the ROV can immediately investigate. The data provided by acoustic campaigns gave a very limited overview of the pipeline status as SSS data is very open to interpretation, whereas FDI provides unambiguous results so quick decisions can be made on mitigating actions.

New challenges

New survey techniques bring new challenges to the industry. With fast ROVs, data can be acquired at a rate and quantity never before experienced, but processing and reporting have yet to fully catch up. New deliverables have proven challenging to handle, process and report in a cost-efficient timeframe and, even then, operators must find a way to utilize the data in their pipeline integrity management systems in a meaningful way.

New data requires new processing and reporting routines which in turn require trial and, inevitably, error – but as these latest deliverables become operators' standard requirements, service providers and software developers are becoming ever more adept at producing them. Soon, survey processing software should be capable of producing photogrammetric deliverables at a 1:1 processing speed, whereas before service providers relied on bespoke software. Production of the new deliverables through

▲ *Figure 3: Video still at 1.5m/s.*



▲ *Figure 4: Image-derived high-density 3D point cloud and stitched image mosaic.*

common software will also solve the problem of standardization, something which has been a recurring issue for service providers as operators struggle to define their requirements.

Whilst processing and reporting will eventually catch up with acquisition speeds and increased data size, it remains important to decide how much data is too much. For example, do operators really need LoD mesh, orthorectified mosaics or high-density 3D point cloud models for the entirety of a 200km pipeline, or is it sufficient to provide these datasets for gross defects and critical anomalies? Data accessibility is another challenge. As deliverable production improves to match acquisition speeds, the benefit will eventually be lost if the connection offshore is insufficient to transfer the data where it is needed onshore. Nevertheless, reduced processing and reporting onshore will always be welcomed by service providers and operators alike.

Innovative technology brings with it new expectations. One of the first and most critical tasks the industry faced was aligning the expectations and realities of this fresh technology. Cleverly marketed sample data can cause integrity engineers' imaginations to run wild, and whilst high-density 3D point cloud models and LoD meshes give a more detailed insight into the status of a pipeline than ever before, there are still limits to the current capabilities. However, advances in virtual and augmented reality may soon see the data's full potential realized.

The road to digitization

The development of fast ROV technology and associated sensors has provided a platform for innovation in both ROV technology and the sensors it carries. This has resulted in high-speed subsea data acquisition ROVs, and an adaptable platform for legacy sensors (MBES, SSS, HD cameras, pipetracker) and new sensors (UHD still cameras, lasers, Ultra HD video cameras).

Faster acquisition leads to fewer vessels days, which leads to reduced cost. Historically, acquisition speed and processing/time have been linked; a reduced acquisition time coupled with high-quality data and new types of data has created a real challenge in terms of keeping up with data deliverables demands. Further to this, the introduction and market interest in new deliverables – orthorectified mosaics, LoD mesh and high-density 3D point cloud models – means that both contractor and the client have to find new ways to work together and align the production workflow and the client front-end workflows. This problem is twofold, comprising data volume and standardization of data formats.

This has created a growing demand for the industry to find new ways to re-invent how we structure the delivery and reporting workflow – a grass-roots approach to data delivery is required. This calls for collaboration between industry stakeholders. Focus areas include:

- Controlling data deliverables through standard formats
- Developing standard workflow compliance between contractor and client
- Controlling data size and quality – create a 'fit for purpose' framework
- Creating sector-wide, cloud-based processing and delivery platforms that are futureproof and ready for the next phase of automation and artificial intelligence
- Sensor integration – as we move towards a USV and ASV offshore model, sensor integration and power efficiency will become increasingly important.

Fast ROVs have helped us moved forward; they have a provided an innovation platform. There is a global evolution in how all industries are handling data, the internet, the carbon footprint and artificial intelligence (AI), and these developments are creating a huge paradigm shift. This is especially relevant to the offshore industry because the cost model has been turned upside down; technology and the cost pressures are following six-month cycles rather than five-year cycles. This means we not only need to automate and standardize, but we also need to create dynamic solutions that allow for quick change. Cloud computing, AI and remote/onshoring opportunities are at the heart of these changes.

Conclusion

Rapid technological development is driving a new wave of innovation in the survey industry, making it unrecognizable from even a couple of years ago – but radical technology requires radical new thinking to achieve its full potential. The industry is still in a transitional period between the old and the new, with fast ROVs bridging the gap, eventually to be augmented by autonomous vehicles, automatic processing and reporting routines on the road to digitization. There will be growing pains as the industry evolves, and we all need to be willing to embrace the change. ◀

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Further Reading
https://www.youtube.com/watch?v=1ndeC1Ky90M

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