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APRIL 2016 | VOLUME 20 NUMBER 3

Hydro INTERNATIONAL

Hydro INTERNATIONAL 20th ANNIVERSARY

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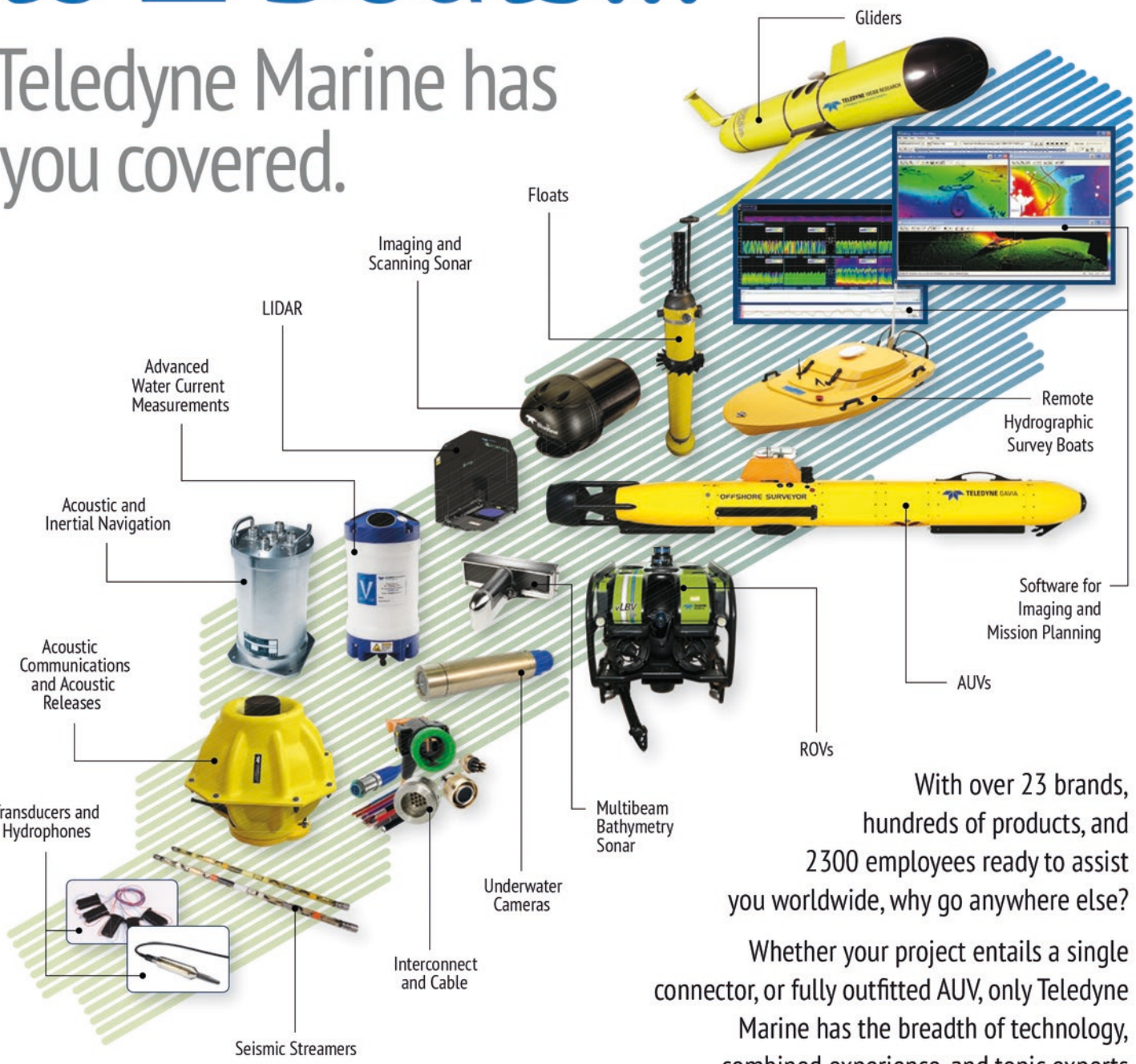

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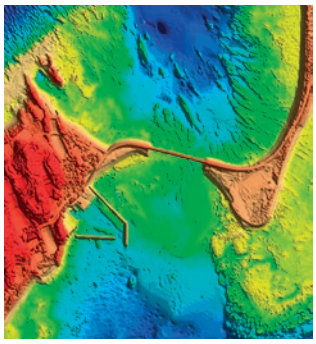

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Survey lines for Australian's RV Investigator *displayed on a screen on the bridge. Image courtesy: CSIRO, Australia.*

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Hydro International is an independent international magazine published 8 times a year by Geomares Publishing. 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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Diversified and **Strong**

Returning from Oceanology International 2016 after a hectic week at Excel, I took some time to reflect on all the conversations I had in London with many of our readers and business relations over the course of the show. It left me with mixed feelings. It has been a rough sea for many of the companies in our business. The sudden dip to a longtime record low oil price in November 2014 resulted in a difficult business year 2015 for most of them. Oil & gas companies have suddenly pushed back lots of projects, not getting back the profits they had expected after heavy investments in the years before. Major cutbacks and lay-offs being the logical answer to that. The effect on suppliers in the chain are just as immense and the number of survey jobs also decreased. 2015 has been, for many of the companies in the hydrographic business, one of the worst of the last decades. Because it's not just the oil price, remember… tensions on the stage of world politics are making international business unstable, sometimes even impossible with economic boycotts in place and economic crises putting enormous pressure on prices. And it doesn't look like the oil business will gain ground again any time soon because the driving forces have changed for good.
So much for the bad news. On to the good news. As always, a disruptive period like the one we have had since the autumn of 2014 serves as a wake-up call as well; after the shock comes adaptation, anticipation and then, hopefully, innovation. I sensed a lot of anticipation during my talks in London. Shifting business focus (or dependence) from the oil and gas industry to offshore renewables is of course one of the most seen in hydrography. Renewables, and then mainly offshore wind parks, are on the agenda of most governments of coastal states in Europe (however, less the case in the United States though…). Other renewable sources of energy are in a somewhat earlier stage and having less impact on hydrography, but early adapters are certainly looking into tidal energy and even deep-sea exploration for alternative ways of energy like hydrothermal vents. Reinventing products – smaller, cheaper, and new production methods – faster, smarter and cheaper are another way to be better prepared for new markets. In other words, adjusting your business model to new times. I saw quite a few companies on the show floor taking that road.
It is never easy to adapt after a shock has hit you. Anticipating and innovating is even harder. But looking at the balance of the mixed feelings, I think, looking back at Oceanology International 2016, that optimism and resilience set the tone. And this is the good news! Hydrography will show a different, but more diversified and stronger face in the future.

Durk Haarsma durk.haarsma@geomares.nl

Considerations for **Harbour Access Surveying**

Most continents have long histories of utilising their waterways to facilitate trade but, with a few notable exceptions, Africa has not yet taken full advantage of possible riverine trade systems.

▲ *An example of the type of survey vessel used in the survey.*

A riverine outlet to the sea from a landlocked state could provide direct access to the world markets and it could establish new inter-modal transport networks that will combine water, rail and road transport systems, which will significantly reduce the cost of imports and exports from and to these countries and make them more competitive on the domestic, regional and global markets. In addition, it could promote sustainable growth of these States through the development of an integrated system of physical and social infrastructures, eco-tourism, energy and mining and a new enabling environment for local and foreign investors in these countries.

Part X of the United Nations Convention on the Law of the Sea (1982) (UNCLOS) details the responsibilities of the States concerned and their rights enshrined in this Convention. Pre-Feasibility Studies would have to be conducted and the following issues would have to be considered as vital in any agreements made to establish a waterway. They include

1) The final position and extent of the proposed corridor
2) How the costs of the system would be borne
3) How the corridor would be maintained
4) What priorities would be established for its use, what regulations would be necessary. How the responsibility for facilities such as docks, locks, lights, charts, communications, traffic-control, rescue services, surveying updates of the river bed and environmental protection would be assumed, at what cost and under whose authority
5) The provision of services to, and control of, the international traders at the seaward end of the corridor
6) The adherence to the international standards of the IMO and to the technical standards and required services as stipulated by IALA, the IHO and any other relevant standards. A Waterway Authority should be established, with the necessary delegation for decision making and have at least the following responsibilities:
   a) the provision of accurate and up-to-date information on the waterway
   b) ensuring that up-to-date charts, sailing directions and other vital information on the waterway are available
   c) the introduction and policing of traffic rules
   d) the promulgation of the technical and safety requirements for the vessels
   e) the protection of the environment
   f) the development of other facilities on the rivers including cross-channel ferries, bridges, coordination with other means of transport that could be associated with the waterway traffic and structures in the vicinity that could affect the nature of the waterway
   g) seaworthiness of the vessels
   h) the monitoring of the standard of the crews
   i) control of dangerous goods
   j) aids to navigation and dredging
   k) vessel control centres at critical points
   l) the assessment of National legislation that may be affected
   m) the dues that would be payable

◀ *Rear admiral Neil Guy (retd).*

While these tasks may appear onerous, the ultimate benefits of a well surveyed and controlled waterway would far supersede these considerations to the benefit of all concerned.

African Order for SIG France

Christian Assouke, from Locatech Services in Cameroon, is placing the order for a new SIG Pulse S1 sparker/boomer system. Locatech is working off the coasts of Western Africa, for platform positioning, pipe routes, and is constantly investing in new equipment to be in a good position to reply to the tenders without the hassle of getting equipment coming over and delays in transit and customs.

▸ ***http://bit.ly/1S3x6Xu***

Christian Assouke sealing the deal.

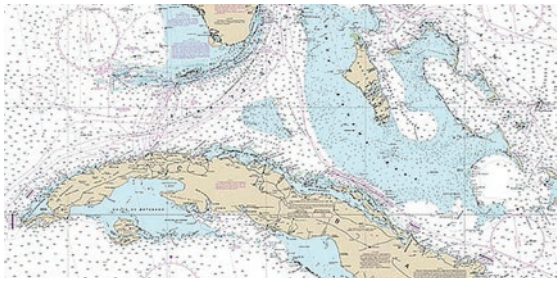
Van Oord Selects Valeport SVPs

Van Oord Dredging and Marine Contractors, a leading contractor for dredging, marine engineering and offshore energy projects has selected Valeport's SWiFT SVP for its various survey activities. The compact unit features high accuracy sound velocity, pressure, temperature, salinity and density measurement, plus integral GPS and re-chargeable battery. Suited for coastal, harbour and inland hydrographic survey use, Van Oord is to deploy the SWiFT SVP as part of their operations worldwide.

▸ ***http://bit.ly/1MICfO3***

The Valeport SWiFT SVP.

US, Cuba to Improve Maritime Navigation Safety



NOAA Chart Strait of Florida.

Ambassador Jeffrey DeLaurentis, the Chief of Mission at the US Embassy in Havana, and Col. Candido Alfredo Regalado Gomez, Chief of Cuba's National Office of Hydrography and Geodesy (ONHG), have signed a Memorandum of Understanding to improve maritime navigation safety and related areas of mutual interest to protect lives and property at sea.

▸ ***http://bit.ly/1MIBYL4***

NaSCOM Cable Route Survey in Maldives for Gardline

MV Duke *is mobilised for the cable route survey.*

Gardline (UK) have been awarded a survey contract by Huawei Submarine Networks for the Nationwide Submarine Cable Project initiated by Ooredoo Maldives. The project consists of surveying 5 interisland cables with 6 landing sites spanning the entire length of the country. The scope of work includes multibeam bathymetry from 3m to 2,800m WD. Topographic work and diver swim surveys are also required at all landing sites. Gardline mobilised its multipurpose survey vessel MV *Duke* for this project. The project covers an area of 1,200km with the offshore survey work scheduled to be completed within 12 days. The landfall surveys will take approximately 45 days to complete.

▸ ***http://bit.ly/1VMmUIz***

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Most shared during the last month from www.hydro-international.com

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Landsat Satellite Spots Shipwrecks - http://bit.ly/1U4Mb1c
German Shipwreck Discovered Using Mini-ROV - http://bit.ly/1U4MYz2
Underwater Electromagnetic Propagation - http://bit.ly/1PxDKt2
Oceanology International Gives Update on Ocean Technology - http://bit.ly/1U4NPQg

Project Investigates the Global Warming Hiatus

To investigate why the global warming trend varies from decade to decade, scientists from the National Oceanography Centre (NOC, UK) will work alongside those from nine other research organisations as part of a major new multidisciplinary research project. Over the last decade a slowdown, or hiatus, has been observed in the global warming of the Earth's surface, although it is important to note that heat is still accumulating in other parts of the climate system, such as the deep ocean.

▸ ***http://bit.ly/1U4LYef***

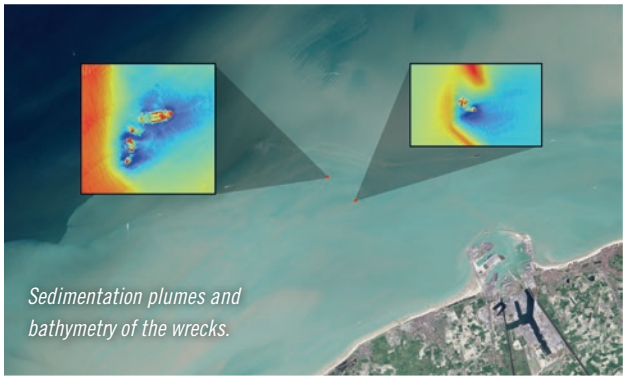
Second HyDrone for SCCS

At the 36th Oceanology International held in the London Excel, Ohmex presented the new HyDrone ASV with its integrated mission control box. The same ASV (Autonomous Surface Vessel) control box was demonstrated live at the show with the larger Echoboat designed for oceanographic applications. The demonstration held in the adjacent London Docklands showed the complete sequence of mission planning software, vessel launch/deployment, hydrographic data acquisition, live tracking and finally vessel recovery with data retrieval.

▸ ***http://bit.ly/1U4Pc1p***

Sealing the deal in the Ohmex stand.

Landsat Satellite Spots Shipwrecks



Sedimentation plumes and bathymetry of the wrecks.

An estimated three million shipwrecks are scattered across the planet's oceans. Most maritime mishaps occur close to shore where hazards to navigation — such as rocks, reefs, other submerged objects and vessel congestion — are abundant. It is desirable to know where they are located for many practical reasons. Streams around the wrecks create plumes that can be seen on satellite imagery in depths up to 15m, making wrecks easier to find as a recent test in Belgium showed.

▸ ***http://bit.ly/1U4Mb1c***

German Wreck Discovered Using Mini ROV

On 22 June 2015, after a six-year-long search for the sunken German warship *Rio de Janeiro*, the companies Agder-Tech, Adykk and Seabed Services found the vessel sitting off the coast of Lillesand, Norway. The three firms have teamed up and set out every spring for the past six years to find the warship that sank on 8 April 1940. This historically significant vessel, which was ultimately found using a Deep Trekker mini ROV, was the only German ship to be shot down by the Polish during World War II.

▸ ***http://bit.ly/1U4MYz2***

Lantern with ID number of the Rio de Janeiro *wreck.*

Combined Towed Sonar System

EdgeTech has announced the release of a new towed sonar system providing tri-frequency side-scan sonar, enhanced sub-bottom profiling and MPES bathymetry, the 2300 system. The unit combines EdgeTech's line of side-scan sonar, sub-bottom profilers and MPES bathymetry into one fully integrated system. The 2300 system has been developed for deepwater combined sonar operations and provides many enhancements to traditional systems.

▸ ***http://bit.ly/1S3wXU1***

The EdgeTech 2300 Combined System.

Advancing Deep-sea Operations for Unmanned Vehicles

Testing the deep-sea battery pack in a pressure tank.

In October 2015, a consortium of UK companies and academic partners, led by Steatite, began an R&D project to develop a battery pack that will be pressure tolerant up to depths of 6,000 metres. The first phase of the project, recently completed at NOC in Southampton, involved repeatedly testing Lithium-Sulfur cells at pressures and temperatures equivalent to undersea depths of 6,000m. The test results have confirmed that the cell performance is unaffected by being exposed to these extreme conditions, with consistent delivery of energy.

▸ ***http://bit.ly/1U4OTnr***

Linking Satellites With Robot-subs

The National Oceanography Centre (NOC) is to form part of the Centres of Excellence in Satellite applications. As part of this new centre the NOC will develop the technologies to help robot-subs use live satellite data to inform their route through the ocean, not unlike drivers using live traffic updates. These new centres are co-funded by the UK Space Agency and were set up in response to growing interest in how satellite data and technologies are helping businesses generate new ideas and solutions to grow.

▸ ***http://bit.ly/1MICc4P***

Sentinel-3A Tracks Sea-level Change

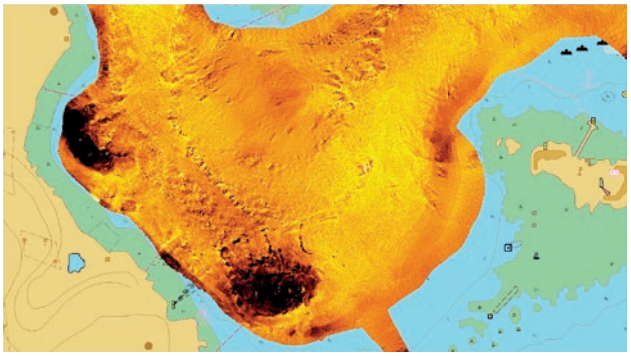
Following the first impressive images from Sentinel-3A, the latest Copernicus satellite has now demonstrated how its altimeter can track sea level change. Just after the radar altimeter instrument was turned on, it traced the height of the sea surface over a stretch of the North Atlantic, some of the most dynamic ocean waters in the world. Showing features relating to the Gulf Stream, the track compares very well with the background map of sea-surface height.

▸ ***http://bit.ly/1MIDddd***

HIPS and SIPS 9.1 Presented

CARIS has released HIPS and SIPS 9.1. This new version includes an alternative method of processing backscatter data which produces high-quality mosaics and is based on industry-recognised algorithms and techniques. The SIPS Backscatter engine is a single additional step at the end of a traditional multibeam bathymetry workflow.

▸ ***http://bit.ly/1S3xnK5***



Bathymetry of Plymouth harbour as seen with the new HIPS and SIPS version.

One Million Nautical Miles at Sea for Wave Gliders

Liquid Robotics' fleets of Wave Gliders have reached one million nautical miles at sea, which the company describes as a milestone for the unmanned surface vehicle (USV) industry. The Wave Glider has completed missions from the Arctic to the Southern Ocean, operated through 17 hurricanes/typhoons and achieved a Guinness World Record for the 'longest journey by an autonomous, unmanned surface vehicle on the planet'. One million nautical miles is the equivalent to 1.29 times a round trip to the moon (at the moon's furthest point) or approximately 46 times around the world.

▸ ***http://bit.ly/1MICuZG***

Wave Glider being deployed. Image courtesy: Liquid Robotics.

iXBlue Launches ROVINS NANO

ROVINS NANO Unveiled on the eve of OI 2016.

On the evening before the opening of OI 2016, iXBlue literally unveiled the ROVINS NANO. This compact unit provides highly accurate positioning at all depths, including for middle water station keeping. ROVINS NANO has been designed for ROV pilots performing maintenance and construction operations. It offers the unbeatable stability and accuracy of the inertial position, outputting true north, roll, pitch and rotation rates. iXBlue also updated the audience on developments within the company.

▸ ***http://bit.ly/1MICrNx***

'Full Picture' for Kongsberg

The MGC R3 gyrocompass is one of the newly launched products.

Integrated Solutions for Research Vessels were in focus on the Kongsberg Maritime stand during Oceanology International 2016. Kongsberg's Integrated Solutions for Research Vessels cover all key technology areas on board including navigation and automation, in addition to hydroacoustic and position reference systems. For research and surveying applications, Kongsberg integrates the widest range of multibeam and single beam echo sounders, sonar, Marine Robotics systems (i.e. AUV) and position reference systems available from a single supplier.

▸ ***http://bit.ly/1MICZ63***

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Echologger ECS400 (Connector type)	http://bit.ly/1SiUQto
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Cadden GEOD BALI	http://bit.ly/1T7fVcB
CT Systems GeoSounder	http://bit.ly/1XPfjHJ
Valeport Midas Surveyor	http://bit.ly/1pJz4pC

Industry First for Ashtead Technology

Aberdeen-based Ashtead Technology has become the first subsea services company to be accredited by the United Kingdom Accreditation Service (UKAS) for its calibration laboratory. This official seal of approval from UKAS demonstrates that Ashtead delivers professional and technically competent calibration of survey, positioning and oceanographic sensors crucial to their customers' subsea operations.

▸ ***http://bit.ly/1MICkBy***

Applied Acoustic Engineering Creates Group

The directors of Applied Acoustic Engineering Ltd (AAE) have announced important changes to the structure and leadership of the company, implemented to strengthen its place in the subsea industry and to provide the facility to offer a wider range of products and services across a variety of other industries. The most significant development sees the establishment of a group of companies, operating under the guidance of AAE Technologies Ltd (AAET). With AAET at the helm, the trading group is comprised of three separate companies: Applied Acoustic Engineering Ltd, Ensign Subsea Systems Ltd, and Modulus Technology Ltd.

▸ ***http://bit.ly/1MlD8Gy***

Successful Field Trials for Seiche and MOST

A collaborative venture between Seiche and MOST (Autonomous Vessels) is combining two leading UK technologies, creating the potential to transform passive acoustic monitoring of sound in the sea. The first trials have been successfully conducted on Roadford Lake, North Devon, UK, in which MOST (AV)'s 3.5m AutoNaut unmanned surface vessel (USV) deployed Seiche's wireless passive acoustic monitoring (WPAM) system.

▸ ***http://bit.ly/1MlDjBE***

The Autonaut in operation.

US Navy Orders Next-generation Fathometers

Knudsen Systems Inc. (KSI) has received delivery orders under its multi-year contract with the Naval Undersea Warfare Center (NUWC), Division Keyport for supply of 320N COTS fathometers and peripheral equipment. Deliverables include 12 320N systems, 12 sonar simulators and 36 remote displays. The orders come on the heels of a recent sale of 10 systems to the US Coast Guard, as well as delivery of a unit to the US Foreign Military Sales Office.

▸ ***http://bit.ly/1MlDixH***

N-Sea Expands into French Offshore Wind Industry

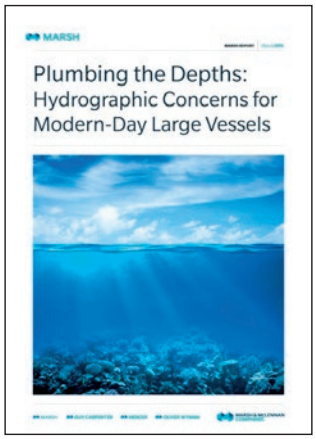
N-Sea and CERES signed a contract for cooperation, witnessed by the King and the Queen of the Netherlands.

Subsea IMR provider, N-Sea, has signed a letter of intent with CERES Recherches & Expertise Sous-Marine and TechSub Industrie Environement, to provide subsea survey, installation and remediation services to the French offshore wind industry. The partnership will also include the provision of unexploded ordnance (UXO) detection, identification and removal services and will allow all three companies to utilise their international experience, vessels and specialised equipment.

▸ ***http://bit.ly/1MlCcC1***

Report Highlights Poor State of Surveying and Charting Worldwide

Marsh, a global leader in marine insurance broking and risk management, has issued an industry information report that highlights the inherent risks involved in operating ever larger ships in poorly surveyed waters - *Hydrographic Concerns for Modern-Day Large Vessels*. The Marsh Report quotes IHO President Robert Ward, UK National Hydrographer Rear Admiral Tim Lowe, among others. The report, referring to IHO publication C-55 - *Status of Surveying and Charting Worldwide* as one of its references, notes that many of the world's charts continue to rely on older or inadequate data that may not be appropriate for the operation of ever-larger, modern vessels.



The Marsh report expresses concerns about the state of charting in the world for larger vessels.

▸ ***http://bit.ly/1MlBTXQ***

Oceanology International - Looking Back on the 2016 Edition

The London event venue ExCeL was once again the host of the biennial Oceanology International, attracting the marine science community from 15-17 March 2016. The organisers, Reed Exhibitions, welcomed 7,836 unique attendees from 79 countries, with many revisiting on consecutive days to provide an overall show attendance of 14,161. The exhibition counted over 8,500m^2 occupied by 520 exhibiting companies from 33 countries.

Figure 1: A captive audience during Catch the Next Wave. Image courtesy: Aidan Synnott.

Traditionally, the trade show is the place where contacts are made, relations built and of course, new products announced and launched. Major suppliers such Teledyne Maritime group, Kongsberg, Hydroid, EdgeTech, showcased their innovations and informed customers and potential clients during training sessions.

Figure 2: There was attention to detail on the stands. Image courtesy: Aidan Synnott.

On the Water

Another important item on the programme was the on-water demos. A total of 11 vessels were moored at the quay alongside ExCeL, having a busy time with 1,107 people going aboard for one of the 93 trips in the five vessels giving demonstrations in cooperation with, for example, R2Sonic, Teledyne RESON, Kongsberg and Norbit; and 847 people visiting the moored vessels, exhibiting offshore surveying equipment that is not normally that easily available to examine in its operational environment. A total of 142 people attended the dockside demos.

http://bit.ly/1RmPAT8

Marine Spatial Planning in North Sea Region

Ocean businesses gathered online to discuss the challenges and perspectives of marine spatial planning (MSP) in the North Sea region at a World Ocean Council (WOC) and Scottish Association for Marine Science (SAMS) webinar on Monday 29 February 2016. Industry representatives were able to explain the approach to MSP in the North Sea and beyond and strengthen the network of ocean industry leaders in the region.

http://bit.ly/1U4Q5Hk

Paul Ridout Wins Business Person of the Year 2016 Award

The annual AMSI Council Business Person of the Year Award was presented on 14 March 2016 to Mr Paul Ridout, executive chairman of Ocean Scientific International Limited, by Mr Richard Burt, chairman of the AMSI Council of the Society of Maritime Industries. The presentation was made during a special award ceremony at the Catch the Next Wave conference.

http://bit.ly/1RmPQBN

Image courtesy: Aidan Synnott.

Paul Ridout receiving his award from Richard Burt.

NOAA's ENC Training Programme

The key objective of NOAA's ENC Training Programme was to educate Hydrographic Offices (HOs) on ENC workflow in the Office of Coast Survey's Marine Chart Division (MCD). The workflow included: acceptance of new sources, data compilation, validation and quality control, distribution and contracting. A nine-day training was held in Silver Spring, Maryland, USA, from 1 to 9 March 2016. The attendees were cartographers from the Hydrographic Department at the Survey of Israel (SOI).

The training began with a meeting between Limor Gur Arie, the head of the Hydrographic Department - SOI and the chief of the Marine Chart Division, John Nyberg to match expectations on the visit, emphasising that the focus of the training is to provide a comprehensive overview of ENC policy and production at NOAA. Lead instructor, Sean Legeer, added that the overall goal is to provide the participants with the ability to conduct quality management. ENC production can require years of experience and many HOs around the world use contractors in their workflow.

▸ ***http://bit.ly/1RwMooa***

▲ *Figure 1: The participants of the training programme.*

▲ *Figure 2: Training was provided on the job.*

Hydro International Interviews Capt Brian Connon, Director NGA Marine Safety Office

Much More Than a **Typical Hydrographic Office**

Since October 2015, Capt Brian D. Connon has assumed the role of Director of the National Geospatial-Intelligence Agency's Maritime Safety Office. The organisation is an important, although not always visible, link in the global maritime safety chain. Their work contributes to generic marine safety and due to the nature of the data collected and analysed, their role is especially for security, humanitarian assistance and disaster relief.
Hydro International interviewed Capt Brian Connon and lays out the role of hydrographic data and technologies in the NGA.

Can you briefly outline the work of the NGA?
The National Geospatial-Intelligence Agency (NGA) is the United States' primary source of geospatial intelligence (GEOINT) for the Department of Defence (DoD) and the US Intelligence Community (IC). GEOINT is the exploitation and analysis of imagery and geospatial information that describes, assesses and visually depicts physical features and geographically referenced activities on the Earth. As a DoD combat support agency and a member of the IC, the NGA provides GEOINT, in support of US national security and defence, as well as, humanitarian assistance and disaster relief situations.

What does this mean for hydrography or oceanography?

Basically, the NGA is an authoritative source for maritime data, products and services, including global maritime safety information and nautical publications and charts, both digital and paper. The geospatial information that the NGA provides has been defined as: information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the Earth and includes statistical data and information derived from, among other things, remote sensing, mapping, and surveying technologies; and mapping, charting, geodetic data, and related products. Therefore, when one thinks about the collection of data and the degree and diversity of information that is analysed and included in a nautical chart or publication, one can see how hydrography and oceanography play critical roles in the compilation of these products.

What are typical products of the NGA? Are they available for civic use?

Like most Hydrographic Offices, the NGA maintains a comprehensive database of maritime information. From this, we develop a portfolio of charts and publications, as well as other products and services, based on the requirements of our customer, in this case, the Department of Defence. We maintain worldwide coverage in both Standard Nautical Charts (SNC) and our electronic chart, the Digital Nautical Chart (DNC), which is similar to the Electronic Navigation Chart (ENC) in content, but very different in format. The DNC was chosen many years ago to serve the needs of DoD due to its Vector Product Format (VPF), which was already in use by our topographic counterparts. Regarding civil use, the majority of the NGA's SNC and DNC portfolio is limited to DoD use only, although we do have a small number of SNCs available for public sale in areas of the world where the NGA is recognised as the primary charting authority. Electronic access to databases and products is available. The site includes US Notice to Mariners and other selected publications in PDF format, a marine navigation calculator and corrections to the NGA, NOS and US Coast Guard hydrographic products.

What is the specific task of the Maritime Safety Office?

The Maritime Safety Office collects, evaluates and compiles worldwide marine navigation products and databases. This mission is anchored in statutory law under US Code Title 10 which states in part that the NGA shall improve means of navigating vessels of the Navy and the merchant marine by providing, under the authority of the Secretary of Defence, accurate and inexpensive nautical charts, sailing directions, books on navigation, and manuals for instruction for the use of all vessels of the United States and of navigators generally. Publications include the US Notice to Mariners, Sailing Directions, NGA List of Lights, US Coast Guard Light Lists, American Practical Navigator (Bowditch) and other navigation science publications. One of our most important tasks is our role as a NAVAREA Coordinator for the Worldwide Navigational Warning Service's NAVAREA IV and NAVAREA XII safety messages, an essential part of the Global Maritime Distress and Safety System. We maintain a 24/7 Maritime Safety Watch that monitors events not only within our assigned NAVAREAs from other national authorities for promulgation to both civilian and military mariners but also worldwide from all NAVAREA Coordinators to inform our US military customers of emergent impacts to safety of navigation around the globe.
The Maritime Safety Office is an active participant and leader in international forums, including the subcommittees and working groups of IHO's Inter-Regional Coordination Committee (including Regional Hydrographic Commissions) and Hydrographic Services and Standards Committee, as well as, many other organisations related to maritime safety, hydrography, oceanography, and bathymetry.

The NGA shall improve means of navigating vessels of the Navy and the merchant marine

How does the NGA's mission support the NOAA objectives?

The NGA, NOAA, the US Navy, and other US government agencies are committed to improvements in hydrography, nautical charting and maritime safety. It can be confusing to see different US agencies at meetings, but we all work very hard to provide a common US perspective. We meet regularly to discuss strategic objectives, opportunities to burden share, and the future of hydrography in the US and abroad. In some areas of the world, like the Arctic, we have to work very closely to ensure both national and defence objectives are addressed. At the technical level, our personnel are in frequent contact to exchange data, processes and ideas.

Does the NGA conduct its own hydrographic surveys? If so, how is it organised?

The NGA does not conduct organic hydrographic surveys. We rely on our partnerships to provide the data required to maintain our portfolio. Our primary sources of hydrographic survey data are the Naval Oceanographic Office and the Fleet Survey Team, who conduct hydrographic surveys worldwide in support of DoD. We do occasionally contract surveys in areas of highest priority, but that is not common.

Does the NGA make use of datasets from other sources? Is there a quality requirement?

The remainder of our source data comes from other US government agencies, such as NOAA

and US Army Corp of Engineers, agreements with international Hydrographic Offices, publicly available sources, and satellite imagery. Before any source data is used in our products, it is evaluated very carefully for quality and suitability for use. Today's challenge is to embrace new data sources, such as, Volunteer Geographic Information, satellite derived bathymetry and crowdsourced data, while ensuring sufficient quality for intended use. In the end, there is a subjective determination of risk that must be made before adding these data, a determination as to how to portray this type of data, and a method to communicate the risk to the customer in the final product must be developed.

How do you judge technology like satellite derived bathymetry or at the other end of the scale – marine autonomous systems?

We are very involved in the evaluation of remotely sensed data for use in hydrographic products, including satellite derived bathymetry (SDB). SDB is a fascinating technology that the NGA is very excited about for use in our production process. The ability to remotely assess areas without utilising expensive ship or aircraft survey time is certainly a huge benefit. There are drawbacks, of course, to using this technology. Not every area of the world is conducive to SDB collection, not everyone has access to the satellite data and algorithms to make it work, and, finally, SDB may not be suitable for updating certain products.

Autonomous underwater vehicles (AUV) and autonomous surface vehicles (ASV) are certainly coming into their own and are becoming much more common in the inventory of Hydrographic Offices. The two biggest challenges for these systems, in my opinion, are battery life and positioning. In the early days of 'unmanned systems', a ship was dedicated to launching, monitoring, and retrieving AUVs with very short operational cycles. Improvements to battery life have greatly extended mission length, which necessitates improved navigation and positioning systems. Integrated GPS and inertial navigation systems (INS) are meeting the challenge to maintain IHO accuracies throughout much longer submerged missions. Now, multiple vehicles can be launched without requiring a ship to remain in close proximity, allowing for substantial gains in survey efficiency. I am looking forward to small, unmanned aerial vehicles outfitted with imagers and a Lidar system to provide fast surveys along the land-sea interface.

I imagine future survey vessels will carry several of these autonomous systems, but will still require highly trained hydrographers to plan the mission, operate the vehicles, and process the data.

The two biggest challenges for these systems, in my opinion, are battery life and positioning

Is there a change in the NGA's role in time? What are typical items these days?

Over the years, the largest change for the NGA has been the transition from paper to electronic charting and now the advent of a data centric approach. Since 2004, NGA has maintained a worldwide vector product and we are very excited to see global vector coverage in the commercial sector becoming a reality. Our goal now is to transition away from DNC to ENC, in concert with our customer base, which will greatly improve our ability to collaborate with other Hydrographic Offices, accelerate chart production, and improve overall safety of navigation for our customers. There is so much more that can be provided for maritime safety, naval operations, and commercial shipping in the form of Marine Information Overlays (MIO) and Additional Military Layers (AML). Providing weather and ocean forecasts, Notice to Mariners, routing information, etc. in an efficient data package to a ship's ECDIS is a powerful capability that will greatly enhance safety at sea. In addition, the presentation of electronic charts in a three dimensional context, the inclusion of time varying data, and the incorporation of real-time AIS data from navigational aids and even portrayal of virtual aids to navigation into a consolidated display for the mariner offer exciting opportunities in how traditional navigational products of today will transform in the future.

We are also focusing heavily on the Maritime Spatial Data Infrastructure (MSDI) initiative which will allow all of the hydrographic data and information held at the NGA to be used for purposes other than charting. MSDI is critical for governance of activities like coastal zone management, fisheries, and pollution response, just to name a few.

How should (or can) hydrographic professionals work with the NGA?

The NGA is a willing partner and has agreements with many international and commercial partners. We are always looking for new production technology, additional data sources, and collaborators who share our commitment to improving navigation for the mariner and making maritime information easily accessible to those who need it.

In addition, the NGA is a great place to work! You are exposed to so much more than a typical Hydrographic Office due to our unique and global DoD mission. There are always opportunities to apply for positions as a nautical cartographer, marine analyst, bathymetrist, or data steward. ◀

More information

Electronic access to data and databases
http://msi.nga.mil/NGAPortal/MSI.portal

NGA Maritime Safety Office Vacancies
https://www.nga.mil/Careers/Pages/default.aspx

Capt **Brian D. Connon** assumed the role of director of the National Geospatial-Intelligence Agency's Maritime Safety Office. Prior to his arrival, he served as the superintendent of the US Naval Observatory. Previous duties include deputy Navigator of the Navy, deputy Oceanographer of the Navy, and commanding Officer of the Navy's Fleet Survey Team. A certified hydrographer, he holds a BSc in Geography from the University of South Carolina, an MSc in Oceanography and Meteorology from the Naval Postgraduate School in Monterey, CA, and an MSc in Hydrography from the University of Southern Mississippi.

3D Hydrodynamic Model Developed for Sustainable Water Abstraction

A **Flooded** Landscape **Revealed**

During the last week of a hydrographic survey of Lough Derg, Ireland's third largest lake, the remnants of a preserved flooded landscape were unveiled beneath the surface with each passing swath. In early 2015, Geomara was commissioned by the utility company, Irish Water, to undertake a bathymetry and side-scan sonar survey of Lough Derg as part of the planning and design process for the Water Supply Project, Eastern and Midlands Region. This project aims to find a new water source to supply the future needs of the Midlands and Greater Dublin Area.

▲ *Location of survey, Lough Derg and Parteen Basin.*

Over the course of a typically wet and windy Irish summer, 1687 linear kilometres were sailed. Lough Derg is located on the lower reaches of the River Shannon and covers an area of 115 km² (Figure 1). The survey area included the entirety of the lake along with the section of the River Shannon south of Killaloe Bridge known as the Parteen Basin, as far as Parteen Villa Weir. This was constructed in the 1920s forming part of the intake works for the Shannon Hydroelectric Power Station at Ardnacrusha, one of the largest civil and electrical engineering projects of its type worldwide at that time. Figure 2 shows Parteen Villa Weir with Parteen Basin to the north and the intake works to the headrace canal to the west.

Project Scope

The project brief was to produce a comprehensive bathymetric and side-scan dataset in order for the client to refine a 3D hydrodynamic model of the entire lake that they were developing. This model is now being utilised to assess the characteristics of a new sustainable water abstraction regime from the lake. The challenge was to efficiently acquire data which would meet the client requirements of IHO Special Publication No. 44 specification, in a body of water known locally as having large shallow bays and unforgiving submerged hazards. The only systematic hydrographic survey carried out of the lake prior to this was the Admiralty Survey of 1839 by Commander

▲ *Parteen Villa Weir and intake works.*

▲ *MV* Dolphin *with bow mounted 6205 sonar head.*

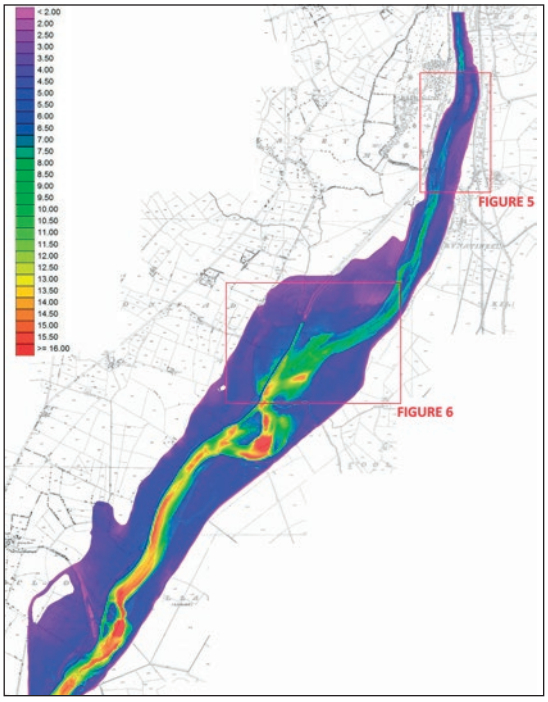
James Wolfe RN and Lieutenant RB Beechey RN published in 1843 as Admiralty Chart 5080 (since withdrawn). Estimated water depths ranged from 1 to 35m across the lake with an average of 7.5m. Much consideration was taken in choosing the right tools for this survey and with recent improvements and technological refinements of Phase Differencing Bathymetric Sonar (PDBS) systems; the EdgeTech 6205 appeared to provide a good fit for this environment.
The EdgeTech 6205 is a PDBS system providing co-registered dual frequency side-scan imagery that also utilises beamforming techniques analogous to traditional Multibeam Echo Sounders (MBES). This hybrid technology has come to be known as the Multi Phase Echo Sounder (MPES).

Features clearly revealed 86 years after they were first submerged

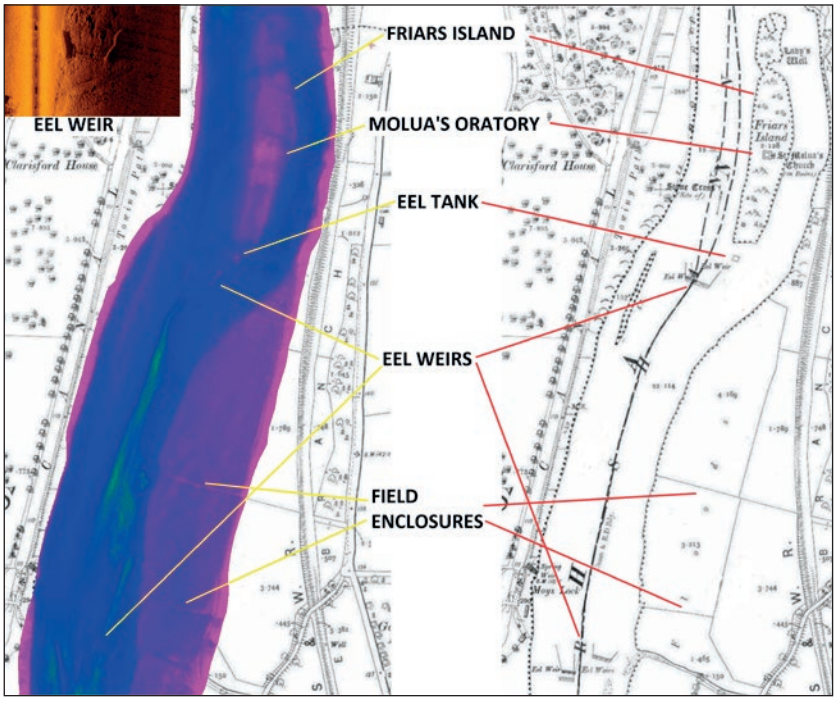
The 6205 considerably increased the efficiency of the survey campaign while achieving the level of accuracy required. This was done by providing wider swath bathymetric coverage at an average of eight times water depth, which increased productivity in the shallow water when compared to traditional MBES. It also increased the line spacing in the nearshore environment where navigation hazards were most prevalent. EdgeTech's Full Spectrum processing techniques allows for full coverage at nadir, minimising surface reflection and enhancing multipath suppression.

Equipment Set-up

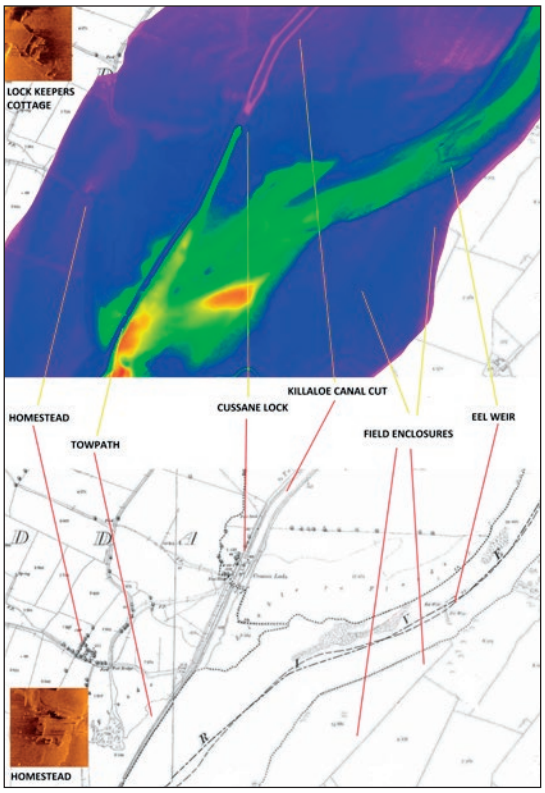
The Edgetech 6205 uses its own topside processing system and software (Discover), which was interfaced with a high performance desktop computer. Data was streamed to the processor in the sonar head where it was processed and combined into one data string before being corrected and logged in Hypack 2015 Hydrographic Survey Software.The processed bathymetric data was merged to create a grid model of the lakebed with the soundings reduced to the Irish Ordnance Datum at Malin.



▲ *Parteen Basin bathymetry at 50cm resolution overlaid on Ordnance Survey 1:2500 historic mapping.*



▲ *Detail of the bathymetric survey data around Friar's Island overlaid on historic ordnance survey mapping. Insert - detail of the eel weir from the co-registered side-scan mosaic.*



▲ *Detail of the bathymetric survey around the Killaloe Canal overlaid on the historic Ordnance Survey mapping. Inserts – detail from the Lock Keepers cottage and nearby homestead from the co-registered side-scan mosaic.*

Wider swath bathymetric coverage at an average of eight times water depth

The side-scan data was processed and mosaicked using SonarWiz.

The MV *Dolphin*, a 7.4m inshore survey vessel, was deployed for the duration of the project. The 6205 sonar head was pole mounted and rigidly fixed in position via a bespoke cantilevered bow mounting bracket and frame arrangement that also facilitated mounting of the Motion Reference Unit (MRU) and GPS position antenna. These were vertically aligned around one common reference point in order to minimise offset errors (Figure 3).

Vessel and equipment positioning was provided by a Trimble SPS461 GPS with heading and positioning antennas (Figure 3).The Trimble SPS was used in conjunction with a Trimble VRS Now network RTK correction to provide centimetre level accuracy. Heave, pitch and roll corrections were provided by a Teledyne TSS DMS 05 MRU. The MRU was fully aided with position and speed readings via an NMEA data string from the GPS.

Parteen and the Shannon Hydroelectric Power Scheme

The creation of the Parteen Basin waterbody was initiated on 22 July 1929 when construction of the Shannon Hydro Power Scheme was completed and the intake sluice gates were formally opened by W.T. Cosgrave, President of the Irish Free State. The water level at Parteen was raised at a rate of 80 – 100mm per day, raising the level of the River Shannon by 7.6m and permanently flooding an area of 3.4km².

A number of islands, farmsteads, roads, houses and drainage ditches were all inundated. The lake also submerged parts of the Killaloe Canal, including locks and ancillary buildings.

Between 1888 and 1913, the Ordnance Survey carried out a large survey of Ireland at 1:2500 scale. Extracts from this historical series, compiled prior to the construction of the Shannon Hydro Power Scheme are shown in Figure 4, overlaid by the recorded bathymetry of the Parteen Basin. The features revealed by the hydrographic survey correspond accurately with the historic record of the area.

Friar's Island and Eel Weirs

Friar's Island was a narrow strip of land located mid-channel, approximately 1km

downstream from Killaloe Bridge. It was an area of historical significance, upon which St. Molua the leper founded a monastic settlement in the 6th Century. The remains of a tiny oratory, (3.2m x 2m) and nave (6.5m x 3.9m), built in the 9th or 10th century was the final incarnation of the monastic foundation. Once it became clear that the rising waters associated with the Shannon Hydro Power Scheme would flood the island, an archaeological investigation was completed following which it was decided to carefully deconstruct the ruins of the early church and re-erect the structure on the grounds of St. Flannan's Cathedral in Killaloe, where they remain to this day. The raised stone and clay platform which formed the foundation for the early church can clearly be seen on the bathymetry and side-scan imagery.

A thriving eel fishery was operated on the River Shannon in the 19th and early 20th century. A series of eel weirs and an eel tank in which the captured eels were stored were located to the south of Friar's Island as recorded on the historic Ordnance Survey Map. Eel weir structures were generally built from stone and were designed to 'funnel' the eels towards a series of nets across part of the river channel. These stone structures remain on the river bed.

All of these features were successfully imaged by both the side-scan sonar and bathymetric records (Figure 5). Eel fishing was a lucrative business and contemporaneous records show that significant financial compensation was paid to a Mr. Anthony Mackey in 1929 for the loss of the Friar's Island eel fishery.

Killaloe Canal and Cussane Lock

The Killaloe Canal formed part of the Shannon navigation scheme which was completed at the turn of the 19th century in order to bypass the falls, shoals and eel weirs between Parteen Villa and Killaloe, boosting trade and commerce across the region with increased agricultural exports and industrial production, particularly from the most extensive slate quarry in Ireland which was located near Lough Derg at Garrykennedy. Three locks were constructed on the canal including Cussane Lock; a large stone built double lock with a staircase pair arrangement. The lock pair was approximately 55m long but was only 5.5m wide. A raised towpath embankment was constructed along the western bank of the main river channel below Cussane Lock. The Limerick to Killaloe Canal became obsolete in 1929 when Cussane Lock, the lock keepers cottage, towpath embankment and the stretch of canal upstream of Cussane were submerged below the waters of Parteen Basin. These features can be clearly seen in the recorded data in Figure 6. The bathymetric data also shows that the lock successfully dropped the water level by 4.9m.

Conclusion

The survey results from the Parteen Basin revealed a detailed view of a landscape last seen before the area was immersed by the Shannon Hydroelectric Power Scheme.

A whole system of field enclosures, water channels, roads and buildings were recorded on the Ordnance Survey Maps of the time and all were inundated by the march of progress. The survey revealed these features in remarkable clarity, 86 years after they were first submerged. The results from this survey also highlight the achievement of the Ordnance Survey Mapping Campaign undertaken across Ireland in the 19th and early 20th century. ◂

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Inventory and Characterisation of More than 4,500 Shallow-water Bodies

Lidar Bathymetry on the Alaskan North Slope

In June 2014, the Bureau of Economic Geology, a research unit at the University of Texas at Austin, was contracted to conduct an airborne bathymetric Lidar survey on the Alaskan North Slope. The purpose of the project was to further determine, understand, and map the local landscape and thaw-lake attributes of an area west of the Dalton Highway and Sagavanirktok (Sag) River, approximately 30km southwest of Deadhorse, Alaska. Researchers from the Bureau had visited the area in 2012 and found bathymetric Light Detection and Ranging (Lidar) to be an effective tool for measuring the area's lakes. The group returned in July 2014 and conducted numerous flights using the Chiroptera airborne Lidar system manufactured by Airborne Hydrography AB, a Leica company, of Sweden.

Chiroptera has a near-infrared red wavelength of 1.064µm for topographic (topo) data collection and a green wavelength of 0.515µm for bathymetric (hydro) data collection. The system also encompasses a high-resolution Hasselblad camera that collects natural-colour (RGB) or colour-infrared (CIR) imagery. All of these sensors were used in conjunction to acquire precise 3 D geographic data and supplemented with high-resolution CIR imagery.

The unique Alaskan North Slope micro-topography supports various potential fish habitat water bodies and wetland areas with arctic tundra vegetation. Shallow thaw lakes, less than 2m deep in general, are a major component of the tundra landscape of the Alaskan North Slope, where they compose approximately 20% of the total area. They are completely ice free only a few weeks in a calendar year, so fieldwork was scheduled accordingly, beginning in mid-July. The lakes' depth, ice growth, and decay determine whether they are suitable habitat for wildlife and aquatic fauna, as well as for industrial development. Winter ice is assumed to be 1.5 to 2m thick in this area, and any liquid water most likely lies below winter ice and talik in the central basins of these lakes if the water is deeper than 2m. Survey findings were particularly important for the project sponsor because they would reveal lakes deeper than 2m, suitable for building ice roads). Findings would also assist other environmental and hydrological assessments in the area.

▲ *Figure 1: De Havilland Twin Otter aircraft in Grand Junction, Colorado, for system installation.*

A De Havilland Canada DHC-6 Twin Otter aircraft, along with two pilots and a mechanic, was assigned to the project. Researchers from the Bureau travelled from Austin, Texas, to Grand Junction, Colorado, where the aircraft was staged. Equipment was shipped to the base location at Grand Junction, where system installation and local

▲ *Figure 2: AHAB Chiroptera installed in the aircraft.*

testing procedures were completed (Figures 1 and 2). Test and calibration flights were completed in Grand Junction to ensure full system functionality before the production phase of the survey began in Alaska.

Survey Set-up

GNSS receivers on the ground were set up at different locations to maximise geometric data quality of the acquired Lidar data. Static geographic positional data acquired from each ground station were differentially corrected by using precise GNSS orbit and clock information. Because of the remote location of the survey area, we used multiple post-processing services and averaged the final solutions to achieve the most acceptable values. Canadian Spatial Reference System (CSRS), University of New Brunswick GAPS, and Trimble CenterPoint RTX provide such services free of charges and turnaround time is generally a few minutes for each 1-hour data file uploaded. In addition to temporary established ground stations, data from two permanent (PU01 and PB0C) Continuously Operating Reference Stations (CORS) were downloaded for confirmation and/or backup purposes. For Lidar system calibration purposes, geodetic level ground-truth data were acquired over the taxiway at Prudhoe Bay Airport using a kinematic dual-frequency GNSS system. For both Lidar scanners, the average vertical offset was measured at less than 1cm, while the standard deviation was calculated at approximately 3cm compared to the points collected at runway pavement. We also examined and corrected any evident Lidar system calibration errors caused mostly by incorrect inertial navigation system (INS) rotation angles of roll, pitch and yaw. These errors can be detected through analysis of adjacent and opposing Lidar strips. In theory, if no rotational misalignments are present, Lidar points registered from different strips should match each other seamlessly on an unobstructed surface; although not expected to have perfection, it is possible to achieve very close results in practice. Calibration procedures were applied to both scanners individually, where average roll and pitch biases were measured to be less than 2.6cm.

Conducting the Survey

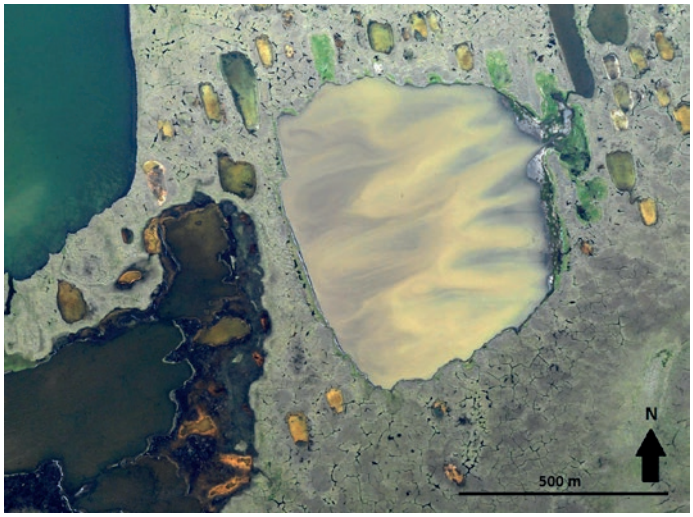
A total of 95 lines were flown from north to south and south to north to cover the survey area. The average flight line was approximately 50km long, where laser swath footprint on the ground was calculated to be 280 to 290m wide, flying at 400m altitude from the ground. To compensate for the changing ground elevation (30m in the north, 95m in the south), pilots monitored the atmospheric pressure and adjusted the aircraft altitude to maintain a constant Lidar swath width. Both topo and hydro scanners acquired data simultaneously; the topo scanner emitted light pulses at a speed of 300kHz and recorded discrete pulses (up to 4 returns), compared to the hydro scanner, which acquired data at 35kHz speed and recorded waveform information with 1,024 samples in each shot. The average point density on the ground surface was calculated at 14 points and 1.8 per m^2 for each scanner respectively. An average flight line consisted of 33 million points (~1GB) for hydro lines and 220 million points (~7GB) for topo lines. A total of 21 billion points were recorded with the topo scanner, and the hydro scanner registered 3 billion points, for a total of 4 terabytes of raw data.

Leica Lidar Survey Suite LLS v2.09 was used to convert raw data files into industry-standard LAS1.2 and XYZ (ASCII) file formats for output. Because LAS datasets are in binary format, they provide quick and easy access to information, either for analysis or visualisation purposes. Datasets from both scanners were tiled to 1,000 x 1,000m to simplify the computational requirements for data viewing and analysis. As a result, 829 tiles were generated across the survey area, and each tile included a 20m buffer zone in each direction to generate a seamless 1m digital elevation model (DEM) for mapping purposes. For bathymetric calculations, water bodies shallower than 0.1m and smaller than 1,000m^2 in surface area were excluded. The minimum volume calculation was set at 34m^3. Every water body was labelled with its latitude and longitude information, in Universal Transverse Mercator (UTM) coordinate format, based on the midpoint determined from the Lidar dataset. Table 1 illustrates two samples where each water body was

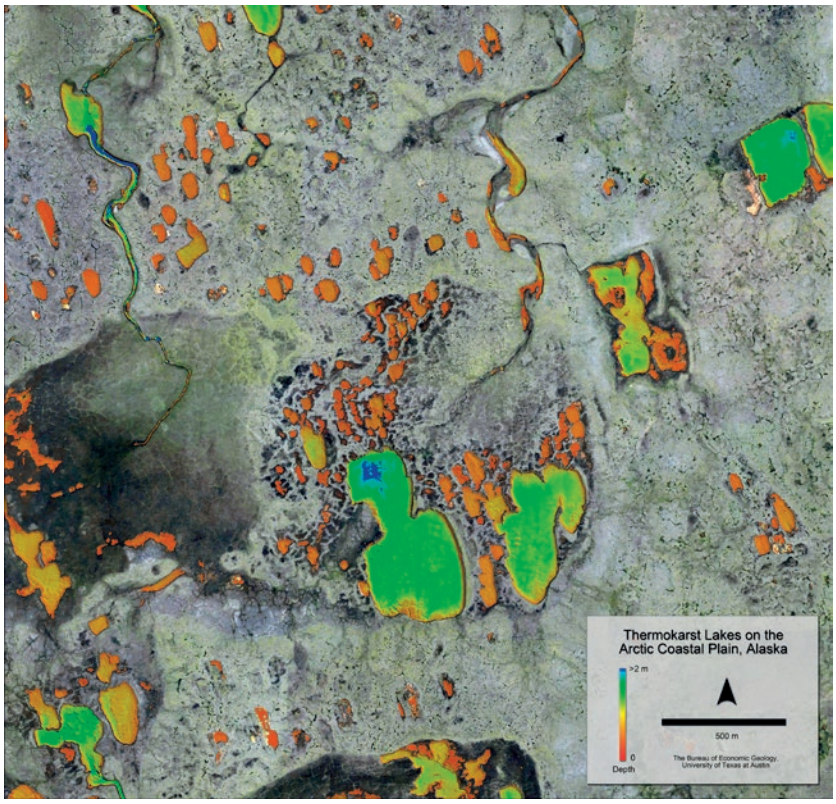
Name X_Y UTM	xUTM	yUTM	Area (m^2)	Area (acres)	Max. depth (m)	Max. depth (ft.)	Avg. depth (ft.)	Avg. depth (m)	Volume (m^3)
412966_7745072	412966	7745072	8991	2.22	1.87	4.75	1.61	0.49	4415
413089_7744655	413089	7744655	1327	0.33	3.17	8.05	4.05	1.23	1640

▲ *Table 1: Sample hydro report output.*

▲ *Figure 3: A lake with clear and visible bottom.*



▲ *Figure 4: A lake with turbid water content.*



▲ *Figure 5: Aerial imagery fused with Lidar bathymetry.*

calculated to include area size, depth, and volume.

Though a dense sampling of bathymetric Lidar returns was captured from the bottom of the water column, a number of larger water bodies (<20) did not have sufficient returns registered from the bottom to have full representation. This deficiency was due to depth, clarity and reflectivity issues in the water column or at the water surface (Figures 3 and 4), possibly caused by suspended materials or aquatic vegetation content. In such scenarios, maximum possible depth was calculated by averaging available returns.

Due to environmental restrictions in the tundra environment, researchers were not able to conduct in-situ water clarity measurements either with a Secchi disk or turbidimeter. Furthermore, the survey area included thousands of lakes with varying water clarity, making it unrealistic to sample all or most of the water bodies. As an alternative, researchers purchased 5-band satellite imagery, acquired in conjunction with Lidar survey and classified all water bodies with their respective electromagnetic energy release. The literature review and study approach supported the hypothesis that appropriately chosen, and carefully corrected satellite imagery can be an effective and complementary approach to estimate water depth and clarity by measuring the water-leaving radiance. Preliminary findings indicated that low or moderate-low reflectivity represented clear water-column and deepest water bodies where shallower and slightly turbid water columns were represented by moderate-high and higher reflectivity levels.

Lidar bathymetry provided accurate, detailed and cost-effective results

Lidar bathymetry revealed 4,697 distinct water bodies in the survey area. The cumulative water body surface area was 85km^2 (11.3%), with an average (mean) surface area of 18,076m^2. Results also showed that 11.5% of water bodies exceed 16,000m^2 in surface area, the largest covering more than 3 million square meters. The

deepest water was calculated at 3.5m. Only 4.6% (216 total) of all lakes had depths that exceeded 2.0m. The average depth was calculated at 0.67m and 64% of all lakes contained less than 1,000m^3 water volume, where the average volume was 12,771m^3.

Once again, Lidar bathymetry provided accurate, detailed and cost-effective results that permitted analysis of microtopography and hydrological features in a remote location of the world. Water bodies of all shapes and sizes—riverine environments, wetlands and uplands, hills and flat areas, and all other terrain features—were mapped and analysed rapidly and accurately (Figure 5). The Lidar survey produced detailed and precise topographic and bathymetric data in areas where traditional survey methods would not have been feasible.

Acknowledgments
This study was sponsored by Great Bear Petroleum (GBP) Operating LLC. Flight services were provided by Aviation Systems Engineering Company (ASEC) of Lexington Park, Maryland, with cooperation from Twin Otter International of Grand Junction, Colorado. Bureau of Economic Geology research staff member Aaron Averett operated the airborne Lidar system, and graduate student Chuck Abolt provided ground GPS control support in Alaska. Rebecca A. Brown studied the satellite imagery and reflectivity from the water bodies. Jeff Paine, Michael H. Young, and Tiffany L. Caudle provided valuable overall assistance throughout the project. ◂

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Technical Records Set for Lidar Penetration

Surveying **Japanese Inland** and Coastal **Waters**

In March 2015, Leica Geo-Systems conducted a series of demonstration surveys in Japan, which highlighted the capabilities of the HawkEye III Airborne Bathymetric Lidar system. The system demonstrated its capability with full datasets in diverse environments and it also set new records for depth penetration for both the HawkEye III deepwater sensor, and the Chiroptera II shallow-water sensor. This demonstration was designed to prove the depth performance and general capabilities of the latest state of the art HawkEye III system in Japan and ambitiously targeted 13 geographically separate areas ranging from land locked rivers, coastal estuaries, and coastal strips, to offshore islands and coral reefs.

Leica mobilised a HawkEye III Bathymetric Lidar system, consisting of a HawkEye III 10KHz deepwater sensor, a Chiroptera II 35kHz shallow-water sensor with a 500kHz integrated IR topographic sensor, and a Leica RCD30 60MP camera to Japan in February 2015.

The system was fitted to a PASCO Corporation Cessna 208B aircraft. A multi-national project team was established to manage the trial with the Singapore office of Leica Geosystems providing overall project management, Leica Geosystems of Sweden providing equipment, specialist operators and technical support and Australian sub-contractor Coastal Hydrographic providing specialist technical project management and operational advice as well as field-based data-processing and quality control services.

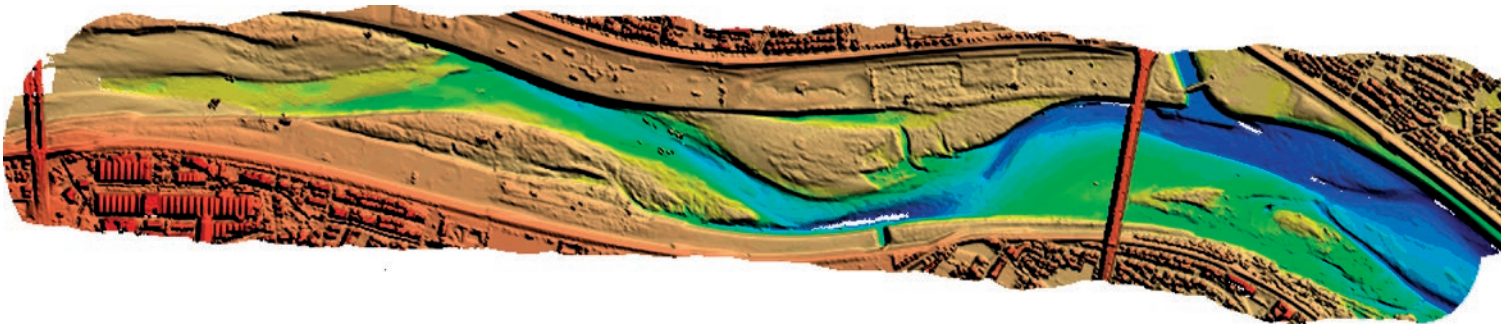
Lidar Calibration and Data Collection

Flying operations commenced in several rivers and coastal areas centred on the Tokyo regions in early March 2015. All three sensors were installed into a single PASCO Cessna 208B aircraft using a two hatch configuration, the Chiropter II and topographic sensor along with the RCD 30 Camera were installed over the forward hatch, while the larger HawkEye III deepwater sensor was installed over the aft hatch. A GNSS receiver and IMU were attached to each base plate assembly over each hatch.

Increased coverage in turbid areas

Calibration of all sensors was conducted simultaneously by Leica engineers in a traditional topographic Lidar manner at the commencement of operations. Processing of calibration data for all sensors was conducted within the Leica Lidar Survey Studio (LSS) software. Once calibrated, the system is then flown over known seabed areas to confirm the depth accuracy standards are being met.

During data collection all three Lidar sensors and the RCD 30 camera were controlled and operated by a single operator using the dedicated Leica Operating console software. This approach ensured the optimum settings for each sensor were utilised during the critical data collection stage and the best possible overlap and depth performance for each



▲ *Figure 1: Oblique Scanner Pattern.*

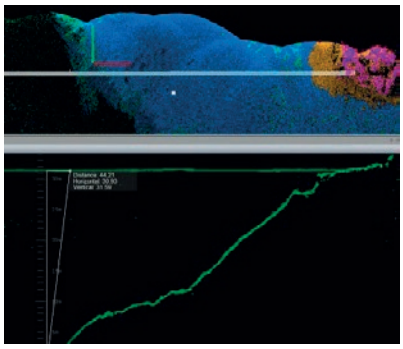
sensor is achieved in the prevailing water conditions through simultaneous integrated operation.

All three sensors operated with the new oblique orbital scanner, which maintains scanning at a near optimum angle of incident to the water surface reducing the effects of wave action and calm conditions on accuracy, increased density and feature detection through the forward and backward scanning to each point and reducing shadowing on near vertical features. This pattern is indicated in Figure 1.

GNSS / IMU data for each sensor hatch combination was processed in a tightly coupled solution relative to local GNSS base stations. All data was processed relative to the GRS80 ellipsoid and WGS84 datum. This approach allowed the generation of a seamless topographic / bathymetric dataset. Raw Lidar sensor data for each sensor from

Overlap between sensors was automatically determined

each flight was then processed simultaneously in a truly integrated process within the LSS. This approach to the processing of multiple sensors not only allows for the best possible outcome for each sensor maximising very shallow-water performance whilst obtaining the best possible deepwater penetration and ensuring no gaps between the two sensors, but also allows for the most efficient processing and cleaning of the three datasets. A further advantage of processing all three

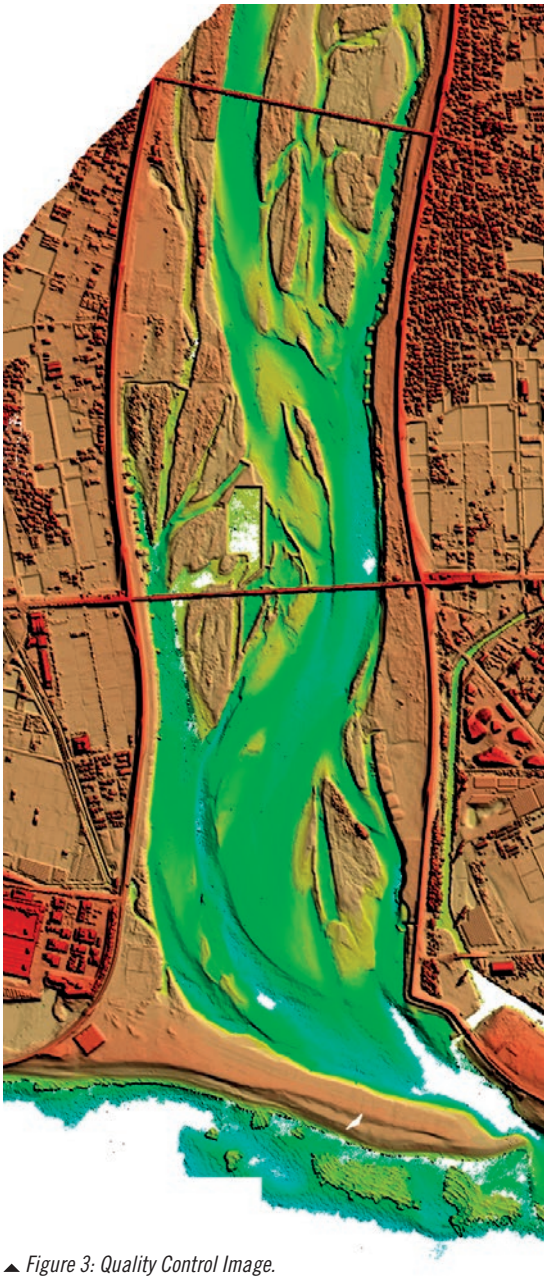


▲ *Figure 2: Water Surface modelled over dam.*

sensors simultaneously in the same package was that data from all three sensors was used to determine a truly integrated surface datum for the automated classification of seabed points which combined with localised water surface level measurements allowed for a consistent and accurate correction for refraction of light across both bathymetric sensors. This approach allowed for an efficient modelling of the water surface which resulted in all data being consistently classified and corrected for swell along the coastline and for slopes in the water surface in the river environment. An example of the surface water modelling results achieved is shown in Figure 2. This image shows a dam across the Yoshino River measured with the Hawkeye III system. Results in the more turbid environments were further improved through the application of the new Leica Turbid Water Enhancement Technology. This new processing technology applies specialist processing algorithms to the full waveforms to allow additional seabed data to be extracted from the returns in more turbid shallow-water environments such as rivers and coastal estuaries. The outcome of this software is increased coverage in turbid areas, which is critical for survey in coastal estuaries and river environments.

Field Processing and Quality Control

A 4-stage approach to the processing of bathymetric Lidar data ensures that the data collected satisfied the requirements of the demonstration and was of a suitable quality prior to leaving each mobilisation site.
The first stage involved the processing of GNSS Data and then Lidar data from all three sensors simultaneously within the LSS software to produce an initial automatically classified point cloud corrected for refraction from the water surface.
The second stage then involved the field quality control of the water surface model, optimisation of the algorithms to generate the



▲ *Figure 3: Quality Control Image.*

best possible results followed by rapid cleaning of the water column and seabed data to allow quality control checks of the sensor overlaps, line overlaps and assessment of achieved point density and coverage. These overlap checks were presented as colour coded images and statistical comparisons, and in general the differences between sensors and lines and flights was in the order of 0.1m or better.

Images in this article were generated from stage 2 field processed data which was supplied at the end of March as the team and system demobilised. Further stages involve the post field final cleaning of the data and

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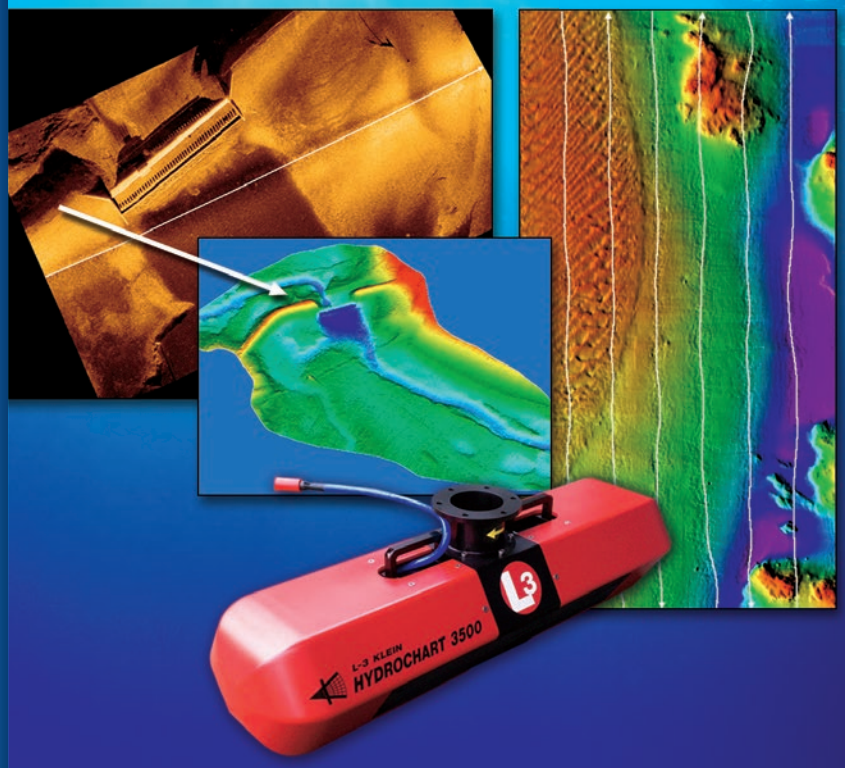

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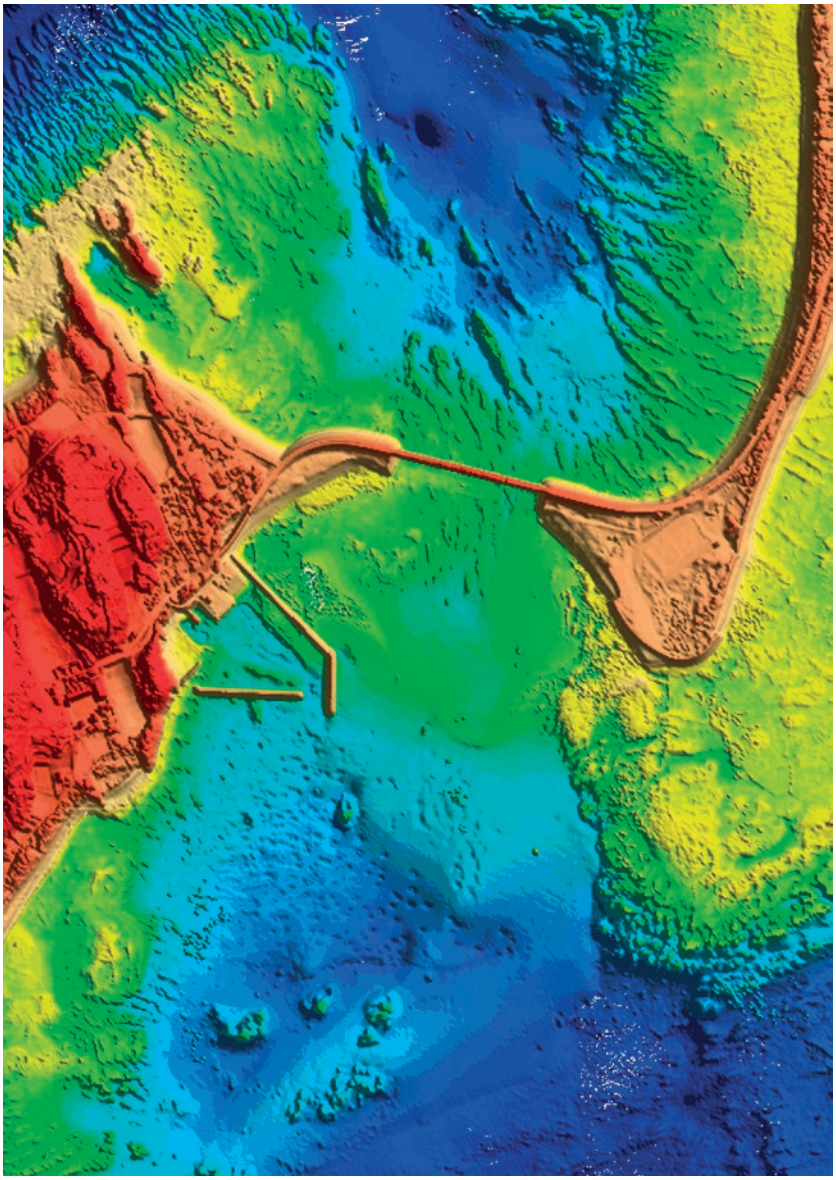
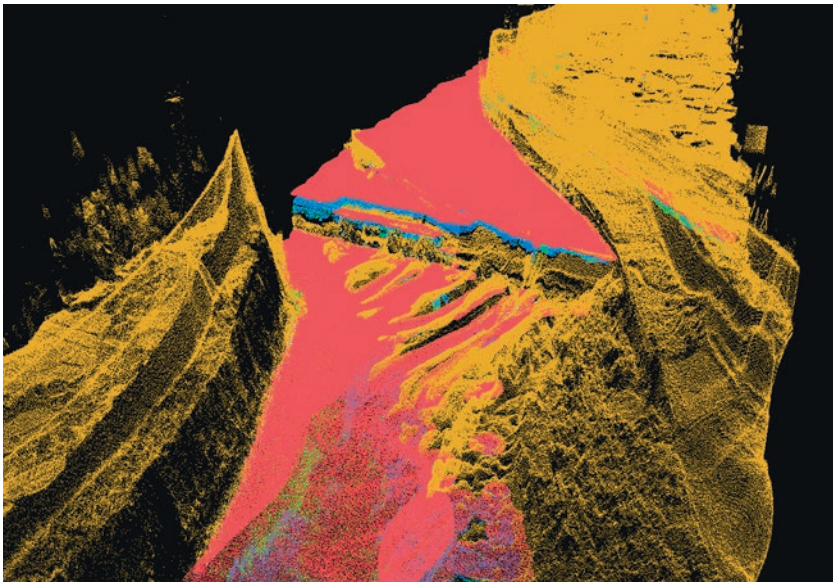


▲ *Figure 4: Tama River Coverage.*



▲ *Figure 5: Tenryu River Estuary Coverage.*

generation of derived products such as seamless DEMs and final products.

Demonstration Results

The trial was an outstanding success; despite the challenging weather and water conditions the project team efficiently positioned the aircraft to take advantage of the best weather windows as they appeared, allowing 9 of the 13 target areas to be successfully flown. Seamless data was collected from 500kHz topographic data, to 35kHz shallow-water bathymetric data to depths down to 30m in places using the Chiroptera II, and then 10kHz deepwater bathymetric data down to depths greater than 50m in places using the Hawkeye III. Overlap between sensors was automatically determined and generally of the order of 0.1m or better.

Despite recent rainfall and less than ideal water conditions in the Tokyo region at the start of data collection, results were obtained in the inland Tama River (see Figure 3) west of Tokyo and in the Tenryu River coastal estuary south west of Tokyo (see Figure 4). The HawkEye III system was the first airborne Lidar Bathymetry system to successfully collect data in some of these turbid Japanese river environments.

In the clearer waters of Japan's southern islands records were broken, with the Chiroptera II system obtaining depths in excess of 30m (extending its operating specification well beyond the quoted 15m, see Figure 5), and the HawkEye III sensor achieving depths over 50m proving their capabilities in clear waters.
The HawkEye III system proved its capabilities in a wide variety of demanding shallow-water survey environments as well as excelling in the deepwater environment. The HawkEye III System exceeded manufacturers operating specifications for flying altitude and depth performance for both the shallow and deep sensors. ◀

Nigel Townsend is the founder of Coastal Hydrographic Pty Ltd. Nigel spent 18 years in the Royal Australian Navy as a hydrographic surveyor prior to 12 years at Fugro LADS, where he led projects worldwide. In 2014, Nigel started Coastal Hydrographic Pty Ltd to provide specialist ALB skills to support the Airborne Lidar Bathymetry industry.
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Knowledge Gained in the Search for Franklin

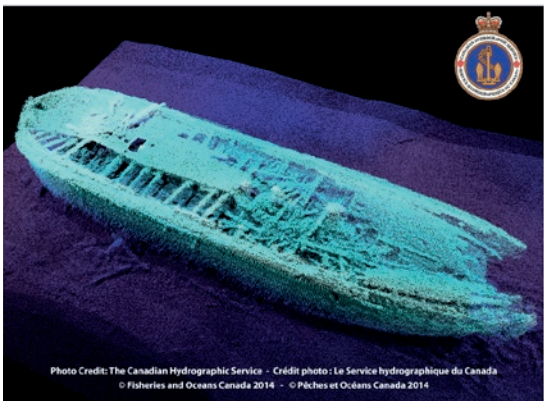
Searching for HMS ***Terror***

"We know where the target is not located" is the only guaranteed result of any search expedition. This statement does not make for exciting headlines, however, the value of knowledge gained during the search itself and its many benefits to a variety of end-users, cannot be easily dismissed. The 2015 Franklin Expedition search coordinated by Parks Canada was the continuing multi-year, multi-partner effort that saw the discovery of HMS *Erebus* in September of 2014. In this article we will discuss the knowledge gained and multiple uses of the data collected toward our conclusion of verifying where HMS *Terror* is not located.

In 1845, Captain Sir John Franklin led an ill-fated expedition to find the final elusive link in the Northwest Passage through what is now the Canadian Arctic Archipelago. Supplied for three years, HMS *Erebus* (Figure 1) and HMS *Terror* sailed from England outfitted with innovative auxiliary steam engines, coal-fired heating systems, and all manner of internal and external hull reinforcement to better withstand the ice -- including bows sheathed in iron hull plating. Given the experience of Franklin, his hand-picked crew, and the well-equipped ships he commanded, few anticipated the tragedy and ensuing searches that continue to this day.

Many motivating factors have contributed to the launch of the searches for the 'Lost Expedition'. Initially it was a rescue mission, and then a recovery mission, when all hope for any survivors was lost. Modern day searches coordinated and funded by the Government of Canada are motivated not only by the important history the lost expedition represents, but the added substantiation to Canada's sovereignty claim to the Arctic.

On 2 September 2014, Parks Canada discovered the wreck of one of Franklin's vessels in Queen Maud Gulf south of King William Island. A month later, the wreck was officially announced as that of HMS *Erebus* by the Canadian Prime Minister on 1 October 2014. Subsequent archaeological dives on HMS *Erebus* have yielded compelling artefacts and new knowledge about the ship, as well as the expedition. With renewed vigour, Parks Canada embarked on 'The Franklin Expedition: Mission Erebus and Terror 2015' to continue diving on HMS *Erebus* and to continue searching for HMS *Terror*.



▲ *Figure 1: Sonic 2022 multibeam image of HMS* Erebus. *Image courtesy: CHS.*

2015 Search

This year's search was a dedicated two-week effort using five vessels, each fitted with multibeam echo sounders. The Canadian Coast Guard Ship (CCGS) *Sir Wilfrid Laurier* and the Canadian Hydrographic Service (CHS) launches *Gannet* and *Kinglett*, each fitted with R2Sonic 2022s. The Parks Canada survey vessel *Investigator* was fitted with an R2Sonic 2024-UHR (Figure 2) and the Royal Canadian Navy's HMCS *Moncton* had an R2Sonic 2026. *Investigator*, *Laurier* and *Moncton* had pole-mounted MBES, while *Gannet* and *Kinglett* had fixed, hull-mounted systems.

Unlike previous years, side-scan sonar was not used as the combined factors of increasing water depth, anticipated target size and physical integrity, as well as the advantages of greater swath size and survey speed made multibeam sonar the sensor of choice.

The ice and weather conditions during the search were relatively favourable, resulting in only 36 hours of down time for the smaller survey launches, while the 3812-ton *Sir Wilfrid Laurier* was unaffected. While the marine surveys were underway, Government of Nunavut Archaeologists, CHS Hydrographers and Coast Guard technicians went ashore to various locations via boat and helicopter for archaeological site surveys, tidal analysis water levelling and NAVAID beacon maintenance. The shore parties were regularly greeted by the local polar bear population (Figure 3).

The ice and weather conditions during the search were relatively favourable, resulting in only 36 hours of down time

Concurrent with the HMS *Terror* search, a Parks Canada dive team was on the HMS *Erebus* site mapping and cataloguing the wreck.

In a combined effort to 'collect once and use many times', all the survey platforms collected data suitable for charting purposes according to Canadian Hydrographic Service standards. A total of 8083 line km and 555.8km^2 of multibeam seafloor data were collected (Figure 4) and included an extensive 3.5m shoal that

was previously uncharted, as well as hundreds of ice scours (Figure 5). Unfortunately, the final resting place of HMS *Terror* was not located this year, but the data collected are of great value to a diverse community of users as we will see in the next section.

Data Assembly/Usage

Several months of preparation were required to assemble existing background data, prepare survey equipment and plan the 2015 survey expedition. The survey platforms needed to be assembled, calibrated and tested, and then all equipment shipped from Ontario to Victoria, British Columbia, to be installed or stored aboard CCGS *Sir Wilfrid Laurier*, prior to her departure for the Canadian Arctic.

The intended purpose of the 2015 mission was to collect high-quality multibeam data for use in charting within high priority navigation corridors in Victoria Strait and to support the ongoing search for the still unaccounted for Franklin Expedition vessel HMS *Terror*. As marine traffic volumes increase in the Arctic, along with increasing ship drafts, it is incumbent upon the CHS to collect as much quality data as possible to create hydrographic products that allow safe and efficient navigation in these corridors.

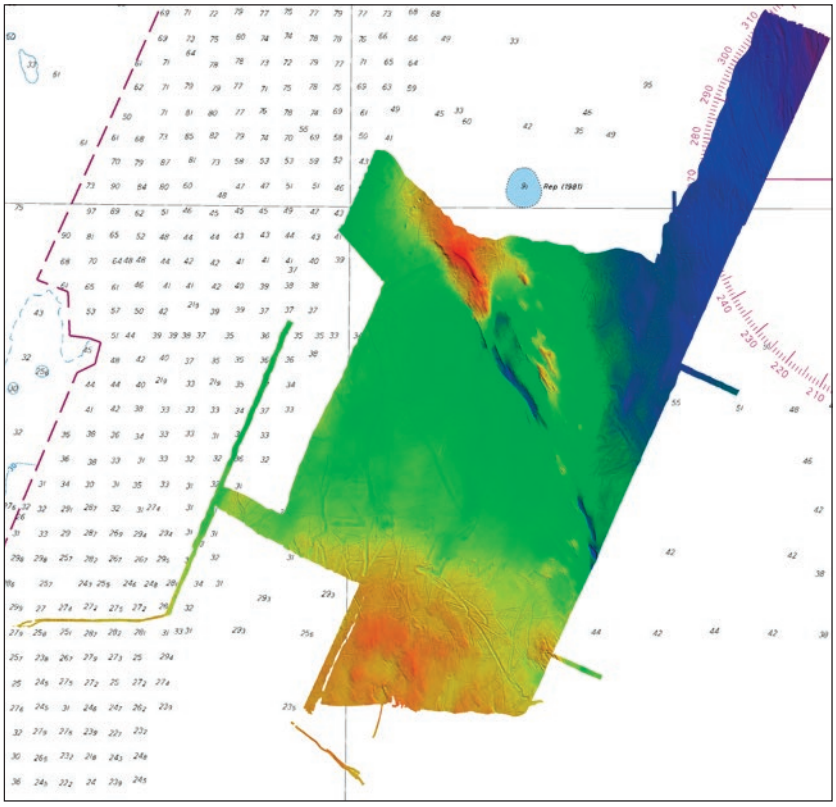
The navigators who are dependent upon this navigational information come from various vectors. With increased commercial activity in resource extraction, those commercial entities need safe and reliable navigational routes to get their product to the intended markets. Similarly, the permanent residents and those who make their livelihood in Arctic communities are dependent upon the goods brought in from the south, as seasonal conditions permit. The most cost effective means of doing this is through marine shipping. The more efficient and reliable these routes, the more cost effective and timely the availability of essential goods, resulting in an enhancement of the quality of life for Northerners.

Additionally, marine tourism is experiencing an increase in Arctic waters. Cruise ships will likewise benefit from the enhanced safety and access derived from updated and accurate navigational products. Finally, when all does not go as planned, as is frequently the case in the potentially harsh Arctic environment, Emergency Response (ER) platforms such as CCG vessels, need access to the most accurate information available to be able to arrive on the scene as quickly as possible. The ER situations may range from a Search and Rescue (SAR) for individuals reported lost or overdue to return home, emergency evacuation of personnel from a marine incident, or the environmental containment of a contaminant spill.

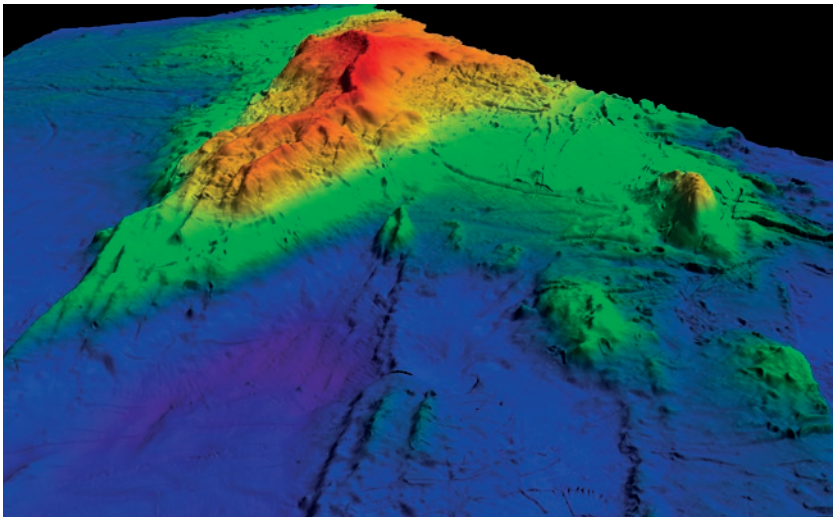
▲ *Figure 2: Parks Canada Survey Vessel* Investigator *with Sonic 2024-UHR. Image courtesy : CHS.*

▲ *Figure 3: Swimming Polar Bear. Image courtesy: CHS.*

While collecting data during the 2015 mission, as is standard practice, new data was continually compared to existing data holdings, especially in areas considered to be critical to navigation. Several Notices to Shipping (NOTSHIP), and resultant Notices to Mariners (NOTMAR), were issued. These notices give a quick 'heads-up' to any vessels navigating in these areas to exercise caution with recognition of a newly determined potential hazard. One notable feature, found in 2015, was a lengthy 3.5 metre shoal that was previously unknown, or erroneously positioned. While this shoal fell outside areas that were previously adequately charted, it was adjacent to a route that might prove, once charted, to be a suitable alternate (and time saving) route to the one currently taken. Awareness of a hazard such as this shoal factors into where future recommended routes may be established. The seafloor from the multibeam imagery around this shoal showed the area to be extremely ice scoured. Being



▲ *Figure 4: Survey area overview. Image courtesy: CHS.*



▲ *Figure 5: Ice Scours Surrounding the Newly Charted Shoal. Image courtesy: CHS and PC.*

the Arctic, certain areas are frequently ice covered or strewn, so even where adequately charted corridors exist, they may not be a safe or efficient option should ice cover persist. Widening known corridors and charting new ones, creates more manoeuvering room and opens up a vessel's safety options.

One other priority of the 2015 mission was to deploy and recover year-long water level gauges on the seafloor; establishing permanent vertical benchmarks on nearby land features, occupying those benchmarks with Geodetic grade Global Positioning System (GPS) receivers, and using them to perform in-situ water level observations. This resultant information will allow CHS to better model the tide constituents for future tidal predictions and contribute toward tying that information directly to the ellipsoid and densifying Canada's Continuous Vertical Datum (CVD) model for the Arctic.

Conclusion

Many years of archaeological work remain: on the wreck site of HMS *Erebus*, along the coastlines where the original Franklin Expedition members left clues after they abandoned their ships, and in the search for HMS *Terror*. It is in the continuing search for HMS *Terror* that new knowledge of the Arctic seafloor and environment will directly benefit many different areas including safety of navigation, environmental protection, and the northern residents themselves. It is only a matter of time before the word 'not' is definitively removed from the sentence "We know where the target is not located".

Acknowledgements

The many important partners that made the 2015 *Erebus* and *Terror* Expedition possible include: Parks Canada, ArcticNet, Arctic Research Foundation, Canadian Space Agency, Department of National Defence, Royal Canadian Navy, Environment Canada, Canadian Ice Service, Fisheries and Oceans Canada, Canadian Coast Guard, Canadian Hydrographic Service, Government of the United Kingdom of Great Britain and Northern Ireland, Government of Nunavut, Inuit Heritage Trust, Kitikmeot Inuit Association, One Ocean Expeditions, Québec-Océan, The Royal Ontario Museum, Seneca College, and the W. Garfield Weston Foundation. ◀

More Information

http://www.pc.gc.ca/eng/culture/franklin/mission2015.aspx

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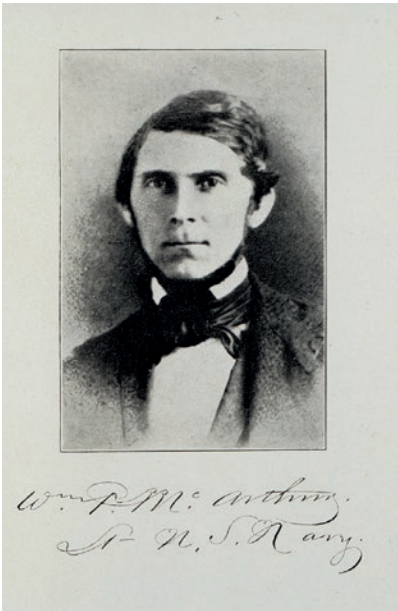
William Pope **McArthur** – A Life **Cut Short**

Lieutenant Pope McArthur was appointed a midshipman in the United States Navy in 1832 and followed a fairly conventional career path for the first few years of his career. He served in the Seminole Wars and in 1838 was shot in both legs, one lead ball remaining in his leg for the rest of his life. After convalescing at the naval hospital he was assigned in 1840 to the United States Brig *Consort*, which was conducting surveys in the Gulf of Mexico under the auspices of the United States Navy. This work apparently was agreeable to him as he requested assignment to the United States Coast Survey.

McArthur advanced quickly and by 1846 was placed in command of the surveying schooner *Vanderbilt*. That year he worked in the northern Chesapeake Bay sounding out numerous rivers to the head of navigation. The following year he worked in North Carolina in Albemarle Sound. At the conclusion of work there he requested that he return to Chesapeake Bay to complete surveys begun the previous year. For this Superintendent Alexander Dallas Bache wrote of his 'characteristic zeal', a rare complement for one who was still active in the work of the Survey. The following year, 1848, saw McArthur working once again in the sounds of North Carolina.

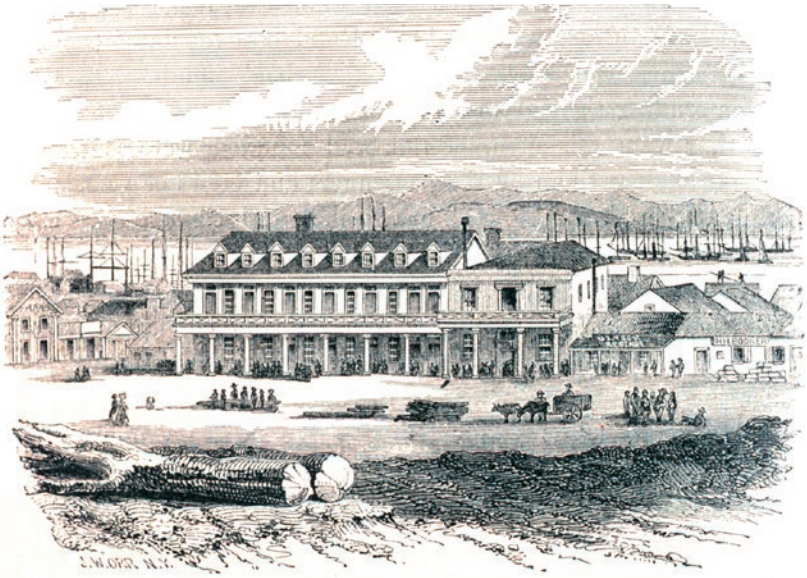
At the end of 1848, McArthur received orders to proceed to the frontier areas of the West Coast of the United States. California had recently been acquired and Oregon Territory had seen an influx of settlers and trade that made hydrographic surveys a high priority. In the winter of 1849-1850, he proceeded to New York to put the Revenue Schooner *Ewing* in shape for both the arduous trip to the west coast of North America and also to outfit it for surveying work. After outfitting the *Ewing*, command of the vessel was turned over to Lieutenant Washington Bartlett who proceeded to the West Coast via Cape Horn on 9 January, an arduous voyage made in the austral autumn. McArthur, because he had to finish office work associated with the North Carolina surveys, left for California on 17 March. He proceeded to the Isthmus of Panama and made it to Chagres on the Caribbean side in relative comfort; but from there to San Francisco it was strictly improvisation. Upon arrival in Chagres, he found an overcrowded lawless town filled with gold-seekers as the great California gold rush was just beginning. Because he was a United States officer, he was made head of a vigilante committee and within 48 hours had restored order. He then took a boat up the Chagres River and went overland by mule train to the city of Panama. There was no transportation available to San Francisco and many of the travellers in the city were becoming sick with various tropical fevers. A delegation of gold-seekers approached a local merchant who was using the Ship *Humboldt* as a coal storeship.

They bought the ship with funds from 400 passengers putting up USD200 apiece and selected McArthur as commanding officer. McArthur wrote his father on 11 May, "So if we have some good luck we will be ready for sea by Sunday. Then ho! For California with 400 of the roughest customers you ever saw-all agog of her Gold. I put the 'G' in gold in capital because it is the custom to pay that respect to deity, and surely they worship this God." The *Humboldt* left Panama on 21 May and took 46 days to reach Acapulco where supplies were taken on board as all on board were nearly famished. Cooking was done in a communal fifty-gallon pot with one meal served per day, coffee served in the morning, and tea at night. Bedding was where one could find a place to lie down. The ship arrived in San Francisco on 31 August, one month after the arrival of the *Ewing*. As Bartlett had taken the ship to Tomales Bay to discourage crew desertions, it was not until 6 September that the *Ewing* returned to San Francisco and McArthur was installed as captain although Bartlett remained attached to the ship.



▲ *Figure 1: William Pope MacArthur.*

Gold fever infected the naval crew of the *Ewing* as it lay in San Francisco Bay. Five sailors, while taking Passed Midshipman William Gibson ashore in a small boat, attacked him, threw him overboard, and escaped with the boat (Figure 3). They were caught by Lieutenant McArthur and brought back for court martial. They were all found guilty of mutiny and desertion while two were also found guilty of attempted murder. All were sentenced to death by hanging from the yardarms of naval vessels in the harbour but the sentences of three were commuted to "one hundred lashes on the bare back, serve out the remainder of their term of enlistment



▲ *Figure 2: San Francisco in 1849.*

▲ *Figure 3: Mutiny on boat off Coast Survey Schooner* Ewing *illustrating naval officer William Gibson being attacked by the Black brothers.*

without pay, and with a ball and chain on the leg, in solitary confinement, or at hard labor, or alternately both...." Of the two hung, John Black was executed on the *Ewing*. In spite of his crimes, he met his death bravely as related by McArthur: "He met his doom very composedly, took leave of all his messmates, and turning around shook hands with all the officers and begged to be forgiven. He walked to the platform with a firm and steady step and at the appointed signal was launched into eternity. May God in his mercy never again place me in such a trying situation."

Some work was accomplished with a survey of Mare Island Straits in San Francisco Bay, but the *Ewing* was shorthanded. Thus, in early December McArthur sailed for Hawaii in order to recruit additional crew and "to run away from the incessant rains which are said to prevail with winter."

He returned to San Francisco and sailed on 3 April for a reconnaissance of the northern coast. McArthur was fairly discouraged by this time and wrote to his father-in-law: "I have made up my mind to be disappointed with regard to the probability of our usefulness on this coast … I feel confident that no work can go on at the present wages of the country as it would require the whole of the Coast Survey appropriation to keep a party together…." However, like most ships, once the *Ewing* sailed, all the gloom and doom evaporated. On 13 April 1850, McArthur wrote from Trinidad Bay, "I may safely say that the only happy days I have spent in the country have been spent since we started. I am at last at work and most usefully employed in making a reconnaissance of the Coast as we go up.... We have completed a very correct outline of the coast, its headlands, Bays, Rivers and indentations from San Francisco to this place, as well as carrying our soundings as we go...." In June, McArthur described the scenery in the vicinity of the Columbia River as "beautiful and some places and some points of view the grandest that the eye ever beheld." He found time to speculate in real estate as he and two other officers acquired homesteads in the Willamette Valley. He felt that if he could hold it for five years "it would be a fortune." In late June and early July he inspected the Puget Sound area on the steamer *Carolina* leaving Bartlett in command of the hydrographic party. He described the waters of the sound as "a strange and peculiar anomaly. The deep blue sea runs up inland passing between straits but half a mile wide with a depth of over a hundred fathoms. Bays, Harbours, Inlets and Roads startle you at every turning forming a perfect labyrinth." From the south end of Puget Sound, he travelled overland to the Cowlitz River and took a canoe to the mouth of the Columbia. He was gone for over a month on this trip.

By the end of August, the *Ewing* was back in San Francisco. McArthur experienced remarkable weather, both at the entrance to the Columbia River (Figure 4) and on his trip back down the coast. In his words, "... We have been successful in surveying the mouth of the Columbia River and up the same as far as Astoria.... the dangers of navigation of this truly magnificent river have been vastly exaggerated. We have crossed the bar sometimes as many as ten times a day for weeks together.... On our way from the Columbia River we were successful enough to make a good reconnaissance of the whole coast from Cape Disappointment to this place

To be published July-August 2016

Hydro International's Unmanned Systems Special

Interest in unmanned (underwater) systems continues to increase, and the latest developments indicate that the range of applications is becoming wider all the time. A special Unmanned Systems edition of *Hydro International*, to be published in July-August 2016, will provide an overview of current – and future – uses for unmanned systems.

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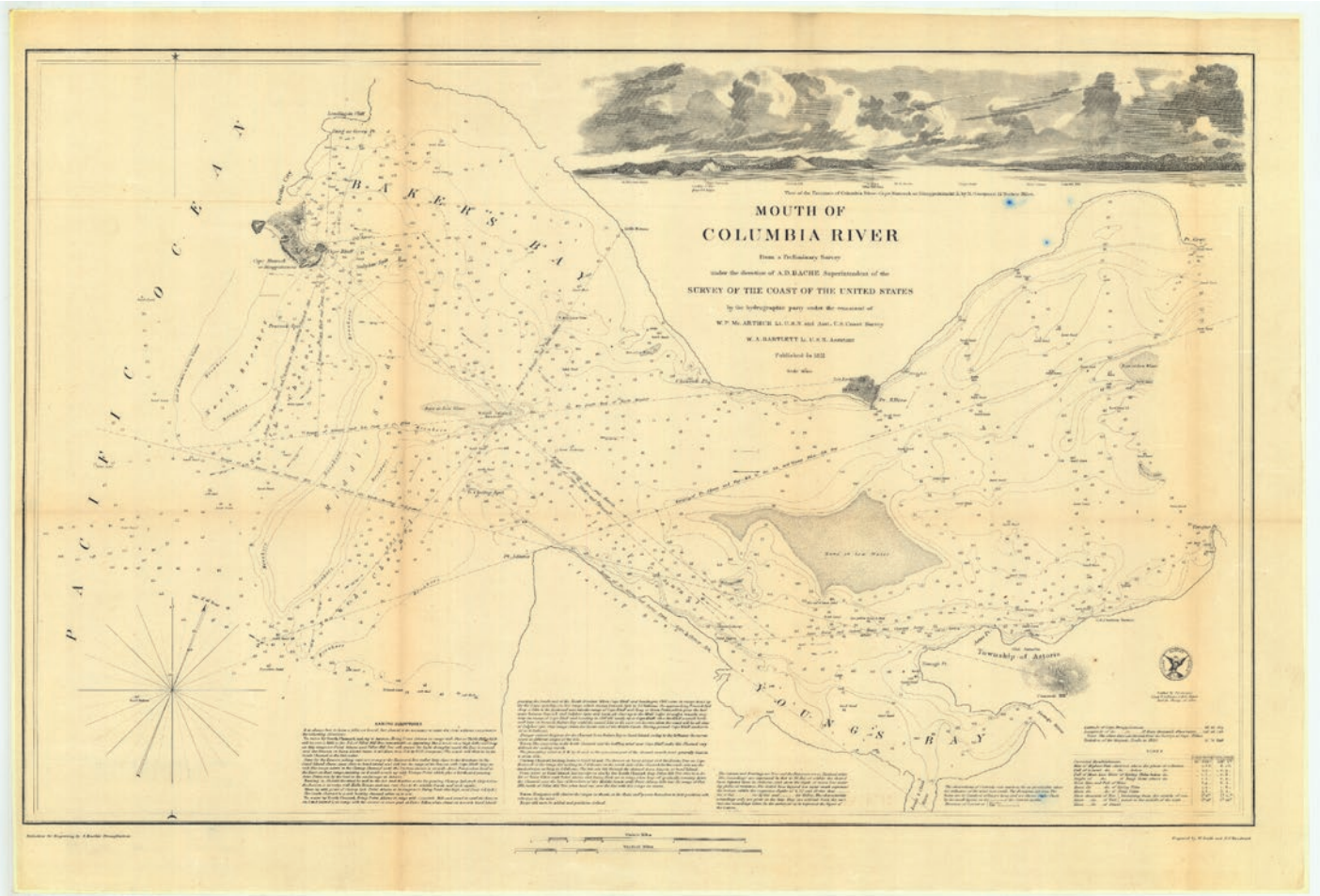


▲ *Figure 4: Mouth of Columbia River from a preliminary survey, including a view of the Entrance of Columbia River-Cape Hancock.*

and the limits of error may be estimated at one mile in longitude and an ½ mile in latitude. This I consider quite a triumph."

While in San Francisco, McArthur was engaged in preparing for the next reconnaissance which was to extend south to San Diego. On 21 November, he received the welcome news that he was to proceed to the east coast and take command of a steamship for West Coast survey duty. Thus, with the prospect of seeing his wife and family a year earlier than he had anticipated, he booked passage with Washington Bartlett on the steamship *Oregon* bound for Panama. The *Oregon* was under the command of his old friend Carlile Patterson who had left Naval service to serve with the Pacific Mail Steamship Company. Patterson had recently served as commanding officer of a Coast Survey vessel that worked in the vicinity of Mobile Bay. Patterson spent the next ten years on the West Coast prior to returning to the Coast Survey at the beginning of the Civil War as hydrographic inspector. He ultimately became its fourth Superintendent. The *Oregon* departed 1 December; shortly after leaving San Francisco McArthur suffered an acute attack of dysentery. He never recovered and tragically died 23 December as the *Oregon* was entering the port of Panama.

The dangers of navigation of this truly magnificent river have been vastly exaggerated

William Pope McArthur's greatest work was his reconnaissance of the Pacific coast of the United States. However, his work inspired his descendants to settle in Oregon where they became prominent in politics, newspaper journalism, and the utilities industry, as well as being scholars of Oregon history and geography. If he had lived, it is probable he would have risen to high rank in the Navy as many of his naval colleagues in the Survey rose to the rank of rear admiral or higher in later years. The Coast Survey and its descendant organisations have commemorated his name by naming three ships *McArthur* and numerous geographic features for either McArthur or his family, most recently McArthur Escarpment and McArthur Canyon, southwest of the Columbia River Entrance in 2005. ◀

▲ *Figure 5: San Francisco with deserted ships as crew left for the gold fields.*

FUGRO, The Netherlands

Providing **Geo-intelligence** and **Asset Integrity Solutions**

Fugro, headquartered in the Netherlands, is the world's leading independent provider of geo-intelligence and asset integrity solutions, collecting data on topography, soil composition and environmental conditions, both onshore and offshore. Acquired data is organised, processed, interpreted and visualised whilst additional services include geo-related design, asset inspection and integrity advice.

Founded in 1962 by engineer Kees Joustra, the original business plan for the company included combining the practice of soil analysis with the theory of advice on foundation design. Over a period of more than fifty years of organic growth, mergers and an active acquisition policy (which included the takeover of Thales Geosolutions in 2003) led to the Fugro of today - a highly regarded company specialising in survey, subsea, geotechnical, geoscience and geoconsultancy services. Headquartered in Leidschendam, the Netherlands, the company has offices and other specialist facilities in more than 60 countries to support its worldwide operations.

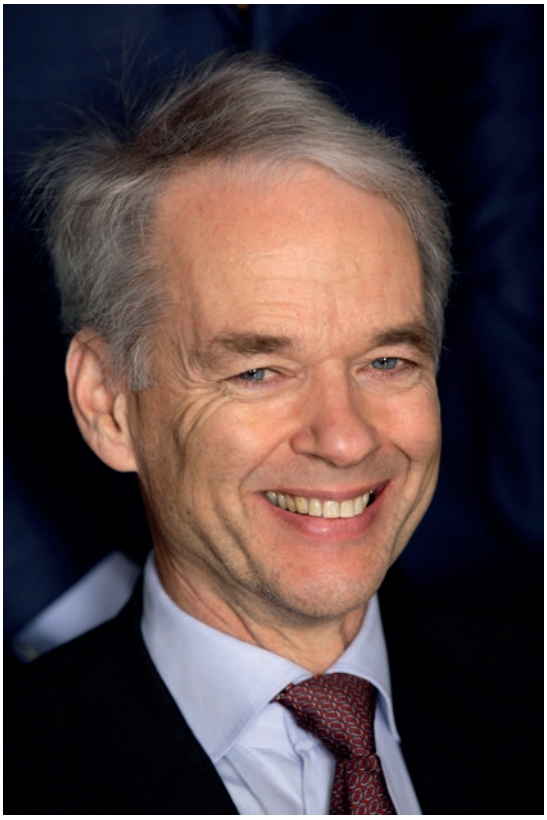


Figure 1: Paul van Riel, CEO. Image courtesy: Fugro.

Fugro Today

Fugro is an independent service provider and strives to be the preferred partner of its clients. Its 12,000 employees deliver quality services safely and consistently, applying world class, innovative and often proprietary technology and performing to high standards of professionalism and integrity.

Enjoying its status as the leading service provider in most market segments in which it operates, Fugro aims for leadership overall. Its extensive expertise and capabilities generate superior value for clients and returns for shareholders. In 2015, its survey, geotechnical, subsea and geoscience divisions together produced revenue of around EUR2.4 billion.

International Perspective

"As leading geo-intelligence and asset integrity solutions provider, we contribute to major constructions and infrastructure onshore and offshore across the world, in all phases from concept, through design, construction and operation to decommissioning. We can be a true long-term partner to our clients contributing objective, independent information, advice and solutions during the entire life cycle of their construction and infrastructure assets." Paul van Riel, CEO.

Oil and Gas

Fugro supplies the critical knowledge and operational support essential for safe, reliable and efficient development and operation of oil and gas facilities, both onshore and offshore. Its expertise in collecting and analysing data removes risk and uncertainty and streamlines projects, from exploration and development to production and decommissioning.

Sustainable energy

For both onshore and offshore energy development, Fugro's resource analysis and ground and environmental investigations support construction activities and monitor the integrity of structures.

Water sector

Fugro's technical expertise helps to increase productivity, safety and efficiency in sectors such as agriculture, water supply, water management, forestry and fishing, whilst reducing project risk and operating costs.

Building and infrastructure

Fugro collects, interprets and delivers technical data to help determine how natural environments and human activity impact upon the design, construction and management of buildings, highways, bridges, tunnels, ports, airports and electrical power and telecommunication networks.

▲ *Figure 2: One of the newer vessels operating mainly in the Gulf of Mexico is the* Fugro Americas. *Image courtesy: Fugro.*

Other sectors

Specialised solutions in defence and intelligence, regional and urban planning, natural resources management, environmental stewardship, marine resources and emergency management are provided, as well as exploration surveys to aid efficient extraction in mining activities together with positioning, site investigation and mapping services.

Increased demand for energy, water, food, raw materials and infrastructure in the coming decades

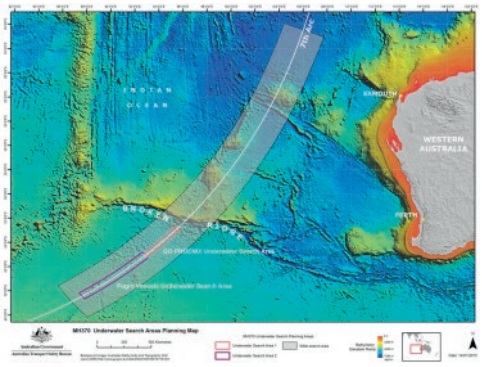
Looking to the Future

Fugro is dealing decisively with the current downturn in the oil and gas market, focusing on winning work, strengthening its leadership positions and efficiently executing projects. It has adopted a strong focus on innovation and performance improvement programmes whilst putting in place plans to reduce capacity, operating cost and investments.

It supports the widely held long-term view that population growth, urbanisation and climate change will increase demand for energy, water, food, raw materials and infrastructure in the coming decades. Fugro is well placed to take advantage of opportunities that result from the increasing importance of low-carbon energy and widespread commitment to lower carbon emissions. The reducing cost of offshore wind and the global spread of new developments in the sector are expected to create numerous opportunities for Fugro, along with those presented by growth in other low-carbon energy developments such as tidal, hydro-power, geo-thermal and nuclear.

The company's sharp focus on clients' requirements for cost efficiency, safety and ease of operation is delivering innovations that support long-term sustainability. Through innovation, integration and standardisation Fugro is providing smarter, more efficient solutions which lead to improved decision making and cost reductions. ◀

More information
www.fugrio.com



▲ *Figure 3: Fugro is involved in the deep-sea search for MH370.*

World Hydrography Day 2016

The **Key** to Well-managed **Seas** and **Waterways**

On 21 June 2016, and in appropriate related events every year, the IHO will celebrate World Hydrography Day. World Hydrography Day is an opportunity to increase public awareness of the vital role that hydrography plays in everyone's life. The theme for World Hydrography Day 2016 is Hydrography – the key to well-managed seas and waterways.

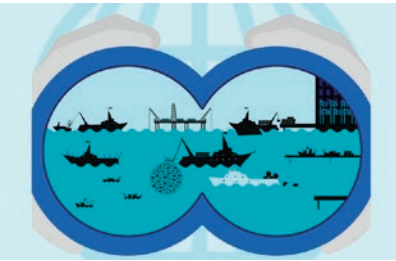
This theme was chosen to highlight the importance of hydrographic information, especially in determining the depth and shape of the seafloor, in properly managing all human activities in the seas, the oceans and navigable waterways.

The theme is especially relevant in light of the 2030 Agenda for Sustainable Development adopted by the UN General Assembly in September 2015. The UN Agenda specifically targets the sustainability of the oceans under its Sustainable Development Goal 14 - Conserve and sustainably use the oceans, seas and marine resources for sustainable development. One target outcome of Goal 14 is to increase scientific knowledge of the oceans. UN Sustainable Development Goal 11 addresses the resilience of cities and human settlements, and refers to Disaster Risk Reduction including the impact of severe weather events and of natural phenomena such as tsunamis. Achieving both Goals 14 and 11 will rely in no small way on improving the currently unacceptable level of hydrographic knowledge about our sea areas - especially in terms of knowing more about the depth and nature of the seafloor.

Limited Knowledge

An uncomfortable fact, and one yet to be fully appreciated by both the general public or most politicians, is that we have better maps of the Moon, Mars and Venus than we do of most of our seas and oceans. We have no measured depths for more than 70% of the water area on the planet. The IHO estimates that at least 50% of the world's coastal waters remain unsurveyed. The coasts in the polar regions, the South West Pacific, West Africa and the Caribbean are barely 10% surveyed. And in those areas where surveys do exist, many are so old or of such a sparse nature that they cannot support modern requirements. This should be a major cause for concern for everyone - at a time when mankind seeks to take more and more resources and support from the sea and is only now beginning to realise how important the sea is to our survival. Not only is the sea a resource for food, medicines, transport and recreation, it is also a major influence on climate and climate change because of its moderating effect. How can mankind seriously contemplate exploiting the sea in a sustainable manner when we do not really understand its shape and the features that lie on the seafloor - all of which are at the core of hydrography? The theme for 2016 is intended to highlight this situation.

▲ *Figure 1: Water covers most of the globe's surface.*



▲ *Figure 2: Professional uses of the Sea. Image courtesy: Global Ocean Commission.*

95th Anniversary of the IHO

21 June 2016 - World Hydrography Day, also marks the 95th anniversary of the establishment of the IHO.

More information
www.iho.int>About IHO>World Hydrography Day>Background briefs for 2016
info@iho.int

APRIL

MARID V
North Wales, UK
→ 4-6 April
www.maridv.bangor.ac.uk

Arctic Shipping Forum
Helsinki, Finland
→ 19-22 April
www.informamaritimeevents.com/event/arctic-shipping-forum

Maritime & Offshore Career Event
Rotterdam, The Netherlands
→ 20 April
www.moce.biz/nl

Joint IOGP/IMCA/THSiS Industry Day
Aberdeen, UK
→ 20 April
bit.ly/215YVVZ

Convencion Mexicana de Hidrografia
Del Carmen, Mexico
→ 27-29 April
digaohm.semar.gob.mx/hidrografia/hidrografia.html

MAY

Offshore Technology Conference (OTC)
Houston, USA
→ 2-5 May
2016.otcnet.org

All-Energy
Glasgow, UK
→ 4-5 May
www.all-energy.co.uk

International Conference on Coastal Zone Management
Osaka, Japan
→ 16-18 May
www.coastalzonemanagement.conferenceseries.com

Canadian Hydrographic Conference
Halifax, Canada
→ 16-19 May
paecanada.eventsair.com/QuickEventWebsitePortal/chc/chc2016halifax

Connecting Paleo and Modern Oceanographic Data
Boulder, USA
→ 23-25 May
usclivar.org/meetings/2016-paleo-amoc-workshop

UNB-OMG/UNH-CCOM Multibeam Course 71
Den Helder, The Netherlands
→ 23-28 May
bit.ly/MBC071

JUNE

Seanergy
Biarritz, France
→ 1-2 June
www.seanergy-convention.com

UDT 2016
Oslo, Norway
→ 1-3 June
www.udt-global.com

30. Hydrographentag
Oldenburg, Germany
→ 1-2 June
www.dhyg.de

Oceanographic Survey Vessels 2016
London, UK
→ 7-9 June
www.oceanographicsurveyvessels.com

JULY

UK marine Energy Conference
Glasgow, UK
→ 5 July
www.marineenergyconference.co.uk

International Workshop on the Advances in the Use of Historical Marine Climate Data (MARCDAT-IV)
Southampton, UK
→ 18-22 July
conference.noc.ac.uk/marcdat-iv

SEPTEMBER

MTS/IEEE Oceans '16
Monterey, USA
→ 18-23 September
www.oceans16mtsieeemonterey.org

EWEA Annual Conference/WindEnergy Hamburg
Hamburg, Germany
→ 27-30 September
www.windenergyhamburg.com

OCTOBER

SaferSeas/Sea Tech
Brest, France
→ 10-14 October
www.saferseas-brest.org/Accueil-257-0-0-0.html

Offshore Energy
Amsterdam, The Netherlands
→ 25-26 October
www.offshoreenergy.biz

NOVEMBER

Hydro '16
Rostock-Warnemünde, Germany
→ 8-10 November
hydro2016.com

Oceanology International China
Shanghai, China
→ 9-11 November
www.oichina.com.cn/en/home

SUT 2016 Technical Conference
London, UK
→ 15-17 November
www.sut.org/event/sut-2016

GSDI World Conference
Taipei, Taiwan
→ 28 November-2 December
bit.ly/gsdi2015

Sustainable Ocean Summit
Rotterdam, The Netherlands
→ 30 November-2 December
bit.ly/gsdi2015

FEBRUARY 2017

Oceanology International North America 2017
San Diego, USA
→ 14-16 February
www.oceanologyinternational-northamerica.com

APRIL

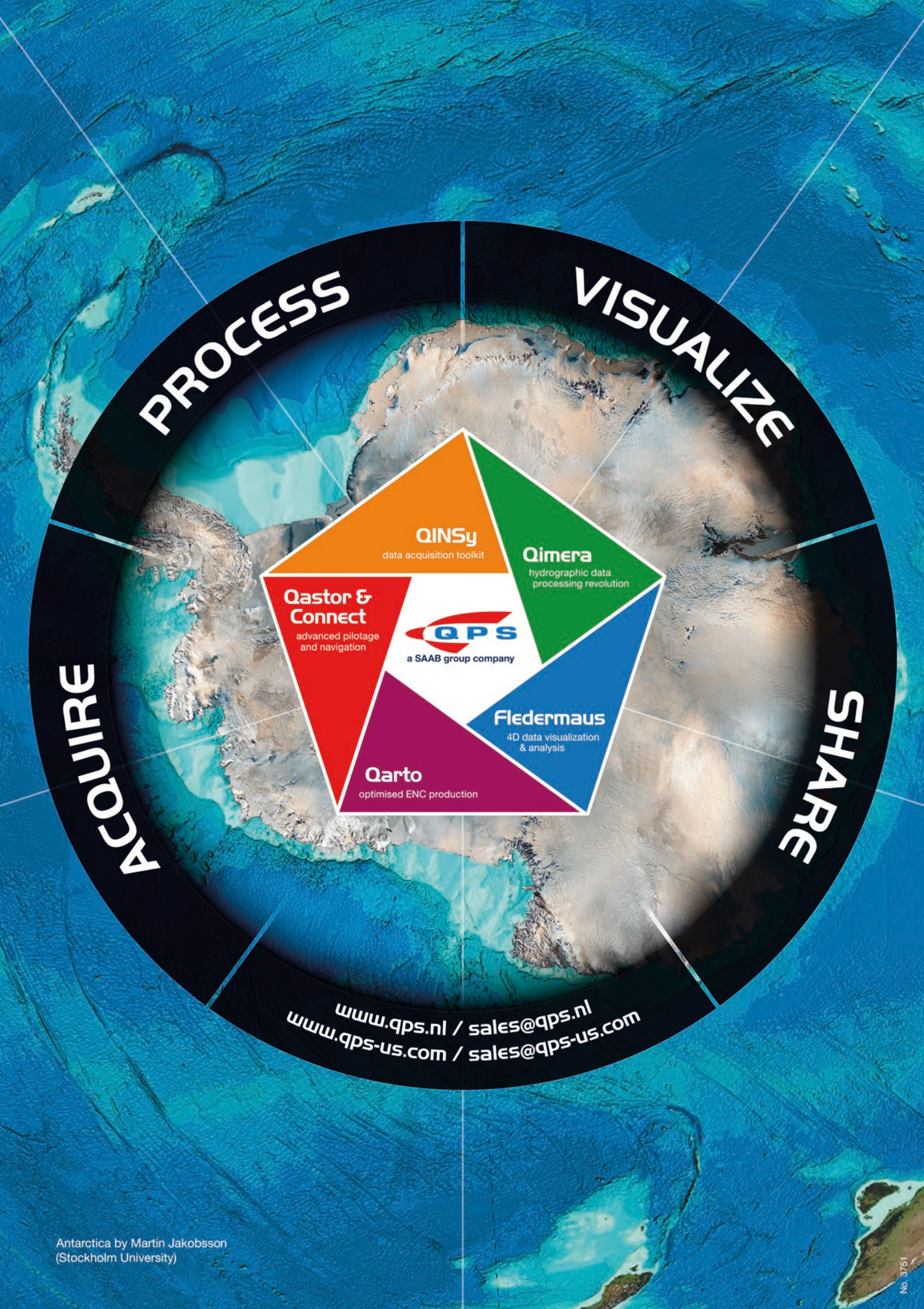
Ocean Business
Southampton, UK
→ 4-6 April
www.oceanbusiness.com

XIXth International Hydrographic Conference
Monaco
→ 24-28 April
For more information:
www.iho.int

JUNE

EWEA Offshore
London, UK
→ 6-8 June
www.ewea.org/events/ewea-offshore

Calendar Notices
For more events and additional information on the shows mentioned on this page, see www.hydro-international.com. Please send notices at least 3 months before the event date to: Trea Fledderus, marketing assistant, email: trea.fledderus@geomares.nl.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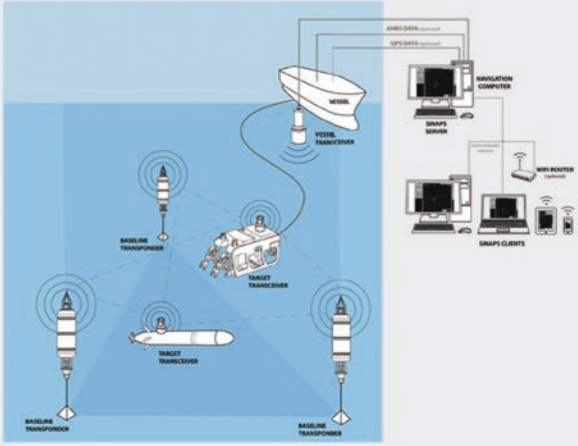

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