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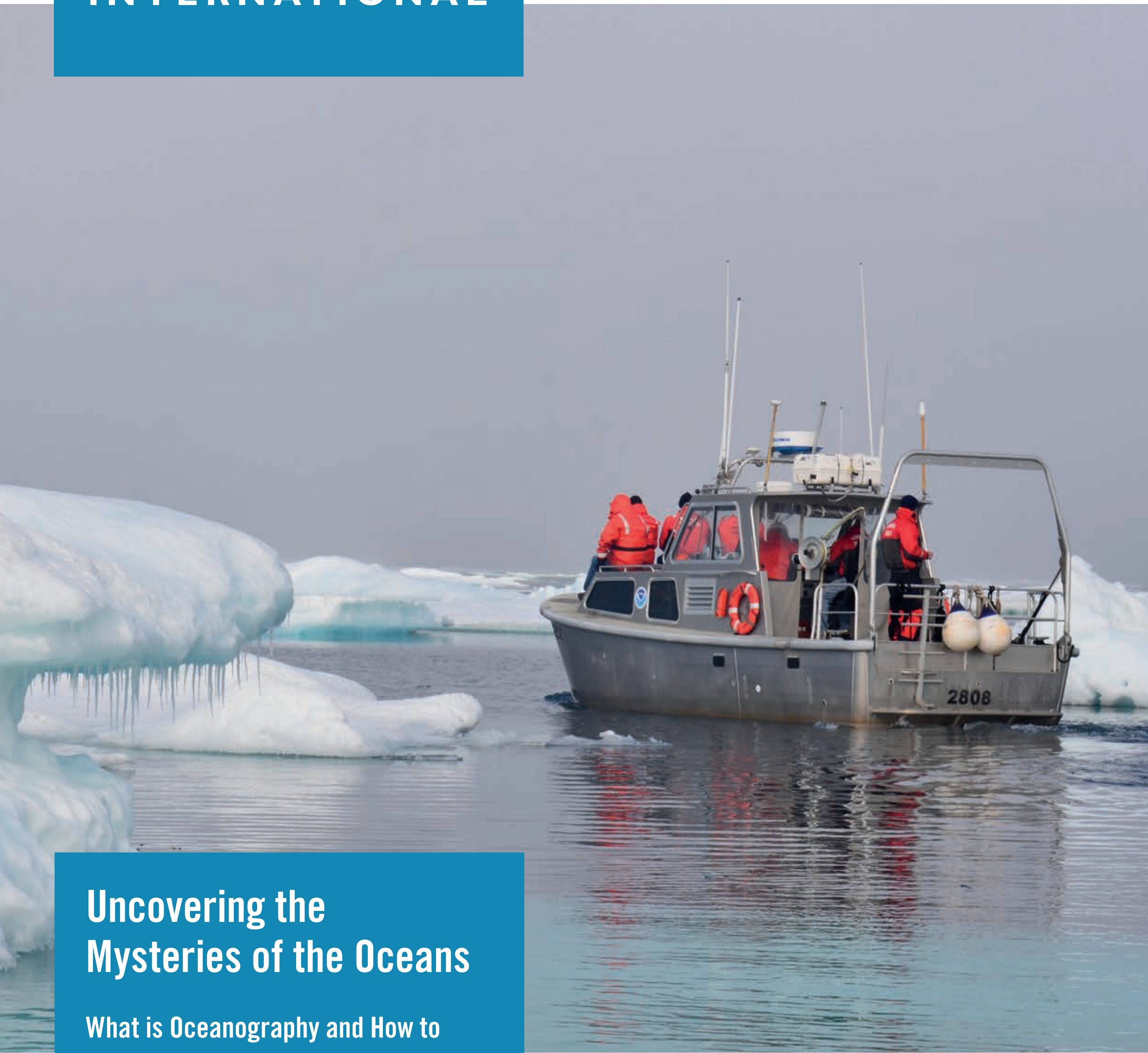

Uncovering the Mysteries of the Oceans

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Real-time Validation of CoVadem Derived Water Depths

Designing a Wave Buoy for Long-term Operational Independence

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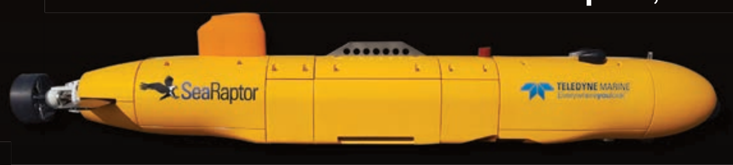

Depth: 6,000M

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Front cover

The front cover shows a surveying crew launched from the NOAA Ship *Fairweather*, fulfilling a piece of the US Arctic Nautical Charting Plan as they conduct hydrographic surveys in the vicinity of Cape Lisburne and Point Hope, Alaska. Seventy percent of this area has never been surveyed. (Courtesy: NOAA)

Climate Chance

Durk Haarsma.

Climate change is a topic on every front page of every newspaper, every day. There has been a clear shift from a debate between believers and non-believers of the underlying scientific research to a consensus that our climate is changing rapidly and measures need to be taken to stop, or at least slow down, climate change and decide how citizens will be best to cope with that. *Hydro International* certainly does not carry climate change as a topic on the cover of its print edition or in the subject lines of its newsletters, but it certainly impacts our industry in many ways. In this issue, we have one clear reference to the impact that climate change has or could have on the hydrographic business. The example is quite straight forward, it is a case study about the surveying job done on the Galloper Wind Farm, a 353 MW wind farm located 27 kilometres off the Suffolk coast of the United Kingdom, completed by Bibby HydroMap (see page 12). This wind farm, like many others, would never have been there without the transition from fossil to renewable energy that is happening, in part, due to climate change. Sceptics could say that climate change has cost the business lots of money, but that would be too cynical. I would rather look at all the chances climate change – which is here now and the only thing we can do is beat it – can offer entrepreneurs. Hydrography can offer major support in monitoring and slowing down climate change – in other words, climate chance!

Durk Haarsma,
director strategy & business development
durk.haarsma@geomares.nl

Ocean Business

Wim van Wegen.

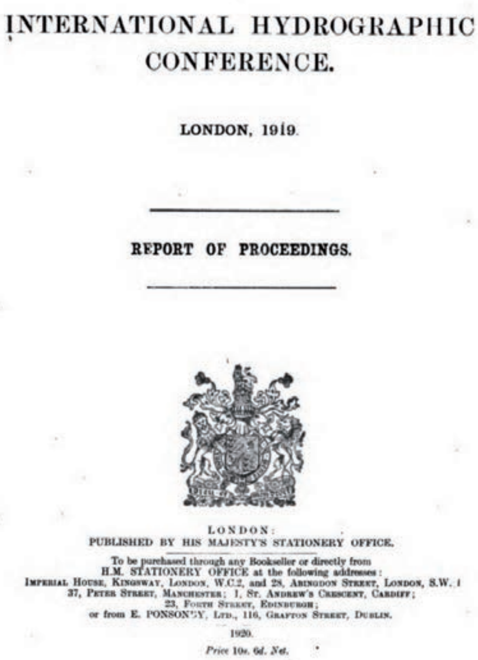
From 9 to 11 April, the hydrographic and ocean technology industry will gather again in Southampton, United Kingdom. Whether it is coastal and offshore surveying, marine engineering, oceanography, environmental monitoring, ports or waterways, the latest technologies and innovations are being showcased at Ocean Business. It goes without saying that *Hydro International* will pay significant attention to this event. As always, we dedicate our double-sized March-April issue every two years to Ocean Business. For those interested in contributing an in-depth article, a thought-provoking column or a relevant news story to this special edition of our magazine, feel free to contact me! We still have a few spots open, and if you think you really have something special to share that is of interest to our audience – let us know! Two topics that we are keen to shine a spotlight on are digital chart production and ROVs, so we would especially welcome stories on these topics.

At *Hydro International*, we are confident that Ocean Business 2019 will be an incredible show, with lots of learning and networking opportunities. We are keen to add something extra with our extensive March-April issue. Don't miss the boat!

Wim van Wegen, content manager
wim.van.wegen@geomares.nl

Resolutions of the IHO

The year 2019 sees the centenary of the first Hydrographic Conference which took place in London in the summer of 1919. Only one year after the end of the First World War, representatives from 26 countries met in London at Trinity House to discuss and agree on future technical cooperation in hydrography. The report of the proceedings starts with the following statement: “The experiences of the War in special relation to hydrographic matters showed most clearly the enormous importance of the possession of accurate charts and hydrographic information generally, and the very grave disadvantage attendant on their no-possession; and also brought clearly into prominence the great divergence in methods of production, etc. obtaining in the various countries of the world. It was also evident that the cessation of the War must inevitably lead to increased activities in shipping trade, and that this must automatically increase the amount of hydrographic surveys which will be required by all maritime countries of the world.”



INTERNATIONAL HYDROGRAPHIC CONFERENCE.

LONDON, 1919.

REPORT OF PROCEEDINGS.

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1920.

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This notable modern phrasing confirms that hydrography was already well understood as a prerequisite of what we call today ‘marine knowledge’. But clearly, the major focus had been the aspiration for uniformity of items such as units of measurement, descriptions of currents and tidal streams, and the design of nautical charts and sailing directions. The appropriate means to establish regulations of international validity that the international community of hydrographic offices agreed to at this conference, were called ‘Resolutions’. This type of resolution still prevails and constitutes the foundation of the International Hydrographic Organization which was established in consequence of the considerations of the London Conference two years later. One of the fundamental documents of the IHO – the Publication M-3, or ‘Resolutions of the IHO’, still holds 23 resolutions which originated from this conference in 1919. Though amended from time to time, numerous basic assumptions related to the objectives of the organization are still laid down here.

One of the prominent outcomes is Resolution 7/1919 – ‘Hydrographic Office arrangements for the exchange and reproduction of nautical products’. This resolution was recently amended by the first IHO Assembly in 2017 to reflect today’s digital nature of nautical products. It can be expected that this has not been the last amendment since uniformity in presentation and support in the ease of handling has been a permanent subject of discussion for both chart and text orientated nautical information. At the IMO Sub-Committee on Navigation, Communications and Search and Rescue conference, held in January 2019 in London, the United Kingdom Marine Accident Investigation Branch (MAIB) and the Danish Maritime Accident Investigation Board (DMAIB) presented a safety study on the use of Electronic Chart Display and Information Systems (ECDIS) onboard ships. The investigators embarked on 29 ECDIS-fitted vessels of various types: dredgers, buoy layers, general cargo ships, container ships, tankers and cruise ships. It is very educating to read the compilation of views of the interviewed deck officers in consideration of future ECDIS improvements, which includes:

- fewer alarms;
- bigger screens and more touchscreen and tablet technology;
- simpler systems (less complex menu structures);
- standardized interfaces such as keyboards;
- more integration (radar/digital publications/NAVTEX);
- increased contour density;
- the display of height of tide data;
- the display of MARPOL limits;
- better font/symbol size and colour;
- better palettes/contrast in all time of day modes; and
- faster internet.

Many of these requests have to be tackled by IMO regulations and emerging communication technology, but some of the more important ones can only be addressed through concerted actions of the underlying hydrographic datasets from providers. The national Hydrographic Offices, now with 89 IHO Member States, is dedicated “to improving global coverage, availability and quality of hydrographic data, information, products and services…” through the IHO Convention. Only by taking careful note of such user remarks will adopt appropriate action to their respective work programmes. The spirit of the very first conference, now a hundred years ago, which was to embark on a cooperative intergovernmental approach, still remains their leading line.

Using RAMMS to Acquire Integrated Land and Sea Data in the Caribbean

▲ *Caicos Islands, as seen from the International Space Station.*

Fugro has completed a data acquisition campaign over the Turks and Caicos islands, marking the first commercial survey using its Rapid Airborne Multibeam Mapping System (RAMMS). Working under contract to the United Kingdom Hydrographic Office (UKHO), the company acquired more than 7,400 square kilometres of integrated, high-resolution bathymetric, topographic and image data. The resulting deliverables will support updated nautical charts and coastal zone management activities in the region. Launched in August 2018, RAMMS is an airborne bathymetric mapping system that uses multibeam laser technology to deliver depth penetration and point densities. The compact sensor is deployed from a small aircraft and can be integrated with other remote sensing technologies for the simultaneous collection of multiple complementary datasets. For the Turks and Caicos project, this approach made it possible to acquire nearshore (bathymetry) and coastal (topography and imagery) data in a single deployment, producing a cost-effective solution and advancing Fugro's sustainability goals by significantly reducing fuel consumption.

▸ ***https://bit.ly/2UrVN96***

Saab Seaeye Cougar XT Chosen for Multi-purpose Support Vessel

▲ *Saab Seaeye Cougar.*

Norway-based Østensjø Rederi has chosen a Saab Seaeye Cougar XT underwater robotic vehicle as a deployable resource aboard their multi-purpose support vessel 'Edda Fonn'. The company is contracted to deliver the vessel to the New Zealand Ministry of Defence in 2019 with an integrated remotely operated underwater vehicle (ROV) and dive system amongst its upgrades. The ship will subsequently be used by the Royal New Zealand Navy. Østensjø Rederi chose the Cougar over other robotic vehicles after hearing 'very good feedback' from end users around the world. The vehicle also had the best overall specification and is backed by Saab Seaeye's 30-year reputation. ROV and diving consultant at Østensjø Rederi, Arvid Bertelsen, explains "The Cougar XT has the best power, thrust and payload in its class, with the widest and most comprehensive range of quick-change tool skids. It was also the most technically compliant to the specifications demanded by NORSOK (the Norwegian Technology Centre), the Royal New Zealand Navy and Østensjø Rederi."

▸ ***https://bit.ly/2SizZPC***

Students and Researchers Get Access to OceanWise Marine Mapping via Digimap

▲ *Digimap, the online map and data delivery service.*

OceanWise's marine mapping data is now accessible to students in Further and Higher Education across the British Isles via Digimap, the online map and data delivery service provided by EDINA, based at the University of Edinburgh. EDINA works with data partners such as Ordnance Survey, British Geological Survey, Centre for Ecology and Hydrology, Getmapping and OceanWise, to offer access to a variety of data collections for the purpose and benefit of education and research. Digimap allows students and researchers to create or interrogate mapping online by selecting an appropriate base map, adding annotations, customizing the content, and using measurement & query tools to learn more about a study area.

▸ ***https://bit.ly/2CWn5NL***

Deep-sea Drilling to Shed New Light on the Stability of the Antarctic Ice Sheet

▲ *IODP drilling ship JOIDES Resolution.*

Geophysicists and geologists from the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, are to gain unprecedented insights into the climatic history of the Antarctic Ice Sheet as part of the International Ocean Discovery Program (IODP). The experts will take part in three Antarctic expeditions onboard the IODP drilling ship 'JOIDES Resolution' and will lead two of the three legs. By collecting the drilled cores, the researchers hope to find evidence of how the ice masses of the Antarctic have reacted to sudden temperature climbs in past interglacial periods – information that is urgently needed in order to more accurately predict future sea-level rise. In terms of modelling, the behaviour of the Antarctic Ice Sheet is still considered one of the greatest question marks.

▸ ***https://bit.ly/2UsPQbH***

MacArtney Expands into New Market Areas

FOCUS and TRIAXUS ROTV systems.

With 40 years of growth and development behind them, the MacArtney Group are growing product lines and continue to strengthen ties within a diverse range of underwater technology industries. Still strongly linked with oil & gas and ocean science, MacArtney is also developing system solutions for renewable energy, defence, civil engineering and fishery industries. The integration of two manufacturing sites; the creation of an operations organization responsible for procurement, supply and service globally, in addition to process enhancements in ERP (Enterprise Resource Planning), IT support tools and IT infrastructure have resulted in a more efficient operation. Through this, MacArtney have demonstrated resilience and continued commitment to strengthening their business platform for future growth.

https://bit.ly/2CTdRS9

€12.8M Awarded to Demonstrate Ocean Energy Farms

North Sea waves.

A new Interreg NWE project, Ocean DEMO, was officially launched on 22 January. Ocean DEMO will provide funding to developers of marine renewable technologies to test their products or services in real sea environments, specifically targeting multi-machine ocean energy installations. This will allow developers to move closer to the market by demonstrating their technologies at full commercial scale. Ocean DEMO will release the first call for applications this year, and devices will be installed from 2020 to 2022. The transition from single machine to pilot farm scale is critical for the future of the ocean energy sector. Scaling up to multi-device farms will improve the competitiveness of the technology by bringing down costs across the supply chain. This transition comes with higher capital requirements and investors now require a proven business case before they get further involved.

https://bit.ly/2DIHcQO

Nigerian Navy Hydrographic Office Establishes New Bathymetric Capabilities with CARIS Software

Commander Okafor and John Stewart.

The Nigerian Navy Hydrographic Office (NNHO) has selected Teledyne CARIS to provide solutions for both current and future national and international charting requirements. Equipped with CARIS Ping-to-Chart technology, the NNHO is establishing new capabilities for bathymetric analysis and completion of hydrographic and other geospatial data. These tools will ensure an efficient workflow for the production of electronic and paper charts according to both the International Hydrographic Organization (IHO) and NNHO standards. The first part of the project was completed in late 2018, with delivery of the software and training at the NNHO office in Lagos. The project will continue into 2019 with professional services from Teledyne CARIS to help ensure a successful launch of their new software infrastructure.

https://bit.ly/2DIhrAa

Swire Seabed Orders HUGIN Autonomous Underwater Vehicle

Kongsberg Maritime has announced that Swire Seabed of Bergen, Norway has ordered a HUGIN AUV System configured for commercial survey applications. The system is rated to 4,500 metres and equipped with Kongsberg Maritime's HISAS 1032 Synthetic Aperture Sonar and EM2040 multibeam echosounder. Other payload sensors integrated in the AUV include the CathX Ocean 48.5-degree field of view still image camera and laser profiler, a sub-bottom profiler, magnetometer and turbidity sensor. To make the best use of the extensive payload sensor suite, the Swire Seabed HUGIN also includes Kongsberg Maritime's automatic pipeline tracking solution, which utilizes the HISAS Synthetic Aperture Sonar or EM2040 multibeam echo sounder to track alongside or above a pipeline, to conduct survey and inspection tasks.

https://bit.ly/2CQoAwK

Kongsberg Maritime HUGIN AUV.

Game-changing Sensor and AI System for Plymouth Sound

▲ *Two Thales USVs entering Plymouth Sound.*

M Subs has installed a 'game-changing' sensor system with connected artificial intelligence (AI) and machine-learning technology around Plymouth Sound, UK, as part of the vision to turn the city into a centre of excellence in maritime autonomy and unmanned vehicles. The Plymouth-based company will operate a secure network of cameras, radars, and other sensors which will provide situational awareness and communications with the unmanned vehicles operating out of the city's harbour. The system will also provide the command & control of unmanned vehicles using the nearby ranges at sea. Data from the network is being collected and analysed by machine-learning programmes by M Subs' growing AI team, with the assistance of Thales, and a leading global corporate partner in the field of machine-learning and AI. The results of this work will finalize development of the computing system at the heart of the maritime AI system to navigate the Mayflower Autonomous Ship across the Atlantic Ocean in celebration of the 400th anniversary of the original Mayflower sailing in 1620.

▸ ***https://bit.ly/2TIX69r***

Tidal Energy Plant Gets Smarter with Data Intelligence Platform

▲ *Sabella D10 Tidal turbine installation.*

Sabella, a pioneering tidal and ocean stream turbine developer, has partnered with QOS Energy to improve the performance monitoring of its Ushant tidal energy project. The first 1MW tidal turbine of the plant, immersed 55m underwater off the west coast of France, is equipped with more than 100 sensors gathering data every five minutes. It now uses QOS Energy's powerful data intelligence platform to identify, assess and anticipate potential failures. Sabella's 1MW D10 turbine was initially commissioned in 2015 in the Fromveur Passage, a strait that lies between Ushant Island and the Molène archipelago, off the coast of the French region of Brittany. After undergoing key technology upgrades, the tidal turbine was redeployed for the second time in October 2018. Once again, the 400-tonne machine lies on the French seabed and captures the tide to provide renewable power to the 800 inhabitants of Ushant island. To optimize the turbine's operation, QOS Energy and Sabella closely collaborated to develop specific data acquisition techniques and innovative analytics tailored to the constraints of the demanding sub-marine environment.

▸ ***https://bit.ly/2TjChv6***

Valeport Sensors Selected for New Micro AUV

▲ *ecoSUBμ-5 SVP in communication mode.*

Valeport has collaborated with ecoSUB who produce a micro AUV that is both advanced and cost-effective. The small and robust sensors are assisting autonomous underwater vehicle (AUV) manufacturers and users to not only get the data they require, but to make AUVs more accessible in the marine environment. ecoSUB is a micro AUV (0.5 metres long) that uses Valeport's sensors to autonomously acquire sound velocity profiles and has been jointly developed by Planet Ocean and Marine Autonomous Robotics Systems (MARS) group at the National Oceanography Centre (NOC) in Southampton. Part funded by Innovate UK and the UK Defence Science & Technology Laboratory, ecoSUB is a disruptive system which aims to democratize the use of autonomous underwater technology in science, commercial and defence applications by using advanced design techniques, materials, sensors, artificial intelligence (AI) and manufacturing methods to produce an affordable yet capable AUV.

▸ ***https://bit.ly/2sTOHOV***

New Official Recognition for Hydrographers

The Institute of Marine Engineering, Science and Technology (IMarEST) has launched a hydrography descriptor for its Chartered Marine Scientist register to allow hydrographers to distinguish themselves by using the letters 'CMarSci (Hydrography)' after their name. No such designation has previously existed and the IMarEST is the only organization that offers the Chartered Marine Scientist register. The hydrography post-nominal has been introduced to reflect the increasing importance of the discipline in allowing the management of future challenges. Every human venture in, on or under the sea depends on hydrographic knowledge. That is a knowledge of the nature of the seafloor, its depth and any hazards that may lie beneath, as well as an understanding of the tides and currents. Obtaining this information is fundamental in progressing within the marine sphere. Only 15% of the ocean floor has been mapped in detail at present and hydrographers are key to not only growing this knowledge but, in doing so, ensuring the preservation of the human race.

▸ ***https://bit.ly/2GaPaEO***

Fugro Receives Award for Efforts to Close Seabed Mapping Data Gap

▲ *David Millar accepting the MTS 2018 Compass Industrial Award.*

Fugro has received the Marine Technology Society (MTS) 2018 Compass Industrial Award for outstanding private sector contributions to marine science and technology. In selecting Fugro for the honour, MTS cited the company's legacy of marine survey innovation and its industry-leading support of the Nippon Foundation-GEBCO Seabed 2030 Project (Seabed 2030). David Millar, Fugro's government accounts director for the Americas region, accepted the award. "We are grateful to MTS for recognizing our efforts with Seabed 2030. Given that a significant proportion of Fugro's work is ocean related, supporting this project is a way for us to positively impact global society and practice good ocean stewardship," said Millar. Seabed 2030 is a collaborative project between Japan's Nippon Foundation and the General Bathymetric Chart of the Oceans (GEBCO). It aims to produce a definitive, high-resolution bathymetric map of the entire world's ocean floor by the year 2030. The resulting data will be used to inform global policy, improve the sustainable use of the ocean and advance scientific research. Meeting the project goal demands strong industry support, as less than 20% of the ocean is currently mapped to modern survey standards.

▸ ***https://bit.ly/2TjCzSI***

L3 OceanServer Awarded General Services Administration Schedule Contract

▲ *Iver3.*

L3 OceanServer has been granted a five-year General Services Administration (GSA) schedule for its Iver3 Unmanned Undersea Vehicles (UUVs). The GSA schedule gives registered government agencies a simple path to procure Iver3 UUVs using pre-established pricing and terms & conditions. A contract was awarded for two Iver3s with associated training, effective 19 December 2018. "L3 OceanServer is pleased to receive this GSA schedule and contract award. GSA schedules provide shorter procurement cycles for federal purchases to streamline ordering processes," said Daryl Slocum, general manager of L3 OceanServer. "This award will allow us to develop existing customer relationships and build new ones."

▸ ***https://bit.ly/2DW6Ba9***

Marine-i Welcomes Important New Tender Opportunities

▲ *Example of a floating wind turbine.*

Marine-i has applauded the announcement of three new tender opportunities in the floating offshore wind energy sector. Partly funded by the European Regional Development Fund, Marine-i was set up to promote marine innovation in Cornwall and the Isles of Scilly, UK. The three tenders have been announced by the Carbon Trust and are all designed to help improve technology in the floating wind energy sector. The Carbon Trust is inviting proposals from innovative marine companies to tackle three key development areas. The first tender is to identify and evaluate innovative mooring systems and anchoring solutions. The second requires companies to investigate the drivers behind port-to-port maintenance strategies for floating wind farms. The third tender is to assess the feasibility and required technology for heavy lifting offshore operations at a floating wind farm.

▸ ***https://bit.ly/2DVvCC9***

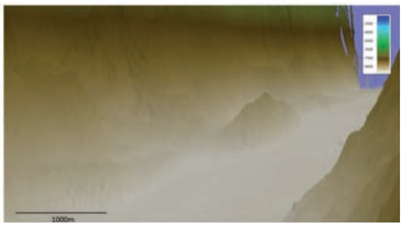
Oil Sensor-equipped Smart Buoy Delivers Data via Satellite

▲ *The yellow Smart Buoy, located south of Helsinki.*

A smart navigation buoy system has started delivering real-time measurement data via satellites of oil and some other water quality parameters in the Baltic Sea. It is located south of Helsinki in the Gulf of Finland. The monitoring data gives many advantages to oil spill response teams and helps revealing illegal oil discharges. The system is part of SYKE's Grace project cooperation and is manufactured by Meritaito. The data is freely available online. The real-time remote measurement is a big advance in oil detection and environmental monitoring. It is significantly quicker with satellite data transfer and can provide more accurate data compared to old systems. A network of oil detecting smart buoys could easily be used to form an early warning system for oil pollution. The sooner oil spill response is started, the better the results.

▸ ***https://bit.ly/2DbNved***

Sonar Plays Integral Role in First Human Reaching Deepest Point in Atlantic



▲ *The Puerto Rico Trench was mapped to depths greater than 8,000 metres.*

Kongsberg Maritime has announced that the EM 124 sonar, installed aboard the DSSV Pressure Drop, played a key role in the deepest solo human submersible dive completed by the Five Deeps Expedition. Expedition founder and submersible pilot, Victor Vescovo, reached the bottom (depth of 8,376 metres) of the Puerto Rico Trench in his private submersible, the Limiting Factor, following precision mapping of the ocean floor completed by the EM 124. The Kongsberg EM 124, released in 2018, is the fifth generation multibeam system from Kongsberg Maritime and the successor of the EM 122. It is a modular multibeam echosounder that performs high-resolution seabed mapping from shallow waters to full ocean depths (11,000m) with unparalleled swath coverage and resolution. It has a broad range of functionality, including the simultaneous collection of seabed and water column imagery. This capability saves time and increases efficiency during the planning, execution and analysis phase of a mission. The low-noise electronics are compact and flexible in design for easy installation and integration into a vessel of any size.

▸ ***https://bit.ly/2RGFDqz***

CGG and TGS Announce Greater Castberg Survey in Barents Sea

▲ *Barents Sea.*

MCGG and TGS have announced the Greater Castberg TopSeis survey in the Barents Sea. The survey is 5,000 sq km and will be acquired and processed with the latest CGG TopSeis acquisition and imaging technology. The survey will include the highly prospective Castberg area and cover existing and newly awarded licenses in addition to open acreage with several play models in multiple geological layers. The acquisition is expected to commence late Q2 2019 with final delivery to clients in Q4 2020. The project is supported by industry funding. Kristian Johansen, CEO, TGS, said "Greater Castberg will expand the great TGS data coverage in the Barents Sea. The survey sits in the right place of the Barents Sea, and production licenses will start producing from this area in 2022. The area calls for high-technology solutions and a tailor-made solution, for this area is created in close collaboration with clients and within the joint venture."

▸ ***https://bit.ly/2SpHLbb***

Depth of Burial – Galloper Offshore Wind Farm

Galloper Offshore Wind Farm is a 353MW wind farm project located 30km off the coast of Suffolk, UK. It is now in full operation and each year will generate enough green electricity to power the equivalent of more than 380,000 British homes. The construction of the wind farm created almost 700 UK jobs and its operation has created around 90 direct and indirect long-term jobs in the local area. A 60-strong team will operate and maintain the wind farm day-to-day from a base under construction in Harwich International Port.

There are 56 wind turbine generators (WTGs) located in water depths ranging from 27 to 36 metres, each of which are connected with a 33kV buried subsea array cable to a 33kV/132kV offshore substation. In June 2018 Bibby HydroMap were commissioned by Innogy Renewables UK Ltd to carry out a depth of burial survey along each of the inter-array cables on the Galloper Offshore Wind Farm. The objectives of the survey along each inter-array cable were to:

- Determine the depth of burial
- Assess the level of scour protection
- Identify any areas of exposure or free span
- Investigate the surrounding seabed to track changes to the environment

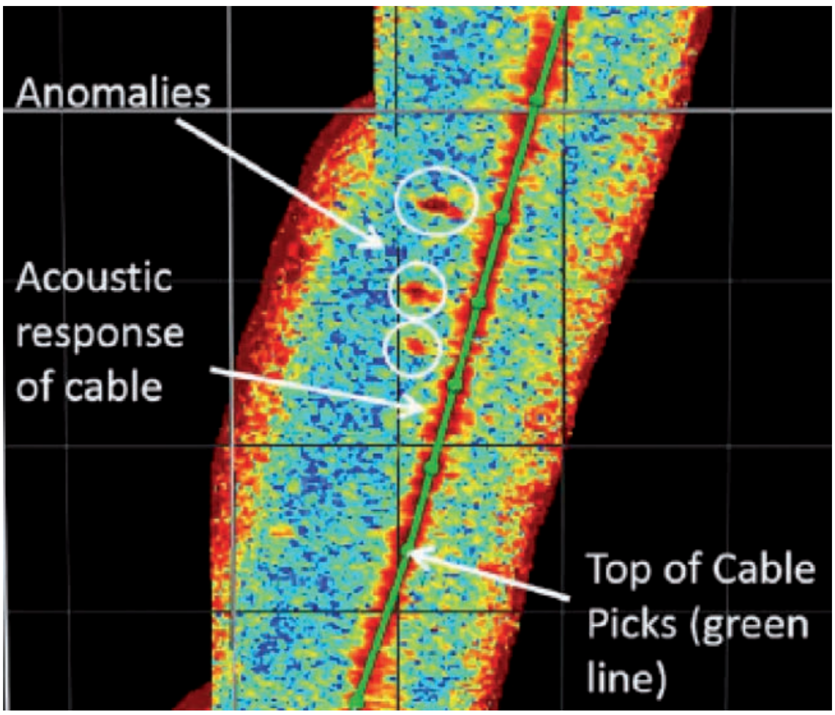
There were two main challenges of the survey which had to be overcome. The first was that each of the inter-array cables had to remain in service throughout survey operations, limiting the survey techniques capable of measuring the depth of burial of the cables. In addition to this, the cables were 33kV inter-array designs, which have a smaller cross-sectional area than other higher voltage cables.

▲ *Galloper Offshore Wind Farm location.*

Survey System

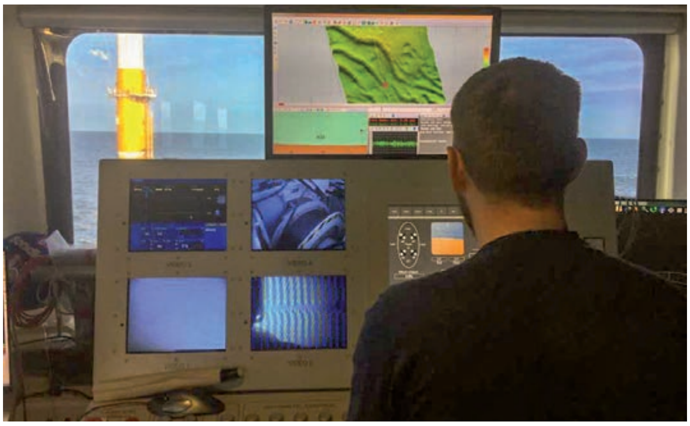
The survey was carried out from Bibby HydroMap's survey vessel Bibby Athena, a 27.5m semi-SWATH (Small Waterplane Area Twin Hull) vessel. The vessel has a pair of iXblue HYDRINS inertial navigation systems (INS) as well as an integrated dual head Teledyne RESON T50 multibeam system. Bibby Athena is capable of DP1 operations, allowing it to deliver exceptional line keeping to accurately follow the cables. For this project, Bibby Athena was equipped with the survey ROV d'ROP and Pangeo Subsea's Sub-bottom Imager (SBI). In addition to the depth of burial equipment, a dual-head Norbit WBMS multibeam echosounder was also mobilised simultaneously on d'ROP.

The SBI uses advanced acoustics to provide a real-time view of the sub-seabed in full 3D, as a continuous longitudinal path measuring 5m wide by 7m deep of the seabed. The SBI integrates with industry standard survey



▲ *Plan view of the Pangeo SBI data.*

▲ *Pangeo SBI mobilised to the d'ROP skid.*



▲ *d'ROP console with a view of Galloper's sister project Greater Gabbard from the bridge of Bibby Athena.*

software to delineate shallow discrete objects, stratigraphy and geohazards with decimetre resolution.

The SBI uses beam forming and synthetic aperture processing to delineate sub-seabed stratigraphy, buried infrastructure, and buried geohazards with a depth-dependent spatial resolution that is a function of the type of seabed.

Key SBI benefits for cable tracking includes:

- Providing accurate and repeatable depth of cover data that clearly shows situations where remedial engineering is required
- Provision of accurate location and size estimates of large objects, such as boulders, adjacent to pipelines and cables
- No need to magnetize and/or apply a tone to the cable
- Surveys can be carried out on energised cables

Deployed vertically below the vessel through the moonpool, d'ROP derives primary positioning through a combination of the vessel's DP system and a heave compensated umbilical winch and combined Launch and Recovery System (LARS). The unit is then able to make fine adjustments to its position using the four onboard thrusters. Overall, this allows d'ROP to either stay on station or follow a set line allowing the system to operate at a fixed height above the seabed to maximise data quality.

d'ROP is capable of small amounts of lateral movement away from the vessel whilst deployed, however, this is limited to approximately 10m and varies with water depth. In addition to the Pangeo SBI, d'ROP can optionally be fitted with the Teledyne TSS350 cable detection and tracking system along with other depth of burial systems; HD cameras can also be utilized.

Survey Design

The survey methodology involved a two-pass solution along each of the inter-array cables. The first pass involved utilising the vessel's mounted integrated dual-head multibeam echosounder system to undertake a reconnaissance survey to ensure the highest levels of QHSE were maintained ahead of deployment of d'ROP. This was to ensure the wider seabed surrounding each cable and turbine foundation was clear of any debris or hazards which could pose a risk to d'ROP, as well as assessing recent bathymetric changes. In addition, it enabled insonification of the wider area providing additional data which can be used during future comparison surveys.

The second pass involved utilising d'ROP at a constant altitude of 3.5m to acquire simultaneous high-resolution depth of burial and multibeam echosounder data along each of the cable routes. Due to the required flying height and the custom mounting design of the multibeam systems, a bathymetric data corridor of approximately 20m was visualised with ultra-high resolution, with the cable at the centre, as well as a full 3D volume of acoustic depth of burial data.

During operations at the Galloper Offshore Wind Farm, depth of burial data beginning from the point where the cable protection system entered burial was required – this was observed at an average distance of 25m from each WTG location. Maximum coverage was achieved using a combination of the DP system and the manoeuvrability of Bibby Athena. In addition, the high resolution multibeam echosounder data acquired during the first pass enabled further visualisation of sections of cable before entering burial.

Processing

Over 140km of SBI data was acquired over the 56 inter-array cables at the wind farm throughout the survey. The acquired SBI volumetric data was processed within Pangeo's 'Pilot Console' software package, and then in-house interpretation was carried out using EIVA Navimodel. All multibeam data was processed in-house utilising QPS Qimera software.

The SBI data was rendered at a voxel (3D bin) resolution of $10cm^3$ to ensure the cables were identified accurately. The 3D sub-bottom images were analysed, and the acoustic response of the buried cables were used to identify the top of the cable.

On this particular site, seabed conditions and the geological makeup of the site meant that some regions exhibited a very hard seafloor with the presence of cobble clusters, limiting the amount of acoustic energy able to penetrate down to the cable and giving rise to frequent acoustic anomalies requiring additional processing and interpretation which was also completed in-house. In addition to the required data, it was also possible to provide information on which occurrences were located very near to the cables for future reference. There was no evidence of such anomalies impinging directly onto any of the cables, so it is thought that the cobbles must have been pushed aside during cable installation. ◀

Amy Gresty started her career as an offshore geophysicist and now works in the commercial department at Bibby HydroMap. As well as being responsible for tender evaluation and proposal creation, she takes an active role in contract negotiation and vessel programming.

Teledyne Gavia – Recommends **Gaps for Tracking AUVs**

Accurate positioning is a key challenge for any underwater operation. Unlike ground systems that can rely on signals from global satellite navigation systems (GNSS), survey grade autonomous underwater vehicles (AUVs) have no access to such signals and need to be equipped with high-end Inertial Navigation Systems (INS). This enables accurate positioning of vehicles operating underwater by combining reliable data retrieved by gyroscopes, accelerometers, and Doppler Velocity Log (DVL).

On the surface, an INS will incorporate GNSS signals to set its initial position but will eventually accumulate navigational errors leading to drift when operating underwater for long periods of time. In addition, when operating in deeper waters, the DVL does not initially have bottom lock and cannot provide accurate velocity information, if any, when the vehicle descends through the water column. This can add a significant error to the position estimate from the INS. To address these limitations, acoustical position aiding systems like the ultra-short base-line (USBL) can be used.
TELEDYNE GAVIA recently carried out a series of tests using the iXblue Gaps USBL system as a positioning solution for the tracking of their AUVs. Shallow and deep-water tests were conducted, and both recorded very accurate positions together with simple integration and operation.

Gaps

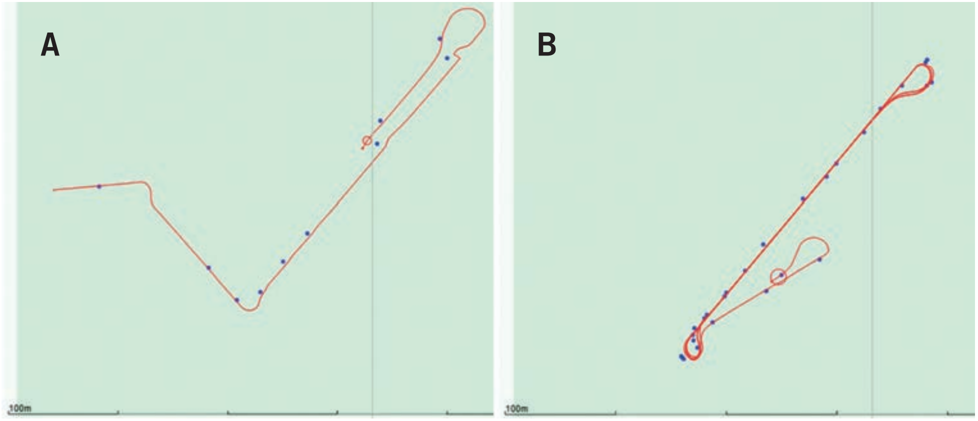
Gaps is a high performance integrated underwater positioning solution which makes USBL underwater positioning extremely simple to operate from any vessel, using a portable and truly pre-calibrated USBL head coupled with internal INS and GNSS.
Gaps measures the absolute position of one or more subsea objects or vehicles which can navigate at depths down to 4,000 metres, with 200 degrees hemispherical coverage below the antenna. Depending on environmental conditions, the positioning accuracy can reach up to 0.06% of the slant range. These objects or vehicles are located using acoustic transponders or beacons and a subsurface acoustic array (Gaps head) typically deployed below the ship hull or from any surface platform.
Gaps is used for tracking subsea devices (ROVs, AUVs, structures, tow fish, divers…) and for dynamic positioning applications when transponders are fixed on the seabed.
Gaps (an all-in-one system) can provide the position of a surface vessel and several subsea vehicles or divers at the same time. It also provides a very accurate heading and attitude for the surface vessel with the highest accuracy and performance in shallow or extremely shallow water depths thanks to its unique receiving antenna design and enhanced digital signal processing techniques.
Gaps is a lightweight portable system that does not require any complicated or time-consuming installation (due to an all-in-one pre-calibrated system) and features very high-performance thanks to data fusion of acoustic, inertial and GNSS technologies. Finally, Gaps has no limit in terms of operational area (shallow or deep water, horizontal or vertical channel, short or long range).

Shallow Water Tests

The shallow water tests were run in the North of

the Snæfellsnes peninsula in Iceland in February 2017. The trials were carried out at around a depth of 200 metres using the Gavia AUV equipped with iXblue Rovins INS.
The surface vessel used for the trials was fitted with a side pole to put the Gaps antenna on. The Differential Global Positioning System (DGPS) used provided a surface position accuracy of 0.5m.
Gavia was made of five modules: propulsion, control module, iXblue Rovins INS/DVL module, battery module and nose module. The DVL was an RDI 1,200kHz Workhorse. A 1310A transponder and a Benthos modem were also fitted on top of the AUV.
The Gaps pinged the transponder installed on the Gavia and sent the estimated position of the transponder to the acoustic modem. The AUV position was transmitted via acoustic down to the Gavia. The Gavia then transferred the message that contained the position to the INS.
The use of Gaps USBL and Rovins INS did not require any modification of the data since Rovins could directly accept timestamped positions from the Gaps and could also be configured with a lever arm describing the offset to the beacon transducer.
When the Gavia received a USBL message, a response message was sent to the surface modem containing status information from the AUV. This information was then displayed in the Gavia Control Centre.
To evaluate the USBL performance, a node equipped with a beacon was deployed as a target. The node was being surveyed from the surface using Gaps to estimate an accurate position for the target (box-in).
After this position was estimated, the AUV executed a short mission to the seafloor. The objective was to provide better information of the seafloor topography and collect a Sound Velocity Profile (SVP) in the operation area. The SVP was then input into the Gaps.
When the target location, seafloor topography and SVP are known, several USBL aiding missions are executed. The side scan sonar is used to detect the target and other features on the seafloor. This allows for an estimation of the navigational accuracy when aided by USBL.
The below figure represents the trajectory of the AUV. Figure A shows the start of mission displaying USBL fixes resulting in large corrections by vehicles that do not have a water track. Figure B shows the path of the vehicle when it has reached the bottom and the DVL acquires bottom track.
After the mission, the side scan sonar images were analysed, and the target position estimated from the sonar records. The standard deviation and average positions of the target were compared to the target position as calculated from the box-in data.

A total of 50 observations of the known target were made during USBL aided missions. Analysing these as a combined dataset gave an as found position of 1.47 metres from the box-in position, with 2.9 metres 2DRMS (95% circular error probability).
For the un-aided shallow water dives, navigation errors can easily reach 20 metres. While using the USBL aiding, the error accuracy goes down to 1-2 metres. This shows the benefits of using USBL aiding.



The blue dots are USBL fixes and the red line is the real-time INS position.

Deep Water Tests

The deep water tests were run off the coast of San Diego, California, in October 2017, at a depth of 575 metres.
The combined Gavia and Gaps USBL system successfully provided repeatable positioning of the AUV. The positional difference between the USBL and sonar averages were within 1 of the USBL position estimate and was one metre from the real location, estimated by box-in.
The performance and repeatability of the AUV positioning could be improved further with the use of a more accurate DGPS feed to the USBL head, and firmware support in the Rovins for lower DVL error values.

Vessel used for shallow water trials.

INS	iXblue Rovins	Inertial navigation system for the navigation of the AUV
USBL transponder	APPLIED ACOUSTICS 1310A	Reply to USBL interrogation
Acoustic modem	Benthos SM-975	Receives USBL telegrams and transfers it to the INS + acknowledge with AUV status
SVP	OEM MiniSVS	Sound velocity probe with temperature sensor
Side scan sonar	Edgetech 2205	Provides image of the target

List of equipment fitted on the AUV.

Find and Compare the Newest AUVs

KONGSBERG

Hugin Superior - The most advanced and capable commercially available AUV

Designed as the most capable AUV, HUGIN Superior carries a comprehensive suite of payload sensors enabling it to be used for geophysical, hydrography, environmental and defence applications. It offers the best data quality and coverage coupled with the most accurate navigation and positioning solution there is. Packaged as a complete system, HUGIN Superior carries more sensors than ever before over greater distances enhancing productivity and cost effectiveness.

HYDROID A KONGSBERG COMPANY

New Generation REMUS 6000

With an unrivaled heritage for reliability, the New Generation REMUS 6000 is a flexible, high endurance, modular AUV that provides precise navigation. It enables the addition of multiple payloads and has expansible energy for long missions. Utilizing the proven launch & recovery system, it can be containerized and operated in mid-ocean conditions from the side or aft of a vessel.

Iver4

L3 OceanServer's Iver4 UUV offers users a new 300-meter workhorse system featuring long duration capability: 40 nm with standard NiMH battery pack. Iver4 comes equipped with industry leading tracking and safety communications, high accuracy navigation, 200m bottom-lock DVL, precise and repeatable measurements and low drag side scan and bathymetry transducers.

L3 OceanServer

SeaExplorer X2

The SeaExplorer X2 is a next-generation glider designed for a large range of oceanographic, defense and oil & gas applications. Its rechargeable battery and its fully-interchangeable payloads greatly simplify its maintenance and enables huge savings of time and money, making it the glider with the lowest cost of ownership in the market.

ALSEAMAR ALCEN

SEARAPTOR

The SEARAPTOR is a new survey grade deep water autonomous underwater vehicle (AUV) from Teledyne Gavia, designed to operate at abyssal depths. A wide range of sensors allow the SeaRaptor to support a variety of applications, such as search and recovery, salvage, exploration, construction support, marine archaeology, and oceanography.

TELEDYNE MARINE Everywhereyoulook™

Hydro International Business Guide 2019

5 Questions to...
Geoffrey Lawes, iXblue

To gain real insight into today's hydrographic business landscape, Hydro International asked some of the sector's most influential companies for their opinions. This series of Q&As focuses on the current state of the industry from various perspectives, such as which technological developments will have the most impact on the market, which market segments are the most promising and which areas offer the most growth. Here, Geoffrey Lawes, regional sales manager Australasia at iXblue, shares his views of and expectations for the business.

How do you expect the hydrographic market to evolve over the coming year?
With capable autonomous survey vessels entering the survey market and being proven as significant drivers of improved efficiency, safety and data quality, all surveyors will need to invest in autonomous capabilities to remain viable. This may result in a widening capability gap between small and larger operators. Some current operators could be priced out of the offshore market as they may not have the capital to invest in offshore USV technology and will not be able to compete on price using their manned systems. Smaller operators will seek to improve inshore survey efficiency with small aerial drones conducting littoral zone Lidar/ photogrammetry and small USVs for ports, infrastructure and approaches.

In what ways could the ocean technology industry benefit from artificial intelligence and/or machine learning?
The industry already benefits greatly from improved AI capabilities in unmanned systems. AI in the form of image recognition and collision avoidance behaviours has permitted the rapid growth in the USV market. USVs enable large-scale hydrographic surveys with high positioning accuracy and low operating costs. Furthermore, there is rapid uptake of machine learning in processing systems (such as the Bayesian Estimator in CUBE). The focus on AI over the next 12 months will likely be on vehicle control systems and sensor control systems. Improvements in machine learning in these systems will permit real-time autonomous optimisation of both survey coverage efficiency and data quality.

How is your company addressing the market for autonomous vehicles?
iXblue is distinguished as one of the only organisations conducting large-scale autonomous blue water nautical charting surveys with our own commercial autonomous vehicle technology. Most other market participants are still operating autonomous systems in an R&D capacity or using them for seabed search or other secondary survey-related activities. iXblue, by contrast, has used its knowledge of survey operations, navigation systems and sonar to conduct commercial navigational safety surveys using autonomous vehicles as the primary tools of trade. iXblue has commercialised all of the related technology so that others may benefit from the same application of survey expertise in their own autonomous vehicle programmes.

What could governments do to support the new market for automated surveying?
Government funding and influence has been heavily fragmented throughout the autonomous market due to a lack of clear strategic guidance. The majority of government funded capability demonstrations (typically in the Defence domain) target systems that are not ready for market and in many cases, will not be commercially viable in the long-term. Government funding should be targeted directly to accelerate unique technologies that are relevant to a long-term, well-articulated strategic requirement, rather than the current scattershot approach. A good industrial strategy, well communicated, will assist providers of autonomous systems to understand how best to invest to achieve sustainable product lines.

What is the main technological advancement to watch for in the future?
Low-cost, worldwide, high-bandwidth satellite internet services. Emerging ventures from SpaceX and LinkSure, for example, aim to deliver low-cost, low-latency, and high-bandwidth internet access to 100% of the Earth's surface using adaptive laser networks of low earth orbit satellites. This type of infrastructure will be invaluable to monitor, control and retrieve data from large networks of autonomous survey vehicles of all types in a cost-effective manner. ◂

Real-time Validation of CoVadem Derived Water Depths at Locations with a Fixated Riverbed

CoVadem has created an up-to-date depth chart of inland waterways. The underlying data obtained came from vessels participating in the CoVadem initiative, each sharing their sensor data in the CoVadem cloud-based processing environment. To make sure the underlying data is both accurate and reliable, we need a method that automatically filters out erroneous measurements. This article presents a method in which measurements are compared in real-time at locations with a fixated riverbed (e.g. not eroding or aggrading over time).

Measurement and Post-processing Method

A growing fleet of roughly fifty vessels participating in the CoVadem initiative continuously measure, log and broadcast data from onboard sensors. The underkeel clearance is measured with a single beam echo sounder, the vessel position with a GPS meter, and vessel draught with a ship cargo meter (a calibrated system of pressure sensors). A video explaining the initiative in more detail can be found at www.youtube.com/watch?v=iMkkHisD4dY.

All collected data is then processed and combined into a chart displaying up-to-date water depths of inland waterways in a cost-effective way. Using hydrodynamic and hydrological models, we enrich the data with a forecast of the water depth. As such, it becomes possible to optimize cargo volumes and sail more efficiently (e.g. Bons et al, 2016).
The vessels participating in CoVadem are no official survey vessels with a correctly set-up, well-calibrated measuring system on board. Therefore, CoVadem does not aim to reach the precision of an official survey. However, the measurements are performed continuously so that the information about the riverbed is always up-to-date, including in dynamic locations or locations that are not surveyed with multibeam equipment. Even more information about the riverbed can be obtained when looking at the trends of the measurements since the latest available multibeam measurement.

Current Post-processing of Measurements

Millions of measurements a day are translated into water depths using a ship squat calculation. Squat is the increased draught due to the flow of water past the ship hull (Figure 1). The forward speed of the ship pushes the water in front ahead, which then must return at the sides and below the ship, resulting in the increased speed of the water, which, due to the Bernouilli effect induces a decreased pressure underneath the ship. This results in a water level depression in which the ship sinks (sinkage). The effect is not spread equally over the ship due to the local changes in the ship hull over its length – this can cause the ship to trim. Ship squat is the combination of sinkage and (dynamic) trim.

Within the CoVadem initiative, the underkeel clearance is measured at the echo sounder location with the position known by all participating vessels. Figure 2 shows that the fairway depth (water depth) at this location can be calculated by the summation of measured

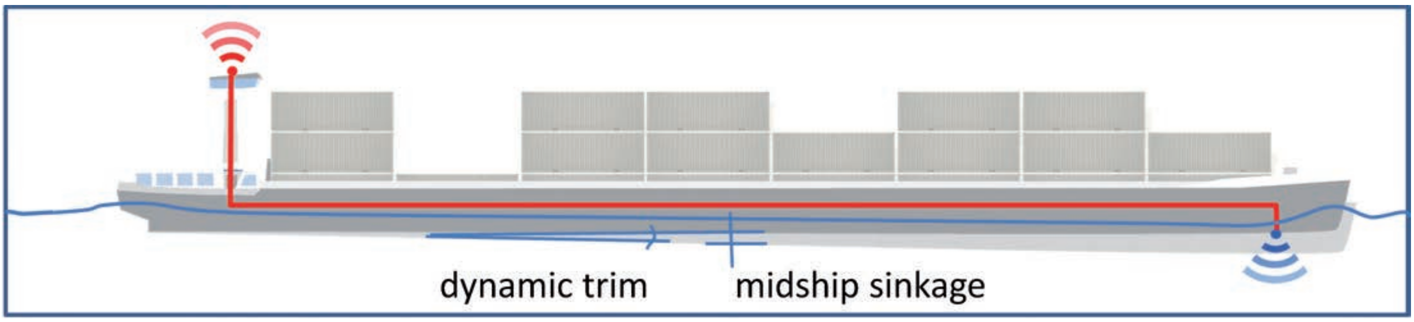


Figure 1: Squat is the combined effect of sinkage and dynamic trim.

underkeel clearance, ship squat and initial zero speed draught.

Validation Results

CoVadem water depth data is validated with multibeam data. To this purpose, the determined water depth should be translated to a riverbed level (Figure 3). This is done by subtracting the measured water depth from the water level of a nearby water level gauge.

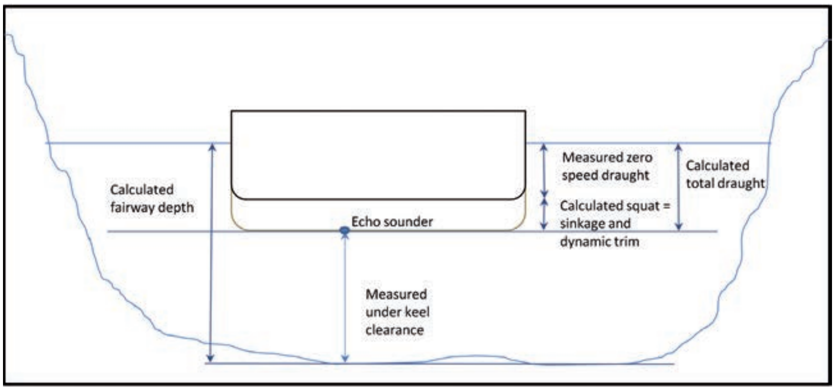
By comparing the riverbed level from CoVadem to multibeam data, we have shown that the average absolute error is around 20cm (Van der Mark et al, 2015). This validation was performed at locations for which recent multibeam measurements were available (Dutch Rhine branches Bovenrijn and Waal).

Outstanding Challenges

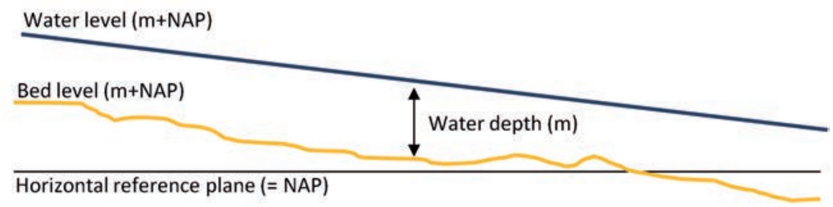
Sometimes, the measurements are incorrect due to problems with the equipment. A structural vertical offset can also be seen, for instance due to equipment settings. To make sure the depth chart is created from accurate data only, we need a method that (a) automatically filters out erroneous data, and (b) corrects the data to minimize the vertical offset. Such filtering and correction algorithms should be applied continuously, as a vessel that measures correctly today, might measure incorrectly tomorrow because errors in the sensors can occur at any moment.

Proposed Real-time Validation

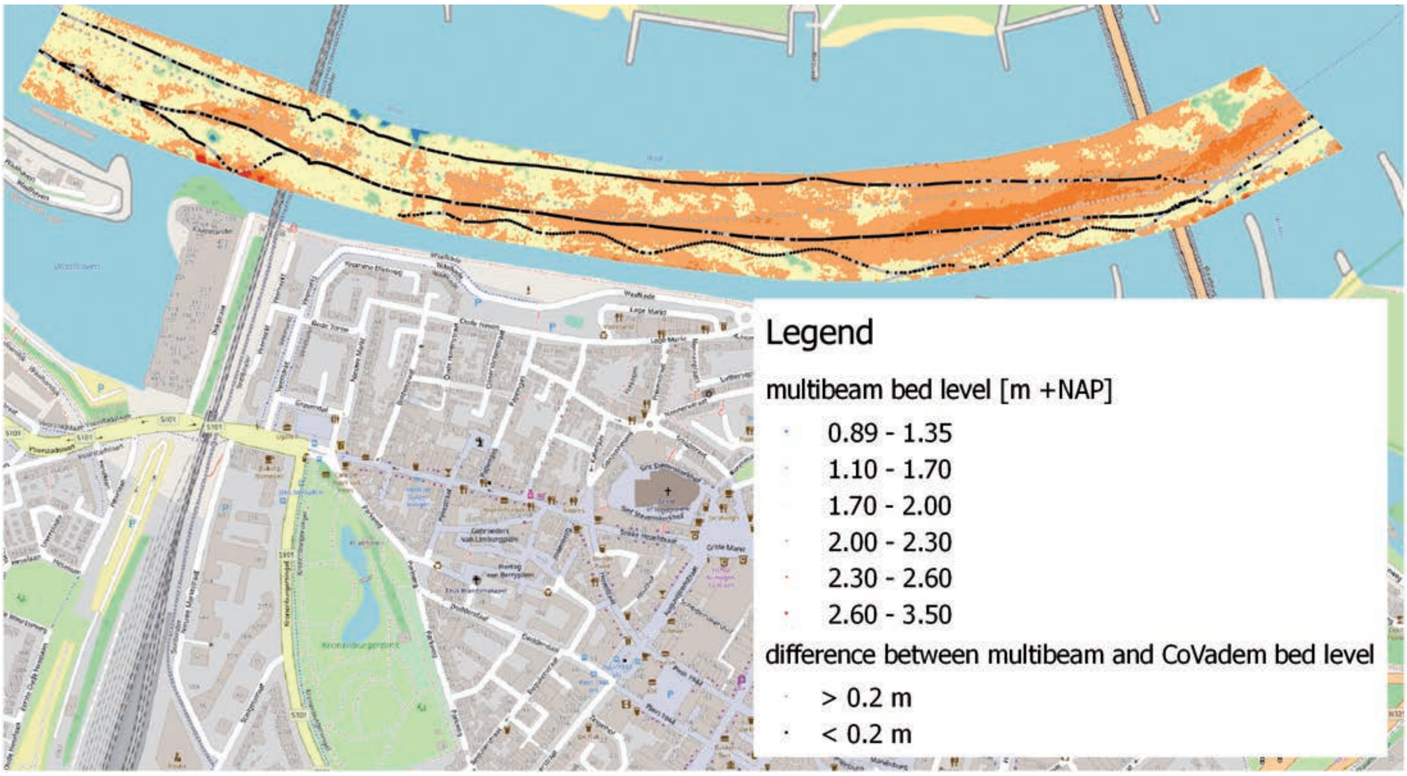
In the Netherlands, the river Waal is one of the main inland transport corridors. The river has an alluvial character, with erosion-sedimentation processes and dunes that migrate quickly over the riverbed. However, the bed level is more or less constant in time at the bends near Nijmegen and St. Andries. The riverbed has been fixated in these two bends to guarantee sufficient water depth over the entire navigation channel by creating an immobile layer of large



▲ *Figure 2: Effect of sinkage and dynamic trim on the total ship draught.*



▲ *Figure 3: Definition sketch – note that both bed level and water level (and thus water depth) in rivers vary in time and space.*



▲ *Figure 4: Comparison of CoVadem data with multibeam data for all measurements of the five vessels passing the fixed layer in the river Waal near Nijmegen on 29 October 2016.*

stones. This results in the riverbed not eroding or aggrading over time at these locations. In the Netherlands, these locations are often referred to as 'fixed layers'.

The CoVadem collected data is then compared in real-time at certain riverbed locations with a fixed layer. Officially acknowledged multibeam measurements are only performed a limited number of times a year, so only at locations with a fixed riverbed can these measurements be used for validation purposes for a longer time span.

The river bend near Nijmegen was selected as the starting location for the real-time water depth validation. Rijkswaterstaat (the maritime authority responsible for, amongst others, management and maintenance of the fairway) performs multibeam measurements of the Waal bi-annually.

Description of Method

The proposed method can be used at locations that fulfill the following requirements:
1. There is a fixed layer in the riverbed
2. The water level is available from a nearby water lever gauge
3. The majority of the CoVadem fleet passes the location on a regular basis

Every passage of a vessel over a fixed layer is automatically categorized and selected. The water level of the passage is then looked up and after a correction for the slope of the river, the riverbed level is calculated. This calculated riverbed level is compared with the riverbed level of a multibeam measurement at the same location.

Results Obtained by this Method

After comparison of the riverbed level at the fixed layer in the bend near Nijmegen, we are able to distinguish between vessels that produce erroneous or non-erroneous data for the current passage of the fixed layer. CoVadem aims at water depth measurements with a 20cm accuracy. Figure 4 and Figure 5 show that most measurements are within the intended accuracy.

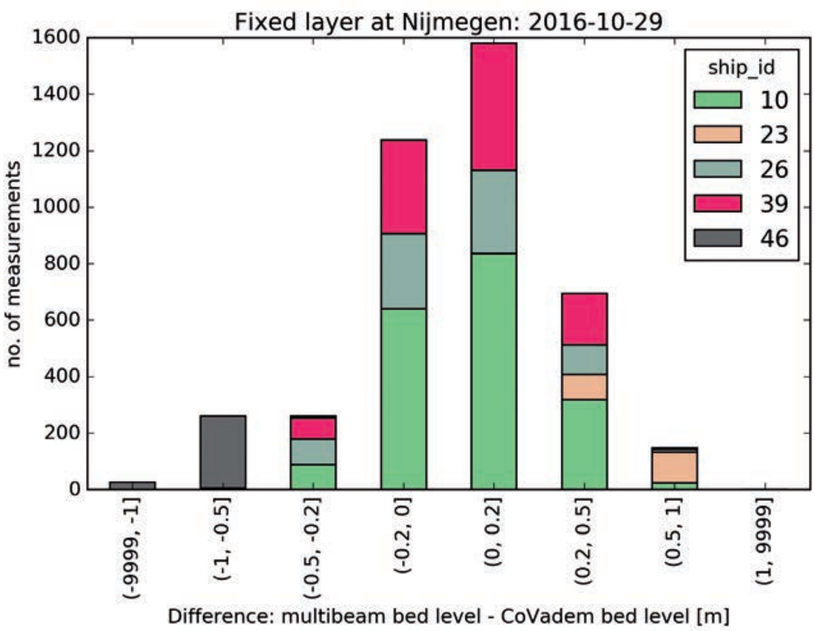
Potential Improvements due to this Method

The presented validation method is first and foremost established to filter out erroneous measurements and applying it to the system will ensure that only accurate data is used in the following analyses.

It also enables us to further improve the ship squat calculation and the hydrodynamic model for the riverbed forecast. It becomes possible to calculate the difference in riverbed levels from CoVadem and multibeam measurements for different versions of the squat algorithm over a longer time span so that it is possible to check whether the new squat algorithm outperforms the old one before it is rolled out in the production environment.

Future Possibilities of Real-time Post-processing
This real-time validation method can be used in other locations with a fixed bed level. Possible locations include the rocky riverbed in the Upper Rhine in Germany, and in hydraulic structures, such as locks, offer the possibility of automated validation.

In the future, when the nature of the most critical erroneous measurements are understood, we will continue development towards implementation of real-time calibration of water depth measurements to correct for a structural vertical offset. This allows for the creation of more accurate depth charts without having to perform expensive calibrations onboard of the individual participating vessels. ◀



▲ *Figure 5: Comparison of CoVadem data with multibeam data for all measurements of the five vessels passing the fixed layer near Nijmegen on 29 October 2016.*

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Ir. A. (Anke) Cotteleer studied marine technology at Delft University of Technology. She started her career in the offshore industry as a marine engineer at Heerema and later at Aker Solutions where she was responsible for calculations regarding the design and installation of offshore platforms. Since 2010, she has worked at MARIN and performs research on marine traffic flows. Currently, she is involved in the CoVadem initiative as a data scientist.

Dr. Ir. C.F. (Rolien) van der Mark studied Civil Engineering at Delft University of Technology. She did her PhD research at Twente University on river bed forms. She is an expert in the field of inland shipping and river dynamics at Deltares where she is responsible for the portfolio and R&D programme 'Inland waterways'. She has been involved in and in charge of consultancy and research projects dealing with navigability of inland waterways, river hydraulics and morphology and numerical modelling. Van der Mark is involved in the Dutch CoVadem initiative in which a fleet of inland ships continuously measures underkeel clearance, and this data is aggregated in a smart way and given back to the skippers for the purpose of more efficient sailing. Examples of other projects are the effects of measures on maintenance dredging, impact of drought on navigation in the Dutch rivers, impact of larger ships and propeller jets on bed and banks of the Gouwe. Furthermore, she is involved in the development of a Deltares Toolbox for River and Inland Shipping.

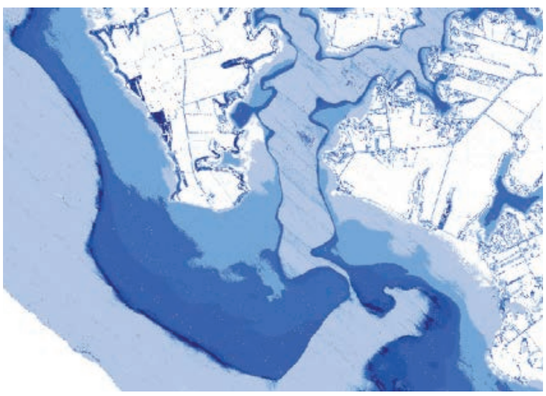
Web GIS Improves **Lidar Collection Response Time**

The remarkable capabilities of airborne Lidar continue to improve, with scanners now able to emit more than a million pulses every second. Although it has never been easier to acquire high-quality laser data, storing and managing the huge volume of Lidar data collected can prove to be a challenge. Combined with associated metadata such as survey information, environmental conditions and flight lines, data management has now become a critical priority and focus. This article outlines an initiative called the Lidar Management and Analytical Processing (LMAP) that provides an automated workflow for uploading and storing Lidar and metadata into a Geographic Information System (GIS).

Developed in a partnership between RIEGL, a manufacturer of ultra-high-performance Lidar scanners, and Esri, creator of the ArcGIS platform, the LMAP initiative provides an automated workflow to upload and store Lidar and metadata into a GIS. Once organized and managed using standard GIS functionality, LMAP utilizes web applications to visualize the information on a map and perform a range of analysis. As a user of both RIEGL and Esri technologies, North American geospatial-only solutions provider Quantum Spatial Inc. (QSI) decided to implement LMAP to improve project data management and provide a venue for clients to quickly and easily provide feedback on Lidar collection quality and completeness.

Bathymetric Lidar

Lidar is a survey measurement technique that uses light in the form of emitted laser pulses to measure distance, resulting in accurate 3D models of the Earth. These models have a wide variety of uses and applications, including in engineering, town planning, mining, archaeology, computer vision and environmental monitoring. Bathymetric Lidar is a Lidar scanning technology that penetrates the water column to measure seafloor depths. To map Chesapeake Bay in the USA for a client, QSI selected RIEGL's VQ-880-G, a fully integrated airborne scanning system for combined hydrographic and topographic surveying. Offered with an integrated GNSS/IMU system and camera, the VQ-880-G also houses both a green laser that penetrates shallow water for seafloor measurements and an infrared laser for improved capture of the water surface. This results in millions of Lidar points collected of the ground, vegetation, water surface and seafloor.



▲ *Esri's ArcGIS platform offers a variety of options to display and visualise 2D and 3D data including the key derivative terrain and surface models created from the bathymetric Lidar.*

Results of a bathymetric Lidar survey are dramatically impacted by the environmental conditions at the time of acquisition, specifically water quality and turbidity. To record these conditions and to validate the Lidar, field personnel take measurements during the collection and monitor water quality data transmitted from nearby buoys.

Timely Client Feedback

In February 2018, QSI collected topo-bathymetric Lidar and aerial photography over the extensive river delta regions of Chesapeake Bay within the states of Virginia and Maryland to generate improved shoreline and bathymetry data. This data provides highly accurate information of the bay's geographic features for official shoreline characterization, nautical charting, geodesy and marine resource management assessments. Environmental factors such as water quality and weather were closely monitored to ensure data collection only occurred during peak windows to guarantee the highest-quality data possible. Additional information was also collected, such as aircraft flight lines, survey ground control locations and photographs from the flight. All this information was shared with project stakeholders in different locations using a variety of computing devices.

Getting timely client feedback on the quality and acceptance of the Lidar data collected is a critical success factor in these types of projects. Long turnaround times can quickly lead to inefficient use of field teams and wasted money. Traditionally, QSI has relied on a myriad of technologies such as email, File Transfer Protocol (FTP), blogs, PDF reports, project status software and public websites in order to share data and receive client feedback. Each of these technologies have constraints and limitations including file size, data formats and bandwidth. Big data presents a growing challenge for mapping companies and the clients they serve, especially as advances in technology generates more and more data. To address these challenges, QSI partnered with RIEGL and Esri using the Chesapeake Bay project data and workflows to discover new ways to efficiently manage large volumes of geospatial data.

This is an extract from the article 'Web GIS Improves Lidar Collection Response Time', written by Cherie Jarvis and Ron Behrendt, published in the September/October 2018 issue of GIM International, the worldwide leading magazine for the geospatial industry and a sister publication of Hydro International.

Design to Deployment: **ToughBoy Wave Buoy**

Designing a Wave Buoy for Long-term Operational Independence

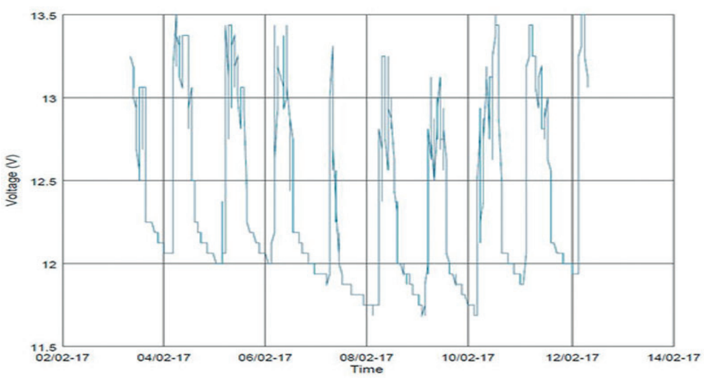
When using sea-going equipment, the elements are invariably one of your greatest adversaries. Whether a researcher waiting for a weather window, or a technician maintaining a sensor platform, the waves and weather should never be underestimated as sensor equipment must endure these conditions. Wave buoys represent a considerable design challenge from multiple perspectives. Physical durability is clearly of fundamental importance, but that robustness must be extended into the functionality and performance of the wave buoy system. A wave buoy must also maintain operational independence over extended periods of times – measured not in weeks or months, but often years. The ToughBoy Panchax high precision wave buoy was developed by EIVA in 2014 to fit these requirements. With a dual power source ensuring data collection and transmission, it comes pre-calibrated and ready for deployment in rough weather conditions, with low service requirements and communication costs.

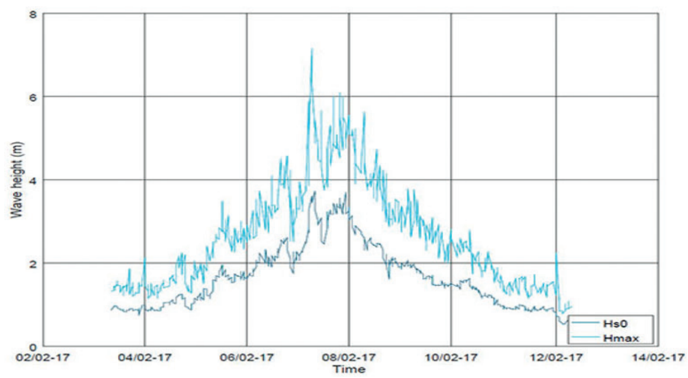
Tough Construction

To allow the ToughBoy to endure rough wave and weather conditions, it is built using tough materials. Stainless steel is used for the frame and counterweights, aluminium for the top, and polyethylene for the watertight, foam-filled, rotation-moulded shell body. The materials serve to securely house the sensors and prevent the wave buoy from sinking should it suffer a severe impact. The plastic shell not only offers important resistance to seawater exposure, but also reduces overall platform weight – a useful attribute for onshore transport. There are two versions of the system, one with a diameter of 1.2m and one with a diameter of 1.9m for deployment in deeper waters with more challenging wave conditions. The increased buoyancy reserve of the larger buoy, from approximately 70kg to 600kg, makes it possible to mount considerably more equipment within the buoy.

Intelligent Power Handling System

The power system is based on two energy sources coupled by an intelligent power handling system (IPHS). The primary source is a system consisting of four 50W solar photovoltaic (PV) panels, a deep-cycle 1,200Wh, 12V Absorbed Glass Mat (AGM) battery (weighing 40kg) and two MPPT (Maximum Power Point Tracking) charge controllers. A 25,920Wh custom-assembled alkaline battery (120kg, non-rechargeable) serves as a secondary redundant energy source. The IPHS prioritizes utilization of the primary AGM battery whenever it can provide



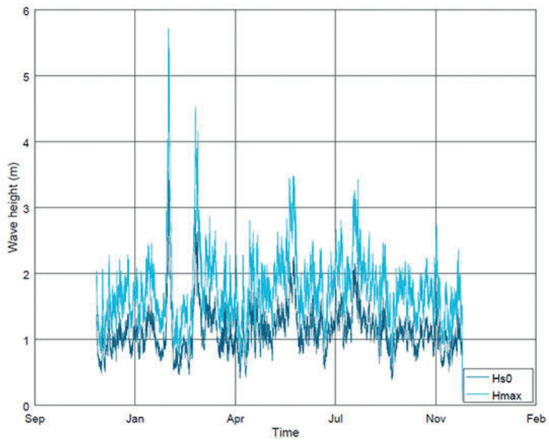


▲ *Figures 1 and 2: Charge cycle of the AGM battery (left) versus wave heights (right) over a period of days.*

sufficient power to the buoy's sensor data collection and processing system. Solar PV charging of the AGM battery is supported by the MPPT charge controllers.

The MPPT charge controllers also ensure the AGM battery is disconnected if the voltage dips below 10.8V DC, and reconnected when it is above 12.5V DC. In response to the connection state of the AGM battery, the IPHS will activate/deactivate the secondary battery via a custom high-speed MOSFET switching circuit to protect against power shortages. Analysis of the wave buoy's performance over a 12 month period of operation demonstrates that the primary solar PV-based energy source is efficient enough that even over prolonged deployments in rough weather, the secondary energy source may not be required in areas with much solar irradiation (Figures 1 and 2).

Reducing magnetic disturbance for more precise heading sensor data is a key consideration for sensor platform designers and numerous battery configurations were tested. An optimal configuration – in which the magnetic fields of the individual cells cancel each other out – ensured a fivefold reduction of the total magnetic field and an eightfold reduction of the magnetic field radiated around the top of the battery packet in comparison to a standard configuration.



▲ *Figure 3: Significant wave height versus maximum wave height over a period of several months.]*

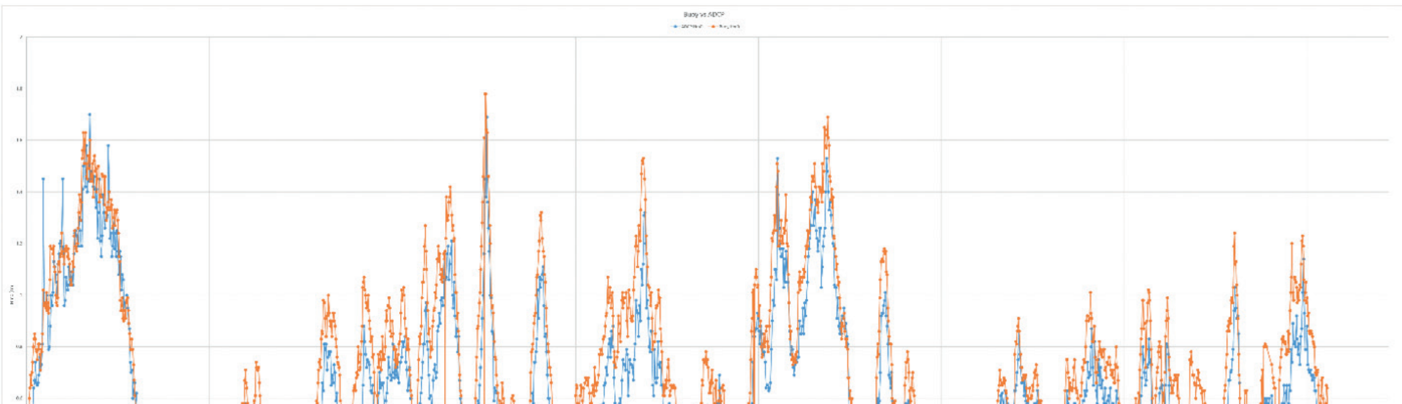
Operational Capabilities

The standard sensor payload features a Teledyne Workhorse Monitor ADCP with bottom tracking and an EIVA wave sensor, alongside a GPS unit. Depending on the sensor configuration and current conditions, up to five extra sensors can be fitted onto the buoy. The entire wave buoy is pre-calibrated and as such is delivered mission-ready. To allow communication, the wave buoy can transmit the sensor data to EIVA servers via standard communications protocols (GSM/3G/HSDPA/GPRS). The buoy also comes with an Iridium transceiver pre-installed (this requires a separate Iridium subscription), alongside UHF as an additional communication option. If the wave buoy is moved beyond a predefined geographic zone an alarm is triggered, reducing the risk of the buoy suffering damage or being lost. The buoy also has AIS transmission capability allowing AIS receiving vessels within range to pick up the data streams and gain insights on local wave and current conditions.

Endurance

The operating firmware of the ToughBoy plays an important functional role in supporting energy efficiency and ensuring transmission costs are kept at a minimum through the implementation of onboard data processing (e.g. wave data). The integrated EIVA wave sensor outputs raw data at 4Hz for calculation of ten output parameters, not all of which are immediately relevant to most users. Sending everything back to shore would be costly in terms of both power consumption and bandwidth. Instead, onboard processing enables raw sensor data to be run through custom algorithms which output only the most significant and meaningful insights on wave conditions. Once the calculation is finished, the transmission system is powered up to deliver the data via the communications protocol with the highest priority (set by the customers).

The wave buoy is combined with ToughBoy Onshore – EIVA's web-based service. As well as delivering sensor data to EIVA servers accessible to customers, the software allows for the remote configuration of the wave buoy; enabling adjustments to how the buoy transmits data, what data is sent, and the transmission intervals. ToughBoy Onshore also allows EIVA



▲ *Figure 4: Significant wave height comparison between wave buoy and bottom mounted ADCP for accuracy confirmation.*

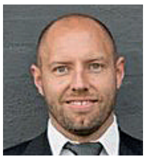
technicians to remotely check the status of the CPU and battery conditions. In the near future, the Onshore software will also support real-time and historic visualization of all data gathered by ToughBoy sensors.

Measurements Results

Wave buoys are used for various applications, one of which is site monitoring during offshore wind farm construction. Wind farm specialist WPD deployed a ToughBoy Panchax two months ahead of the construction of their Nordergründe wind farm, while keeping another one on standby for the duration of the project. Located 16km from shore with slightly more challenging water conditions, in the estuary of the German river Weser, a total of 18 wind turbines with a total capacity of 110.7MW were to be installed. In this industry, it is essential for contractors to know when they can work on the site. Therefore, limited to no downtime, along with secure and uninterrupted data gathering and transmission are primary concerns, as the cost of even a single day's delay is significant.

The deployed ToughBoy was fitted with a 1,200kHz Teledyne Workhorse Monitor ADCP with bottom tracking, suitable for measuring currents at the site's 2.5-10m water depth. In order to secure continuous data transmission, as well as reduce costs and man-hours as data retrieval would not have to take place through a team going to the site, WPD opted for an Iridium data subscription. With the ToughBoy's internal CPU processing the acquired wave and current data on site, the resulting data protocol being sent to shore via satellite is highly compact and thus cheap to transmit.

Real world deployments have also shown that the platform was unaffected by storms and waves up to seven metres (Figure 3). Key to this capability is the mooring technology consisting of a heavy stainless-steel chain, fixed to a clump weight on the seabed. A Kevlar safety rope connects the chain with a length of heavy rubber cord for the upper 15 metres of the mooring system. This rubber cord provides the necessary slack to allow the buoy to ride wave movements on the surface thereby securing accurate wave data collection (Figure 4). ◂



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Uncovering the Mysteries of the Oceans

What is Oceanography and How to Become an Oceanographer

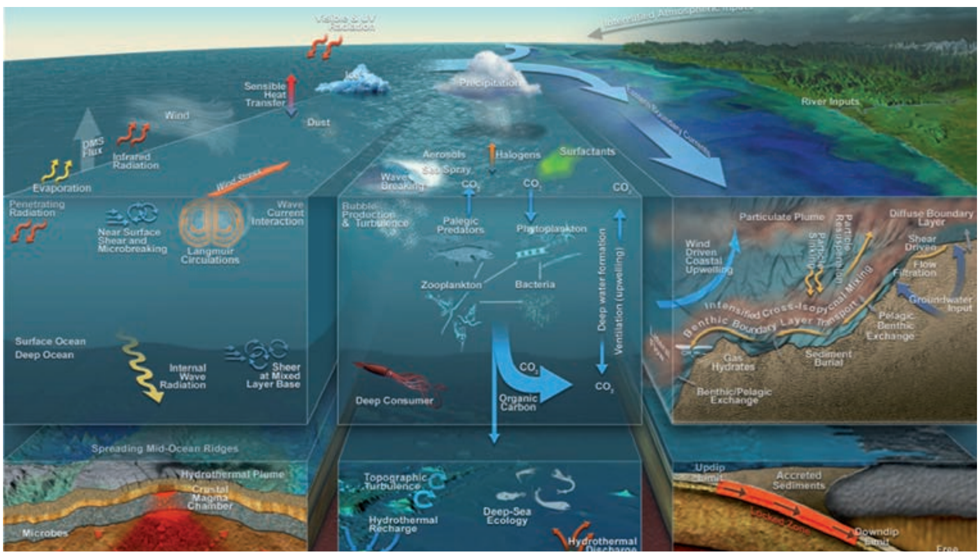
This article will dig into the field of Oceanography and the trends and methods developed over the past decades. Did you know that marine species compound more than 80% of the Earth's biodiversity? Or that seaweed and other sea plants living in the ocean produce around 50% of the oxygen in the atmosphere? With this in mind, many efforts are now concentrated on studies of the ocean, such as identification of those beneficial to ocean resources and organisms that can be used as medicines for many critical ailments. Within this article, you will also get familiar with terms like biomimicry, ocean acidification, ocean conveyor belt and Paleoclimatology. Stay tuned!

What is Oceanography?

Oceanography, derived from the Greek words 'Oceanus' - a Greek water God and 'graph' - meaning writing, is a branch of Geography that studies the ocean and therefore is also referred to as oceanology. The study of Oceanography covers a wide range of topics such as marine life and ecosystems, plate tectonics or the movement of large sections that form the ocean or geology of the seafloor, coastal erosion, movement of ocean currents, formation of waves, and the chemical and physical properties of the ocean. Also within the scope of Oceanography are the natural resources found there [1].

Oceanography's diverse topics of study are generally categorized in four separate but related branches: biological, chemical, geological and physical process of the marine environment.

Biological Oceanography, as its title derives, refers to the organisms which live in the ocean. Researchers in the field (biological oceanographers) study the behaviour of plants and animals (organisms) in the marine environment, their food and breeding habits, and how they affect larger marine creatures. Marine biologists and fisheries scientists are also biological oceanographers. They are interested in the number of marine organisms and how they develop related to one another. Biological Oceanographers also focus on how species adapt to environmental changes and how they interact with their surroundings, such as with increased pollution, warming waters and natural or artificial disturbances. A natural disturbance could be a hurricane or the eruption of an underwater volcano, whilst an artificial disturbance could be an oil spill or overfishing [2].



▲ *Oceanography is a multidisciplinary science involving observation, experimentation, and modelling of physical, chemical, biological and geological processes. Source: United States Naval Academy. (Graphic courtesy: John Delaney).*

The new technologies developed over the last few years are expanding the opportunities for biological oceanographers. Marine technology, for instance, is the study of how marine resources can be used to develop industrial, medical and ecological products. Many efforts are pointed towards developing new medicines from marine creatures. A process called biomimicry allows researches to understand, isolate and fabricate biological properties from the marine species. Natural compounds for example found in the corals and other marine organisms potentially have an anti-cancer capability, and some proteins consisting in

▲ *At habitat's hemispheric window, Dr Sylvia Earle shows algae to an engineer. (Photograph by Bates Littlehales).*

marine algae and bacteria are super absorbent materials used for cleaning oil spills [3]. This makes the application of those studies potentially endless.

Chemical Oceanography and marine chemists scrutinize the chemical composition of seawater and its resulting effects on marine organisms, the atmosphere and the seafloor. Their work includes analysis of seawater components and the impact of pollution on marine creatures. They study the unusual and sometimes toxic fluids released by hydrothermal vents in the ocean floor. By mapping chemicals found in the water, they understand how ocean currents move water around the globe, also known as the "ocean conveyor belt". Chemical oceanographers also focus on how the ocean affects the climate by studying how the carbon from carbon dioxide (CO_2) is buried in the seafloor, highlighting the key role that the ocean plays in regulating greenhouse gases, such as CO_2, that is a major contributor to global warming.

Nowadays, ocean acidification is a key topic in chemical oceanography since the ocean is becoming more and more acidic due to increased amounts of CO_2 in the atmosphere. More recently, anthropogenic activities have steadily increased the CO_2 content in the atmosphere; about 30-40% of the added CO_2 is absorbed by the oceans, forming carbonic acid and lowering the pH (previously 8.2, now below 8.1) through ocean acidification [4, 5, 6]. The pH is expected to reach 7.7 by the year 2100 [7]. Chemical oceanographers have discovered that acid disrupts the formation of calcium carbonate, which is the basic building block of shells and corals [8].

Last but not least, the ocean is rich in minerals and nutrients found in ocean flora. Chemical oceanographers also work to identify the beneficial ocean resources that can be used as medicines.

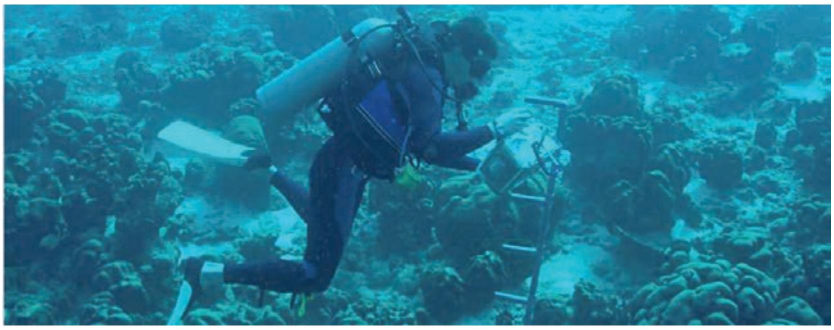
Geological Oceanography studies the structure of the ocean floor, the exploration of the ocean bed and taking cognizance of what changes in the physical structure formed the valleys, mountains and canyons. Geological Oceanographers are the scientists who study the past and present compost of the seafloor structure. Through drilling sediment-core samplers and the collection of measurements from under the ocean floor, they look at millions of years of history of physical movements (e.g. volcanic movements that constructed the sea floor). These researches help scientists understand our paleoclimate. Paleoclimatology is the study of weather and climate patterns over millions of years. Greater knowledge of the world's oceans enables scientists to more accurately predict, for example, long-term weather and climatic changes and leads to more efficient explorations of the Earth's resources.

Physical Oceanography is the branch of Oceanography which studies the relationship between the ocean's physical properties, the atmosphere, and the seafloor and coast. Its principal focus is the investigation of ocean temperature, density, waves, currents, tides, the vortex created eddies, the transport of sand on and off beaches, coastal erosion and the interaction of the atmosphere and the ocean that produces our weather and climate systems. Physical oceanographers investigate deep currents and the transmission of light and sound through water. They predict that global warming will slow the "ocean conveyor belt" which will radically change the climate. The melting ice caps will lead to increasing sea levels and hereby the ocean becomes less salty and dense.

What does an Oceanographer do?

An Oceanographer works in the field of Oceanography and must have a broad understanding of the different topics that reflect multiple disciplines such as chemistry, biology, geology, astronomy, chemistry, climatology, geography, hydrology, meteorology, and physics of the water column.

Oceanographers deal with a number of diverse issues including climate changes, declining



▲ *Oceanographers often need to work as divers to make in situ measurements. (Source NOAA).*

fisheries, eroding coastlines, the development of new drugs from marine resources, and the invention of new technologies to explore the sea. In fact, ocean scientists and their tools have advanced so much that they can even measure the temperature, depth and salinity of the oceans from space using satellites. Oceanographers have the important task of following the circulation of water, their landward movement and their possibility of generating rain clouds. Together with the meteorologists, they provide information of upcoming cyclones, tornadoes, tsunamis and hurricanes, endangering coastal pollutions. Another important task of an ocean scientist is to closely monitor the changes which occur on the surface of the ocean and in the deeper levels to forecast climatic changes and to mark areas for availability of natural resources [9].

History of Oceanography

The history of Oceanography dates back about 30,000 years when the world's first seafarers migrated to colonize small islands in Pacific Ocean. Ancient Greek scientists made observations on tides that were recorded 2000-3000 BC [10]. Around the 14-15th century, the Portuguese Prince "Henry the Navigator" created the first oceanographic school teaching about oceans, currents and mapmaking. In the years that followed, many discoveries were made – both technological and geographical. These ages are named as the "Age of Exploration" in which European navigators and explorers such as James Cook, Ferdinand Magellan, Christopher Columbus and others launched expeditions around the world. Significant information on ocean currents were gathered by different expeditions of the late 18th century, in which important oceanographic devices were launched: the mariner's compass, the astrolabes and chronometers (allowing sailors to figure out their longitude – a massive advance in maritime navigation).

However, the modern field of Oceanography did not drastically change until the late 19th century when America, Britain and Europe joined together to fund expeditions to explore ocean currents, the sea floor and the life that thrive within the ocean [11]. The first organized scientific outgoing to explore the world's oceans and seafloor was the 'Challenger Expedition' (1873-1876). The expedition is claimed to be the beginning of modern Oceanography. Challenger travelled nearly 70,000 miles (130,000km) surveying and exploring. On her journey circumnavigating the globe, 492 deep sea soundings, 133 bottom dredges, 151 open water trawls and 263 serial water temperature observations were taken. Around 4,700 new species of marine life were discovered [12].

▲ *Map of the Gulf Stream by Benjamin Franklin, 1769-1770. (Courtesy: NOAA Photo Library)*

During World War II, the potential to gain an advantage in submarine warfare spiked a further interest in understanding the oceans. Technologies made at that time, such as the sonar, enabled scientists to measure the sea bottom more accurately than the rope-depth-soundings. The magnetometer, originally developed to discover the metal hulls of the submarines, is used nowadays by oceanographers to depict a better picture of the magnetic properties of the seafloor, and by that, has enhanced our understanding of the Earth's magnetic core.

Oceanography Today

Modern oceanographers have a variety of tools that help them discover, examine and describe marine environments. Since 1970, satellites have had sensors for measuring and collecting data on wind speed and direction, polar sea ice conditions, sea surface temperatures, and waves. They also provide high quality images (satellite imagery) of clouds, land and water features.

The satellites send oceanographic and atmospheric data in real-time through a satellite system. This data improves our ability to predict global climate processes or natural phenomena like tornadoes, tsunamis and hurricanes.

Designed to handle more extreme conditions, small autonomous unmanned vehicles (AUV) working as submarines can take samples and high-quality images of the sea floor in depths greater than 5,000-6,000m. They can also collect rock, lava and water samples.

One of the most useful oceanography devices without any hesitation are the oceanographic buoys, mostly moored in the tropical Pacific Ocean. Nowadays, almost all Oceanography devices have onboard sensors for detecting water temperature, salinity, oxygen, CO_2, chlorophyll and light levels. These physical properties are important for the creation of plankton, which is the main diet of many marine animals.

Conclusion

Despite hundreds of years of research, our knowledge about the oceans is still limited to the top couple of miles of the ocean. There are many species living in the ocean, waiting to be discovered. Seaweed and other sea plants living in the ocean produce around 50% of the oxygen in the atmosphere. Through Oceanography we have learned some amazing facts about the ocean, though there are still many questions to be answered. Since 70% of the Earth is covered by water, much of it remains a mystery. Its immense size and depth will hopefully entice scientists in the future to uncover these mysteries. ◂

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Maintaining Windfarm Infrastructure – **Offshore Energy 2018**

The Hydrographic Society Benelux (HSB) organized a workshop in conjunction with the Offshore Energy 2018 exhibition at RAI in Amsterdam, the Netherlands on the 24 October 2018. Four speakers took to the stage discussing the theme 'Maintenance aspects of windfarm infrastructure' related to the Offshore Energy 2018 exhibition and conference.

Rob Lambij, who worked at the Ministry of Waterworks, Directorate of the North Sea and is co-founder of the Foundation "wet" archeological projects (SNAP), started off the day with a talk entitled 'Fishery and bottom related obstacles on the North Sea'.

An estimated 10,000 objects (e.g. ship wrecks, ammunition, lost cargo, ships anchors, oil and gas pipelines, and electricity and telecom cables) are lying on the bottom of the Netherlands Continental Shelf. Offshore pipelines with a diameter <16 inches, and telecom and electricity cables have to be laid at a government prescribed depth below the seabed.

▲ *North Sea Basin and surrounding countries.*

Uncovered Cables and Pipelines

Caused by the mobility of the North Sea bottom, the cables and pipelines frequently become uncovered. Particularly "free lying" cables can be damaged by fishing gear causing a possible cable break or rupture. These "free lying" cables were discussed with particular interest due to the high number of damages. He mentioned a recent case where a fishermen damaged a telecom cable. The cable owner launched a lawsuite against the fisherman with a claim in excess of US$650K. In the final verdict (Feb 2018), the court rejected the claims of the cable owner stating the owner must ensure the cable has a depth of 0.6 metres in the seabed with the groundcover maintained.

The next speaker, Reinier Nagtegaal (CEO - ECE Offshore), showed in his presentation 'The process of a cable repair project', that with the increased amount of offshore wind farms, cable repairs have significantly increased over the last few years. And as cable faults generally come unexpected, the time pressure for these projects is extremely high while the available means are limited. In his presentation he gave the audience an insight into the process of a cable repair project - starting at fault detection and ending at the installation of the repair joint and new cable at the fault location by interesting slides an videos.

The Contribution of Software in the Construction of Offshore Windfarms

The third speaker, Bart van Mierlo (CEO - Periplus Group), spoke on the contribution of software in the construction and maintenance of offshore windfarms as these require an enormous amount of hydrographic and geophysical data to be collected. Different stakeholders might have different objectives and are individually responsible for the collection of new data or at least the interpretation of existing data. A centrally organized data repository would save time and money, but does not exist. By providing access to this data, all parties would benefit while working with the same information. A web-based application will provide up-to-date information of the windfarm area.

The last speaker was Mike Lycke (Survey Offshore Manager – Jan De Nul Group) who spoke in his presentation on 'Scour protection: maintenance and more' and the various aspects of an offshore contractor working on the maintenance of windfarms illustrated by photos and videos.

A well-attended networking drink concluded the interesting workshop. ◀