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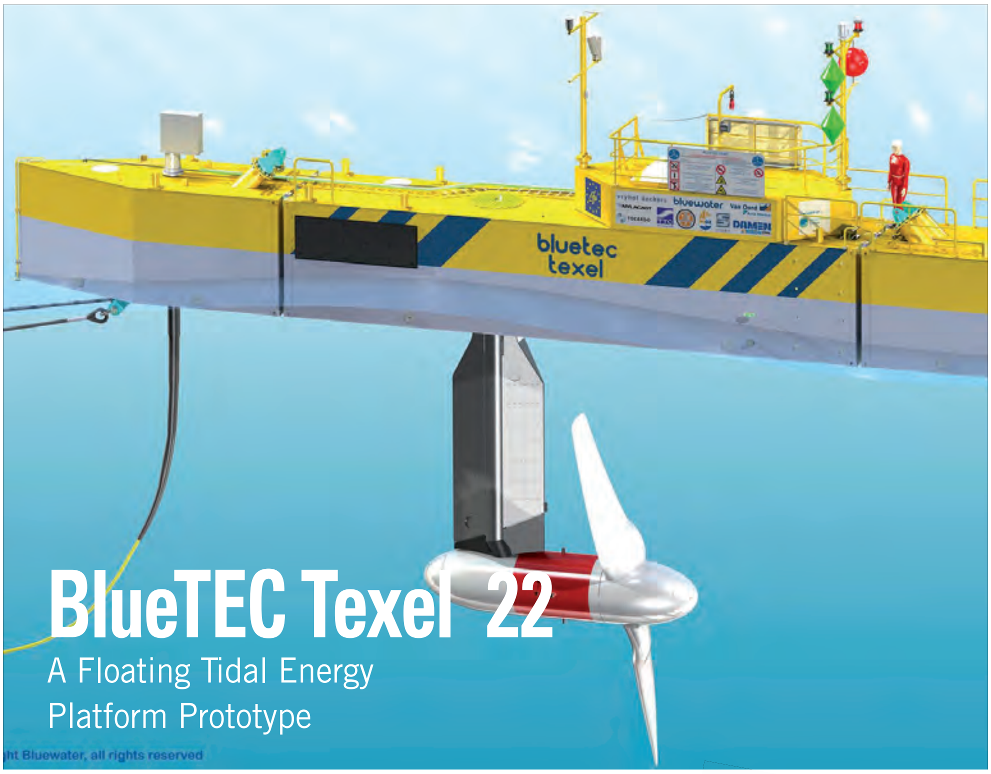
INERTIAL NAVIGATION SYSTEMS

Bridging the Positioning Gap

COASTAL RISK ASSESSMENT

BlueTEC Texel

A FLOATING TIDAL ENERGY PLATFORM PROTOTYPE



September 2016
Volume 20 #6
The tidal energy generation platform BlueTEC Texel with workboat Coastal Chariot *shot from the air by a drone. See also the paper by Janine Nauw et al from page 22. Image courtesy: Acta Marine, The Netherlands.*

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Hydro INTERNATIONAL

Hydro International is an independent international magazine published 8 times a year by Geomares Publishing. The magazine and related e-newsletter inform worldwide professional, industrial and governmental readers of the latest news and developments in the hydrographic, surveying, marine cartographic and geomatics world. Hydro International encompasses all aspects, activities and equipment related to the acquisition, processing, presentation, control and management of hydrographic and surveying-related activities.

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PHOTOGRAPHY: ARIE BRUINSMA (WWW.ARIEBRUINSMA.NL)

Renewing

Entrepreneurs know how difficult it is: renewing your company to adjust to changing circumstances in markets, economies or technologies. There are complete management and business courses on the subject of change management – and there are numerous gurus giving seminars in packed conference halls all over the globe, pretending they've found the solution for all managers and CEOs looking to change. One thing on change management that I picked up during one of the courses I took over the years, and never forgot, is that 60 percent of people working in a company can handle change, 40 percent can't. Of that 40 percent, 8 percent will become unbalanced due to the changes affecting and/or expected of them and 2 percent become almost mentally ill just thinking about having to change their work patterns, their attitude etc. It's therefore not an easy message to put forward: we have to change and renew ourselves for the sake of the company's very existence. But there's no other way: companies, also in our field, will have to change and renew themselves – the sooner, the better. Market circumstances are changing fast – while markets seem to change constantly without any difficulty - and therefore adjusting needs to be quicker, meaner and leaner than before.

In this issue of *Hydro International* we are highlighting a game-changer: renewables, and more specifically, we will of course focus on surveying for offshore renewables. Offshore wind farms account for the majority of offshore renewables, but tidal and wave energy also play an ever increasing part. On page 18 you can read an article by Ian Lewis describing how current profiling improves tidal energy's competitiveness. In addition, on page 22 we are carrying an article by Carly Nichols, Bram Pek et al. on a floating tidal energy platform prototype.

The transition from fossil to renewable energy is going fast and is changing the landscape, not just for energy suppliers, citizens and companies: other choices and consequences, other prices, logistics and other business models. (By the way, in countries where there has been a clear choice for wind energy the landscape of these countries is changing dramatically – and I am fully aware that for many this is worth more than just a side note). For entrepreneurs in the supply chain, including many hydrographic surveying companies, this whole transformation requires a great ability to adjust, to design new strategies and to adopt new business models. I am aware that change is often good, but also challenging. We hope that our articles give you some guidance on the course of the world around us and therefore also the course of hydrography. In a climate that requires hard choices it is inevitable that you have to renew to survive.

Durk Haarsma durk.haarsma@geomares.nl

On the Cusp of A New Hydrographic Era

I became director of NOAA's Office of Coast Survey in late August, and I feel incredibly lucky to be able to take the helm at this dynamic time in hydrographic history. We are on the cusp of a new era in hydrography. I am, like most field hydrographers, very excited by the possibilities of new survey technology, but I want to focus here on the requirement drivers that I see shaping the US hydrographic programme for the next 20 years.

In NOAA's programme, hydrography serves nautical charting, which in turn serves the millions of ships and boats on US waters. NOAA has begun a systematic review of the adequacy of our charts for current and projected use. We compare the charts to AIS traffic patterns and to satellite-derived bathymetry, and we take note of charted reports of shoals, wrecks and obstructions. It is clear that our focus on large ports and approaches in the past 30 years has paid off. These charts are in pretty good shape. On the other hand, charts of the rest of the coasts really need attention. Natural shorelines and water depths have changed dramatically, particularly near ocean inlets. New marinas have been built. There are many thousands of reports of shoals and obstructions, often reported after a grounding or allision. The scale of the charts is often inadequate to depict the detail necessary for safe navigation. These smaller waterways serve our coastal communities and the millions of small boats that help drive the vitality of their economies. Because these waterways are often too shallow for efficient multibeam coverage, we will need a blended solution of topobathy Lidar and sonar, guided by change detection made possible by crowdsourcing and satellite-derived bathymetry.

In addition, our work in ports is not done. As clearance margins are squeezed by larger ships and limited dredging budgets, we are challenged to provide more precise measurements and predictions of water depth, tides, currents, salinity and waves. Putting data on websites is not enough. We need to distribute them in standard formats to charting systems, portable pilot units and port information systems to allow users to quantifiably manage navigation risk. Our old-school ENCs, tide tables and marine radio weather are not sufficient for this purpose. In partnership with other federal agencies, the IHO, port authorities, pilots and navigation systems providers, we will build a new environmental information infrastructure in our ports.

Lastly, even as we see momentum building toward a systematic effort to map the global oceans, US waters are not fully surveyed. Most modern multibeam work has been done either near the coast or along the continental slope. There are solid requirements to finish the job, for fisheries to understand habitat, for minerals and petroleum utilisation, for wind energy, for exploration of unique undersea places, and to protect historic wrecks and monitor those containing hazardous materials. Seafloor and water column multi-frequency backscatter will help us understand subtleties of marine habitat and geomorphology, even as these begin to change with warming and acidifying seas and changing circulation patterns. This will require an ambitious, coordinated interdisciplinary survey campaign.

With the challenges of this new era, has there ever been a more exciting time to be a hydrographer? I think not.

Dredging Point Cloud Software

Charting underwater structures, soils and project progression using GPS, sonar, single and multibeam systems produces a huge amount of data that needs to be analysed. Vast project areas can be analysed with the Point Cloud package by Pythagoras that includes user-friendly drawing, calculation and design tools and 3D visualisation of large point cloud files and vector data.

▸ *http://bit.ly/2baEzve*

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

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Integrating UAS and Multibeam Echo Sounder Data - http://bit.ly/2arcP57

Mediterranean Survey for Applied Acoustics' Deep Tow Sparker

The Applied Acoustics deep tow sparker, the DTS-500, has recently been deployed in the Mediterranean Sea, off the continental slope of Majorca, working on a project with SOCIB, the Balearic Islands Coastal Observing and Forecasting body. Assisted by SOCIB's Oceanographic Instrumentation Technician, Carlos Castilla Álvarez, the DTS-500 was deployed in deepwater, up to 500m, at a distance up to 1km from the SOCIB research vessel.

▸ *http://bit.ly/2baCZK3*

Boone County Water Rescue's Side-scan Sonar Immediately Effective

EdgeTech, USA, recently delivered a 4125 side-scan sonar system to Boone County Water Rescue and the system was immediately deployed in the region.

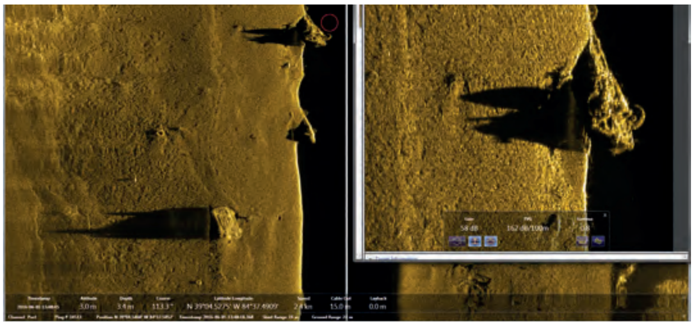

Image of the missing car contributed to finding a missing person.

Upon completion of the training session the Boone County Water Rescue team immediately started utilising the system weekly for bridge and pier surveys. Also very shortly after receiving the new equipment Boone County Water Rescue was called on to find a missing person in a nearby waterway. Using the new equipment, the team brought an emotional, but important closure for family members.

▸ *http://bit.ly/2baCyPS*

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AUV Demand to Grow 49% by 2020

Douglas-Westwood's World AUV Market Forecast 2016-2020 considers the prospective demand for AUVs in the commercial, military and research sectors over the next five years. Demand for units is expected to increase over the forecast at a compound annual growth rate (CAGR) of 10%, with every sector seeing positive growth due to increased utilisation of the technology. The military is expected to remain the greatest user of AUVs with demand in 2020 for over 700 units – 73% of total demand. Research will be the second largest sector – representing 22% – while the commercial sector will account for 4% of AUV unit demand.

▸ *http://bit.ly/2baDLXy*

ISA and IHO Sign Agreement of Cooperation

The International Seabed Authority and the International Hydrographic Organization (IHO) signed an Agreement of Cooperation in Kingston on 14 July 2016. The purpose of the agreement is to specify the scope of cooperation between the IHO and the Authority where both organisations will consult each other on matters of common interest with a view to ensuring maximum coordination of their work and activities and promoting or enhancing a better understanding in the collection and exchange of standardised data and information.

▸ *http://bit.ly/2baHLas*

ISA Secretary-General Nii Allotey Odunton and IHO Director Robert Ward sign the ISA-IHO Agreement.

Dr Parry Oei Awarded

The United Kingdom Hydrographic Office (UKHO) has awarded the 2016 Alexander Dalrymple Award to Dr Parry Oei, director (Port Services) and chief hydrographer at the Maritime and Port Authority of Singapore (MPA), in recognition of his outstanding contribution to world hydrography. The Alexander Dalrymple Award, established in 2006 and named in honour of the first hydrographer of the Royal Navy in 1795, is presented by the UKHO each year. It is awarded to coincide with the celebrations of World Hydrography Day, a United Nations-endorsed recognition of the vital role of hydrography in supporting safe navigation and sustainable use of the world's seas, oceans and waterways.

▸ *http://bit.ly/2baGmAG*

Dr Parry Oei (right), recipient of the 2016 Alexander Dalrymple Award, with Rear Admiral Tim Lowe, UK National Hydrographer (left).

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OGC Requests Participation in its Marine DWG

The Open Geospatial Consortium (OGC) is calling for public participation in its newly-established Marine Domain Working Group (Marine DWG). The Marine DWG was established to address applicability of the OGC standards baseline with regards to marine geospatial data, and to ensure knowledge is exchanged effectively between the relevant standards organisations, the OGC membership, and the broader geospatial community.

▸ *http://bit.ly/2baEmbr*

INS/GNSS System for Demanding Applications

With iMAR Navigation's iNAT-RQT-4003, an RLG-based highly accurate INS/GNSS system has been launched that is not affected by any ITAR regulations and is handled under standard dual-use export control only. The system is designed for navigation and guidance applications as well as for most accurate surveying applications with interface capabilities to external sensors like USBL or DVL.

▸ *http://bit.ly/2baFZ9h*

IMAR iNAT-RQT-4003 INS/GNSS System.

Lighthouse Integrates Ageotec

Lighthouse, Italy, has entered into a definitive agreement to merge with Ageotec, the Italian company known worldwide for its ROVs and the global supplying of survey equipment. In a phase of corporate reorganisation, Lighthouse and Ageotec have decided to improve their organisational structure by creating new synergies, leveraging expertise and strengthening the sales department. The ROVs will continue to be branded as Ageotec.

▸ *http://bit.ly/2baGfoK*

Seiche Takes Majority Stake in AutoNaut

AutoNaut has secured investment from the Seiche Group to advance R&D aims, assure long-term growth and develop business across UK and international markets. AutoNaut Ltd is the new name for the company previously trading as MOST (Autonomous Vessels) founded in 2012. Directors David Maclean and Mike Poole will continue to run the company from their Chichester (UK) base, concentrating on technical and marketing/sales activity respectively.

▸ *http://bit.ly/2baFRXv*

An AutoNaut USV in operation.


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Next-generation **Surveyors** Using Next-generation Technology

Twenty 3rd year students of ocean technology from the Maritime Institute Willem Barentsz (MIWB, the Netherlands) participated in the 4th edition of the Lake Survey. Building on last year's experience and together with three new partners, Teledyne CARIS and Fugro were able to enhance the programme. Three independent platforms were deployed to highlight the potential of modern-day surveying. A survey motor boat (SMB), an unmanned surface vehicle (USV) and an unmanned aerial vehicle (UAV) were used to acquire elevation data on and around the Vlietland lake in Leidschendam, the Netherlands.

Since 2013, Teledyne CARIS has organised an annual practical survey for Ocean Technology students from the Maritime Institute Willem Barentsz. The goal of the Lake Survey is to expand the experience of the young surveyors in a controlled environment. Sand excavation pits in the Netherlands have been the ideal theatre for this purpose. The lakes can be surveyed completely within the limited timeframe and the nature of the lake make for interesting bottom landscapes.

▸ *http://bit.ly/2a0srMM*

▲ *Group picture of all the students and organisers, taken from a drone.*

Offshore Energy Exhibition & Conference 2016

Offshore Energy Exhibition & Conference (OEEC) is an annual event focused on the complete offshore energy industry, from oil & gas to wind and marine energy. The event will be held on 25 and 26 October 2016 at Amsterdam RAI Exhibition and Convention Centre. A fascinating group of business leaders, buyers, investors, engineers and other interested parties will get the opportunity to meet each other.

▸ *http://bit.ly/2bjihro*

Hydro International interviews Neil Kermode, EMEC

Lack of Understanding of **Turbulence Remains** a Hurdle

Renewable energy is 'hot' these days. Many people think of wind farms on the horizon when they think of marine renewable energy. Marine energy can manifest itself in more shapes, including tidal and wave energy. These are more specific to a location but their potential can be surprising. The European Marine Energy Centre (EMEC) in the UK is a test centre for tidal and wave energy devices operating in an interesting area with wave and tidal potential. *Hydro International* interviews Mr Neil Kermode, managing director of EMEC.

▲ *Neil Kermode.*

When talking about 'marine offshore renewables', most people think of wind farms. What is the potential of tidal and wave energy?

The Carbon Trust produced a report some years ago that indicated the UK had the potential to harvest 1/5th of its electricity from wave and tidal energy. To put that into context that is about the same as the UK nuclear fleet delivered last year.

Can you briefly explain the relevance of a tidal and wave energy test centre instead of developing for the operational locations?

There is a lot we don't know about marine energy and there are a lot of details to be worked out based on the individual devices being developed. So the test centre has sought to provide those elements that are likely to be common such as a grid connection, a leased site with resource, safe systems of work, stakeholder involvement, performance verification and a long list of services to help the developers deploy. By providing all this the developers can go and concentrate on their device whilst the test centre does the 'back office' work. This also means that the back office services can work for multiple developers, thus providing an efficiency that spans multiple projects. And crucially, if a developer fails, as some will do, then the investment in the back office activities does not sit with them and is not lost.

In essence we provide incubator space to allow developers to learn their craft as quickly and efficiently as possible.

Why has Orkney been chosen as test location site? What kind of hydrographic and oceanographic surveys were made to achieve this?

The selection of the sites was the result of multiple selection criteria. Hydrographically we sought sites with good wave resource in deep enough water close to the shore to minimise the length of cables. Other factors included the proximity to a good harbour to assemble the flotilla of vessels for deployment/servicing. Bathymetry was obtained along with some cone penetrometer readings in sediment on site. Wave rider buoys have been on the wave site for 13 years and acoustic current profilers have been extensively deployed. More recently X-band radar has been used to look at water movement on the tidal site.

However, one major factor in the success of the centre to date has been the keenness of the supply chain to get involved. Orkney has seen the private and public sector really seek to welcome the industry by providing buildings, piers, vessels, divers and a myriad of expert mariners and generations of knowledge of the area.

Looking back, would you still make that choice?

Yes.

Can you describe the different situations that can be tested for a single tidal or wave energy generator at EMEC?

The sites are real world test facilities, so we have no control over the inputs. The maximum wave height recorded on the wave site has been 19m whereas the maximum tidal velocity is 4m/sec. The machines are therefore designed for the conditions they will experience. However, the machines tend to be nursed along at the start as there are so many systems to check that no-one wants to just throw them out into the water and see how they get on. Regrettably the weather and tides rarely come in perfectly predictable and escalating strengths, so dodging in and out to get the conditions you want in the weather you can manage is always a challenge.

Would it make sense to use EMEC's location more prominently as a production site rather than just a testing facility?

Maybe one day. It depends when the industry and particularly the investors believe there is no value in testing. We believe that is some way off as most mature industries tend to have test facilities running in parallel with sales in order to enable product development.

When industry decides it knows all it needs to then we would probably be converted to production of energy rather than just knowledge and skill.

Wello Penguin at EMEC wave test site, Billia Croo, Orkney. (Image courtesy: Mike Brookes Roper).

How does this test situation relate to operations of the equipment on their production sites with different characteristics?

At the moment the industry is still in its infancy, so there are not the 'standard' production sites to compare ourselves with. Come back and ask me in 5 years when we have some production work going on.

What evolution do you see in the characteristics of wave and tidal energy generators?

We have seen an awakening to the potential that small generators offer. Initial ideas had focused on grid scale generators, but more recently the potential to supplant diesel generation in remote communities/locations has become more attractive. In parallel, we have seen a number of larger scale tidal projects continuing to make progress, so there is something of a divergence into two market niches developing.

We have seen an awakening to the potential that small generators offer

Looking at current sites in use, could they be improved?

I believe fatigue will be the biggest limitation on tidal devices and understanding meaningfully the variability of turbulence spatially and temporally is as yet impossible. The fluctuating and differential loads placed on a spinning body in turbulent water are enormous. The gyroscopic loads induced by the movement of the rotating equipment are similarly challenging. So quantifying them to allow the response to them to be codified remains a challenge.

What hydrographic or oceanographic characteristics need more attention during selection or operation of tidal and wave energy sites?

Over time I believe the industry will reduce the number of critical elements as it gets better at its craft. However, at present the underwater visibility remains important during installation and recovery operations. Some sites have water that is opaque due to the sediments and velocity and I don't envy people trying to work in these conditions.


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The lack of understanding about turbulence intensity remains a hurdle.
The interaction of the industry with existing industries also needs to be better developed. All the evidence so far is that the devices are attractors of fish and it is believed they enhance the biomass potential, however, this needs to be systematically proved.
The levels of macro-trash and marine debris is presently not understood. Will the presence of damaging lumps of material (logs, ice, old shipping containers, discarded nets) prove to be a threat to tidal turbines? What is the distribution of such material across the globe and throughout the water column?

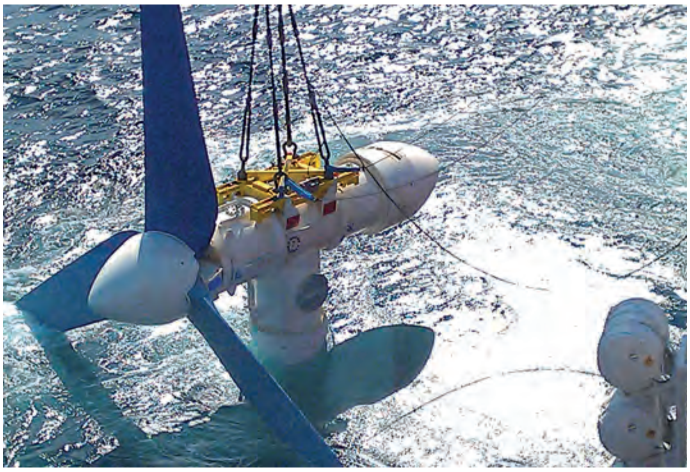
▲ *EMEC Billia Croo wave test site. (Image courtesy: Aquatera).*

How is marine energy being taken up, worldwide? How can countries improve the marine energy potential?
EMEC has seen a number of countries take an interest in marine energy in recent years and Orkney has seen a constant stream of visitors from around the world come to see what is going on here. Their needs are driven by different forces ranging from a desire to re-task existing industries, grid supply and more recently from island communities fed up with running diesel generation.
Companies like Aquatera based here in Orkney have been able to use the islands' experiences of marine energy to help the strategic planning needed to make the most of the resources. Many countries only have sketchy ideas of the scale of the resources they have in their waters, so assaying the estate is a task on the critical path. However, understanding the usability of the resources requires experience of the marine energy sector.
Other countries are also seeking to build their own test centres and EMEC has been pleased to help. Although nationally driven activities, the test centres have met at symposia we have organised in order to exchange ideas and hopefully help the sector develop internationally. As an internationally dispersed resource EMEC has always seen this requiring an international response.

I believe marine energy has the potential to play a part in a sustainable energy mix

What is needed (internationally) to improve the acceptance and use of marine energy?
Nothing succeeds like success. So sharing the experience of successes is critical to building the confidence needed to do this in the challenging environment of the oceans and coastal waters. The more deployments are seen and understood the greater will be the call for them from the public and politicians and the greater the market for the devices.

What additional message do you have for the readers of* Hydro International*?
I don't believe making marine energy work is optional. We know we are accelerating towards a rapidly deteriorating, polluted atmosphere that is starting to fight back against our onslaught. As we over-crowd the globe we know we need to do something about an energy source that is not going to make the earth uninhabitable.
I believe marine energy has the potential to play a part in a sustainable energy mix. It is well suited to island locations as they are often reliant on expensive diesel imported at great cost. There will be many different designs and approaches taken before we kit out our tool box with the machines and skills we will need to make the most of the restless energy of the seas. Already we have shown this is possible; what we need to do now is learn to do it well. Having the kit is part of the answer, but knowing the water environment is equally crucial. It is going to be an interesting journey. ◀



▶ *Deployment of AR1000 at the EMEC test site. (Image courtesy: Atlantis Resources Corporation).*

Neil Kermode is a Fellow of the Institution of Civil Engineers and a Chartered Environmentalist having worked in municipal engineering and the Environment Agency. As an active SCUBA diver he dived all over the UK. This combination of environmental awareness, large engineering experience and empathy with working at sea led him to become MD of EMEC in 2005. He grew EMEC from 4 to 20 people and oversaw the deployment of deployment of 16 technologies from 9 countries. Neil speaks widely on marine energy, is a member of assorted industry groups and is a passionate advocate for a sustainable, carbon free energy future.
✉ Neil.Kermode@emec.org.uk

Higher Sampling Rates Provide Greater Insight

Current Profiling Advances Improve Tidal Energy's **Competitiveness**

The rapid growth of interest in tidal energy has highlighted the role of current profilers, able to measure the speed and direction of currents with increased accuracy in some of the harshest marine environments in the world. While the turbines produce the power, current profiling technology plays an important role in maximising the efficiency of this promising area of renewable energy.

The use of seabed-mounted turbines to generate power from tidal currents has been steadily progressing through the experimental stage, with just a handful of small projects dotted around the world. However, this is a sector that is poised to play a significant role in power generation, where tidal conditions are right.

The tidal industry has huge potential thanks to recent technology improvements and the push to bolster renewable energy production in all areas of the world. Assessing the extent of global tidal resources remains a speculative exercise, but the International Renewable Energy Agency (IRENA) reports that the technically exploitable portion of these resources close to shore could total as much as 1 terawatt of capacity.

▲ *Figure 1: Insertion of the turbine rotor for the Paimpol-Brehat project.*

Ensuring the Correct Turbine Orientation

Power companies are gearing up for commercial production, testing turbines that can be installed in arrays on the seabed in suitable conditions. However, placing the turbines in the right locations and with the correct orientation to maximise the throughput of water – and thus the amount of power generated – requires sophisticated measurement and analysis of ocean currents.

The latest acoustic Doppler current profilers (ADCPs) are able to produce high-quality data that can determine the best locations for future tidal generators and how existing designs should be modified to maximise their efficiency. These ADCPs can also perform increasingly complex tasks depending on the needs of the user, such as allowing concurrent measurements of the velocity profile and the distance to the surface, which improves our understanding of the interaction between waves and currents.

▲ *Figure 2: Nortek Signature500 ADCP.*

ADCPs work by sending out acoustic pulses from transducers on the head of the instrument, which bounce back to it from particles suspended in the water. Measurements can be taken at various points throughout the water column by recording the time it takes for the sound waves to bounce back, while the differing frequencies of the outgoing and returning pulses allow the Doppler shift to be calculated. With this information, current speeds can be derived throughout the water column.

The tidal turbine developer OpenHydro has deployed one of the latest versions of ADCP technology, the Signature500 made by Nortek AS, on its full-scale demonstration arrays in Europe and North America.

Resilient Technology

OpenHydro's demonstration array sites have been selected precisely because of their extremely aggressive flow conditions, but they remain well within the operational envelopes of both the ADCPs and the turbines.

The ADCPs, which are around 27cm by 22cm at their widest, have been fully integrated into the turbine systems.

On each OCT, OpenHydro has deployed two Signature500 units at the height of the rotor centre, pointing horizontally into both the flood and ebb tides. These devices are mounted to project three of the device's five acoustic beams within the horizontal plane upstream of the device, sampling the incoming flow.

In this deployment configuration, any two of the three beams in the horizontal plane can be used to derive the two relevant components of velocity at the 'hub-height' of the rotor, at a number of points progressing further upstream of the turbine.

The use of a third beam provides an insight on smaller scales and higher frequencies of turbulence. It also provides a redundant component of velocity to determine the accuracy of the other two components; and it also provides overall redundancy within the sensor system, should one of the three transponders fail for any reason.

The profiler's fourth and fifth beams can be used in vertical deployments, where there are stronger motivations to derive three-dimensional components of velocity and turbulence.

The faster sampling rates of the new wave of profilers – up to 8Hz on the Signature500 model used in Paimpol-Bréhat and 16Hz on other models – permit an increase in the amount of information that can be gathered compared to older 4Hz models. This simplifies the detection of variations in currents, permitting the collection of many more independent current profiles in quick succession.

AD2CP Flexibility

These latest instruments use AD2CP broadband technology and employ frequency-based coding techniques, which allow more freedom to define the appropriate transmission frequencies. This is particularly useful in long-range applications, where broadband frequency measurements, covering a range of 600m, are interleaved with narrowband frequency measurements, covering a range of 1,000m or more in ideal conditions. This results in a full 1,000m-plus profile with the first 600m detailing high-resolution velocity measurements with very low noise characteristics.

Indeed, this is just one illustration of the flexibility of the AD2CP platform. It is a multi-functioning system, capable of high sampling rates (max. 16Hz), concurrent measurements, and the production of highly

ADCPs can perform increasingly complex tasks depending on the needs of the user

▲ *Figure 3: OpenHydro deploys a second turbine to the EDF site.*

detailed current/turbulence/wave data. It is also capable of producing measurements beyond currents and waves, covering applications involving ice measurements (draft and movement), bottom tracking (DVL range) and biomass movement and distribution (echo sounder). Nortek have taken out an 'AD2CP' US patent (7911880), which covers the concept of this multi-function device.

The platform is a lot smaller, lighter and less power hungry than other equipment of this nature produced to date, so the platform lends itself very well to longer, stand-alone operations in the field.

The platform lends itself very well to longer, stand-alone operations in the field

Another important development has been the application of Ethernet-based communications. With smarter interfaces, AD2CP instruments are capable of syncing relatively easily and accurately (10µs or 7.5mm). This has enabled OpenHydro to use an online interface through which all ADCPs in the array can be accessed, settings can be changed easily and instruments within the array can be synced within microseconds.

The AD2CP electronics platform is sufficiently powerful and versatile that Nortek plans on using it over the next 5-10 years as a basis for all of its future developments.

Collaborative Process

OpenHydro and Nortek have worked together for almost 10 years in the lead-up to their current full scale projects. These projects included test deployments in Bay of Fundy off Nova Scotia and Phase 1 at Paimpol-Bréhat. Throughout this time, Nortek staff have helped OpenHydro to ensure the sensors are deployed correctly and provide the expected outputs.

For the most recent integration of the ADCPs, the project started with a meeting at OpenHydro's technical centre in Ireland, after which Nortek provided support, opening a direct line of contact between the oceanographers at OpenHydro and the engineers and R&D department at Nortek. That resulted in a close collaboration which will continue through the rest of the project, as detailed analysis gets under way.

By improving the understanding of the environmental conditions in which each turbine operates, data from a current profiler improves the level of certainty in power performance assessment and provides essential information for the validation of load derivation methods.

Such improvements offer the promise of higher efficiency, and thus lower cost tidal power. The extent of gains will depend on the circumstances of each individual project, which will become clearer as more tidal facilities are developed. ◀


Ian Lewis is a writer on energy and technology matters for a number of international publications.

A Floating Tidal Energy Platform Prototype

BlueTEC Texel

Traditional solutions for generating electricity from the tides, where tidal turbines are installed on the seabed, require high-end offshore installation vessels and do not allow for easy access for maintenance. The BlueTEC floating tidal energy platform has a different approach. It is a permanently moored platform which generates renewable electricity from tidal currents by holding a tidal turbine underneath. The BlueTEC Texel is the first prototype and serves as a demonstration platform and is being used for R&D testing purposes.

The project was realised through a partnership between companies active in the maritime and offshore industry: Bluewater, Damen Shipyards, Van Oord/Acta Marine, Tocardo, Schottel Hydro, TKF, Vryhof Anchors, Tidal Testing Centre and the Port of Den Helder, with scientific support from the Royal Netherlands Institute for Sea Research (NIOZ). The platform was installed off of the Dutch island of Texel in the Wadden Sea in the summer of 2015, initially equipped with a Tocardo T1 tidal turbine and in early 2016, re-installed with a larger T2 turbine.

The BlueTEC Platform

The platform consists of three modules of standard 20" and 40" shipping container dimensions, allowing the system to be shipped at low cost to ports worldwide. The platform allows for easily assessed, dry storage of all critical electrical equipment. The strut holds the turbine underneath the platform, and a dynamic export power cable transports the generated electricity to shore. The platform is kept in place by four mooring lines, which are under tension with four drag anchors, allowing the platform to stay in place under all-weather circumstances, including storms (Figure 1).

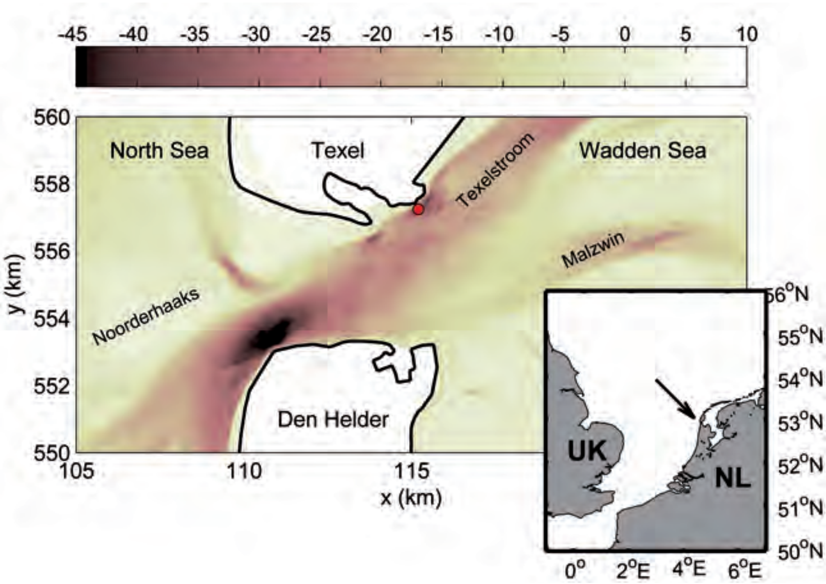
Turbines are kept as simple and robust as possible to achieve very high availability

Pre-operational Phase

Prior to the installation of BlueTEC, NIOZ conducted several oceanographic measurements to better understand the patterns of circulation near the Marsdiep inlet as well as to select an optimal deployment location. The results show that the region is mainly dominated by tidal currents. However, a wind-forced residual component in ebb direction was also identified. During ebb phase, i.e. during the period when the water flows from the Wadden Sea towards the North Sea, the circulation is marked by a strong current, which results in homogeneous vertical velocities. On the other hand, the flood phase is characterised by weaker and vertically sheared velocities, with the core of the tidal current found at subsurface, at approximately 15 metres depth. This peculiarity is particularly interesting, since the turbine is placed close to this depth of maximum velocities.

The transition from neap to spring tides is distinguished by increasing velocities during ebb, while the flood currents remain nearly constant. Spatially, the distribution of velocities depends on the interaction with the bathymetry, being stronger in the Texelstroom, the main tidal channel in the Marsdiep inlet. The BlueTEC location was selected (Figure 2) based on in-situ observations of the local currents, and also taking into account other factors such as, for instance, a safe distance from the navigation channel and proximity to the Royal NIOZ on Texel.

Figure 1: Artist's impression of BlueTEC Texel holding a T2 turbine.



▲ *Figure 2: Location of the BlueTEC platform (red dot) in the Marsdiep tidal inlet in the Northern part of the Netherlands.*

▲ *Figure 3: BlueTEC Texel hoist into water.*

▲ *Figure 4: Offshore installation of BlueTEC Texel.*

Offshore Installation

Prior to the first offshore installation, the turbine was fitted underneath the mid-module of the platform on the quayside. The module was then lifted into the water by a crane and connected to the two end modules while in the water. Meanwhile, offshore, the drag anchors were embedded in the sand at the site using a multi-cat vessel. Hereafter, the platform was towed to the site and hooked up to the mooring lines and tensioned using the multi-cat vessel's on-board winch. Next, the power cable was lifted through an opening in the platform and connected to the platform. The remainder of the cable was laid on the seabed with weights to hold it in place, and its end connected to the grid onshore (Figure 3).

The offshore vessel used was a 37-metre-long multi-cat with dynamic positioning class 1 (DP1). Compared to other ocean energy installations, this is a relatively simple vessel (Figure 4). The offshore installation work required attention to the times of the tides and their direction. The weather window adhered to for the offshore installation was three full days of waves with significant wave height (Hs) lower than 1.0 metre, and wind speeds of maximum 5 Beaufort.

During the turbine change-out, improvements to the platform were made to ease the offshore installation.

Monitoring Programme

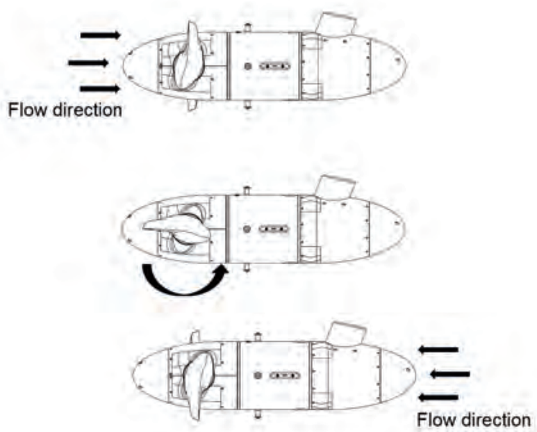
The monitoring programme involves a suite of instruments mounted on and in the platform (Table 1), as well as on the turbine. The Royal NIOZ investigates the impact of the tidal energy extraction on the local flow and sediment balance using two downward looking ADCPs on either end of the platform. They measure the incoming flow and the flow just behind the turbine and can be used to observe local bathymetric changes. Moreover, also the efficiency of the turbine is examined under various hydrodynamic conditions, varying from neap to spring tide; high and low discharge conditions and thus strength of the stratification, and under various wave conditions as measured with the AWAC, which is moored on the seafloor next to the platform.

Turbines and Performance

To achieve very high availability, Tocardo's turbines are kept as simple and robust as possible. It implies no yawing and no pitching

DGPS	The Differential Global Positioning System measures the platform's geographical location and its heading with high accuracy.
Downward-looking ADCPs (x2)	Acoustic Doppler Current Profiles measure the velocity profile throughout the water column in Eastward, Northward and Upward direction using pings.
Horizontally-looking ADCPs (x2)	Acoustic Doppler Current Profilers measure the water velocity at the front and the back of the turbine.
AWAC wave profiler	Uses the same technology as ADCPs to measure wave height, speed and direction.
Weather monitor	The weather monitor records the meteorological data at the site, such as wind speed, wind direction, rain fall and temperature.
Motion sensor	The motion sensor measures the movements of the platform such as the roll, pitch and heave.
Strut strain gauges	Strain gauges were mounted onto the strut to measure the forces from the turbine.
Module coupling strain gauges	The platform consists of three modules inter-connected by six rods. Strain gauges were mounted onto the rods to measure the forces exerted on these rods.
Mooring line load shackles	The mooring lines include a shackle near the platform which measures the forces (loads) on the mooring lines.
Water sensor (x2)	Two water sensors inside the local equipment room detect if there is water within the module.

▲ *Table 1: Monitoring equipment installed on BlueTEC Texel.*



▲ *Figure 5: Functioning of the bidirectional rotor technology*

system. Because tidal turbines are intended to work with flow coming from both directions (front to tail and reverse), the blades need to be orientated according to the direction of the flow. The bidirectional rotor design makes it possible to turn the two blades 180 degrees simultaneously for reverse flow operation (Figure 5).

To evaluate the performances of the T2 turbine, two horizontally-looking ADCPs were installed to measure the water velocity at the front and the back of the turbine. The ADCPs only use the central (forward-looking) beam and measure the velocity at 16Hz. Each cell is 50cm long and the last cell centre is 25m ahead of the ADCP. One ADCP is mounted on the strut behind the rotor blades; observations at instances when the blades are in the path of the acoustic beam are discarded.
To measure the undisturbed water velocity, it is necessary to measure it at least two rotor diameters ahead of the 9 metres diameter rotor plane, explaining the need to have a 25 metres measurement range. Preliminary results show that the turbine efficiency is in line with the expectation.

Marine Growth

The platform was coated with anti-fouling on all subsea surfaces, which was provided through the Seafront project. Although these coatings notably prevented marine growth on the platform, significant marine growth in the form of mussels was found on the mooring lines and subsea power cable auxiliary equipment. Marine growth on these systems can significantly impact the system's dynamic behaviour and potentially the lifespan of the equipment. This experience revealed that marine growth in the local area should be well researched or tested far in advance of a project such that it can be properly accounted for in designs, anti-fouling plans, and operation and maintenance regimes.

Acknowledgements

Thanks are due to Walther Lenting, Belén Blanco and the crew of the *Navicula*. ◀

More Information

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Website BlueTEC: http://www.bluewater.com/new-energy/bluetec-phil/

Carly Nichols works at Bluewater Energy Services, assisting the project engineer and asset manager and often acts as interface engineer between the 10+ Partners within the BlueTEC Texel Tidal project. She has an MSc in Renewable Energy and four years of work experience as a manager of Sustainable Design Services for sustainable building projects.

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Janine Nauw is a researcher working at the Coastal System Sciences at NIOZ. She has vast experience in estuarine hydrodynamics, sediment and fish larvae transport, as well as in methane dispersion in a marine environment. Janine has a PhD in physical oceanography from Utrecht University.
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Leandro Ponsoni is an oceanographer graduate from the University of São Paulo, where he also completed his master thesis. He has a PhD in physical oceanography from Utrecht University. Leandro has extensive experience processing oceanographic data sampled both in-situ and from satellites. His main research interests are ocean circulation and sustainable energy. He has been working at NIOZ since 2013.

Marck Smit graduated in Maritime Technology from the Delft University of Technology. For more than a decade he was responsible for the NIOZ Marine Technology Department. This department has vast experience with innovations in measuring, monitoring and sampling in the sea. Marck is now technology manager of The Netherlands Deep Sea Science and Technology Centre.

Aymeric Buatois is a SCADA development engineer at Torcado, where he is in charge of the development of the software tools to communicate with the turbines and analyse the data to evaluate the reliability and status of the turbines in the field. Aymeric has an MSc in sustainable energy technology from Delft University of Technology.

Pieter de Haas is an entrepreneur with a naval engineering background and international experience in ship building, business development and change management. Actively involved in the project development and commercialisation of Tocardo since 2006, he is now responsible for the development of the Tocardo technology.

Generation of Bathymetric Digital Elevation Models Along French Coasts

Coastal Risk Assessment

SHOM contributes routinely to the preparedness against coastal risks along French coastlines. For this purpose, regional to coastal digital elevation models are built for implementation in forecast systems against rapid flooding. By integrating users' needs and its expertise relative to bathymetric data, SHOM offers new fit-for-purpose products along the French coasts.

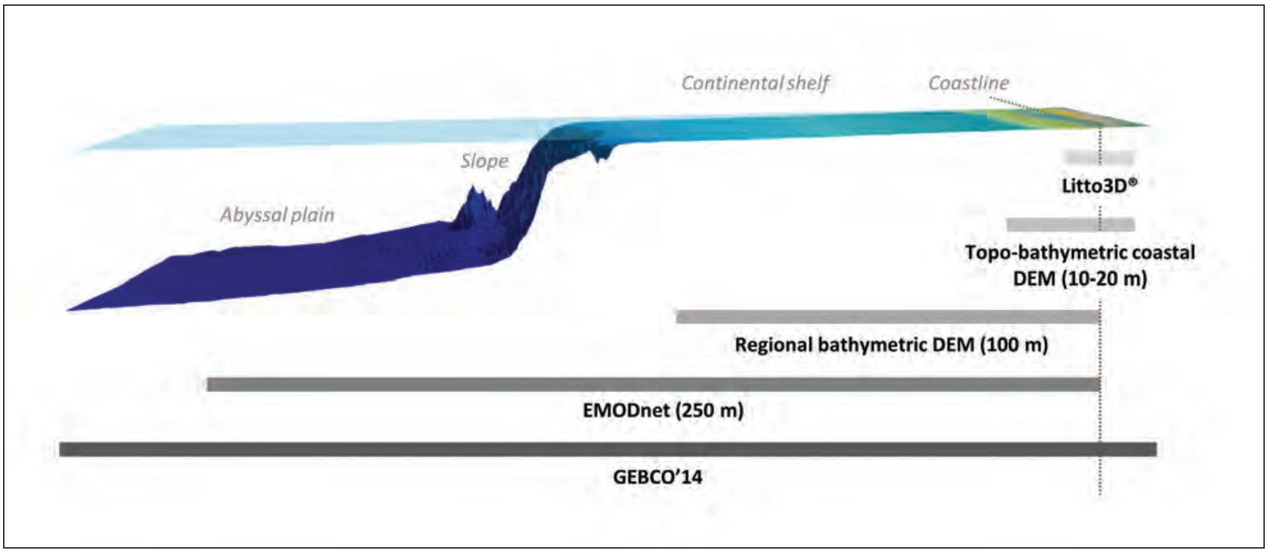


Figure 1: Bathymetric products available along French coasts. Regional and coastal DEM are among the new products provided by SHOM.

Bathymetric data are mainly used for producing nautical charts. However, a wide community of users requires continuous bathymetric surfaces. SHOM has recently started building nested digital elevation models across the French Waters (including overseas territories) for the purpose of hydrodynamic modelling. These are also used for other purposes such as sedimentology, habitat mapping and coastal planning. Building national digital elevation models means that a mix of local hydrographic knowledge, data management and particular attention to users' needs must be brought together.

Specifying the National Bathymetric Product Line

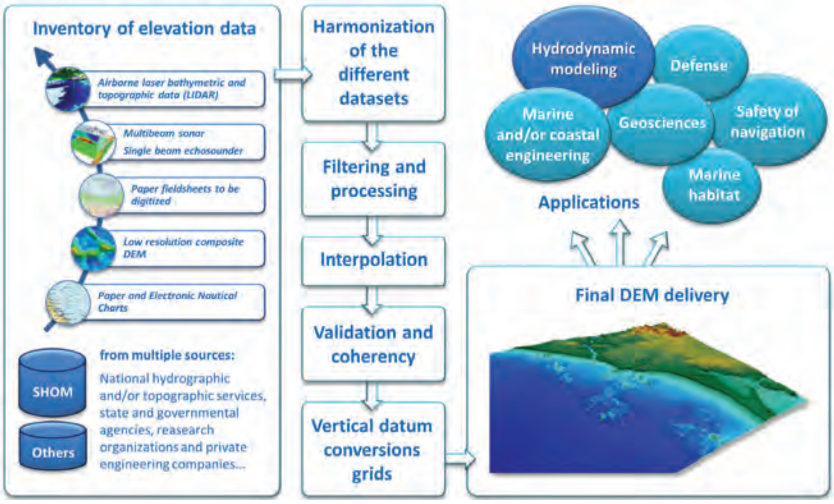
SHOM's DEMs are routinely used by practitioners focusing on multi-hazard marine risk assessment (tsunami flooding, storm surge, coastal erosion, etc.). Their specifications have been defined to be compatible with the requirements of the hydrodynamic modelling community. Following previous work by Eakins and Grothe (2014) and users' requirements (Quadros, 2012), their main characteristics include:

- Continuity of the bathymetric surfaces;
- Resolution of the DEMs to be consistent with the scale of modelled physical processes (Fig. 1).
- Integration of topographic data for the coastal DEM;
- Final products to be provided at the lowest astronomical tide (LAT) and mean sea level (MSL) vertically, WGS84 geodetic system in geographic coordinates, horizontally;
- Licensed under an open data license.

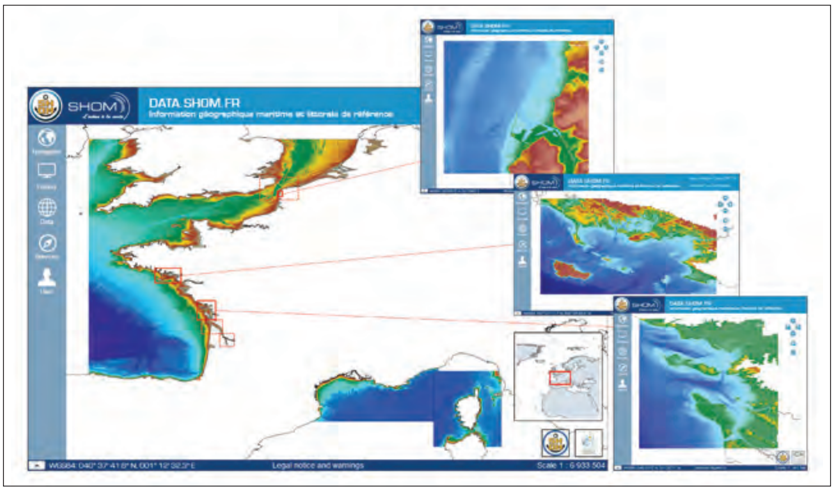
Based on these requirements, SHOM developed a nested products line including regional bathymetric DEMs covering all the French coasts at a resolution of 0.001° (around 100m) and topo-bathymetric coastal DEMs in specific areas of interest at resolutions of 0.0001° or 0.0002° (10-20m, Fig. 1). All of them are supplemented by GEBCO'14 and EMODNet bathymetry at the broad scale end of the spectrum, and from the national Lidar initiative Litto3D® at the other end (Fig. 1).

Building Individual DEMs

Building individual DEMs implies a series of tasks illustrated in Figure 2. The first step includes the inventory of data collected by SHOM along with external data. Although SHOM is benefiting from a national legislation that enforces data owners in the EEZ to provide their data, this work is not straightforward and benefits from collaborations at the local and the international level. EMODnet and/or GEBCO might be used as a complement for unsurveyed areas. The second step focuses on the harmonisation and processing of the different



▲ *Figure 2: Methodological framework leading to the generation of adapted DEM.*



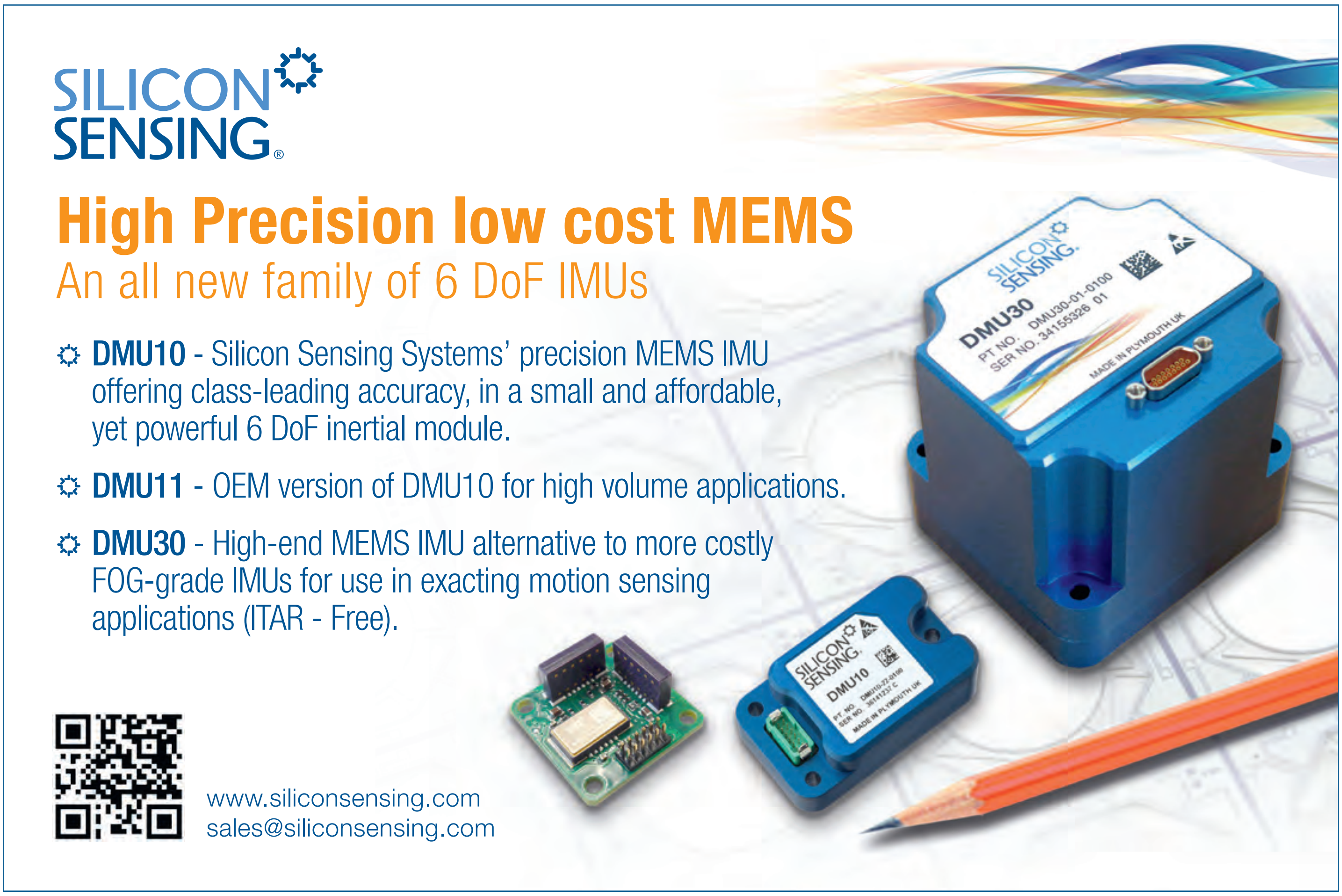
▲ *Figure 3: Overview of the data.shom.fr portal and a selection of available coastal and regional DEM along the Atlantic and Mediterranean coasts. Red solid lines represent the released DEM extends while dotted lines relate to DEM in production.*

sources of data so that they are registered to a similar vertical reference. For this task, SHOM mainly uses the BathyElli conversion grids along the coasts of the Channel, the Atlantic and the Mediterranean Sea. These conversion grids allow vertical shifting from marine vertical references (Chart Datum, LAT, Mean Sea Level …) to the ellipsoid. Following these tasks, filtering and manual edition of non-coherent soundings is undertaken in order to enhance morphological coherency. This process is then followed by surface interpolation. Splines functions are used for their efficiency to honour variable density data providing a representative smooth and continuous surface. Finally, the last task deals with the inspection of the resulting DEM. The lack of coherence or the presence of artifacts is treated by further filtering out of the original soundings prior to a new interpolation. Product quality is evaluated in particular based on visual inspection (slope, cross-section and 3D views) and the cross-validation of the DEM using data sources that have not been incorporated into the generated product. Although this framework is common to the different resolutions, attention is given to the highest resolution products in order to minimise potential artifacts. Results from the work at high resolution subsequently contribute to the products at lower resolution, favouring the coherence at the different resolution.

Data.shom.fr: Providing the DEM

SHOM provides access to its geographic data through data.shom.fr (Fig. 3). This data portal allows users to access reference data that describe the marine and maritime physical environment. Beyond a visualisation service, data.shom.fr offers access to common OGC web services.
Several regional and coastal DEMs were released in 2015 and populated data.shom.fr. (Fig. 3). The portal will be gradually fed by future productions along the French metropolitan and overseas coasts.
Each DEM is released through pre-packed files, including:

- files containing bathymetric surfaces, vertically referenced to two vertical datums (Mean Sea Level and Lowest Astronomical Tide) and converted in four grid formats, including NetCDF format (.grd by GMT), Bathymetric Attributed Grid (.bag), ESRI ASCII Raster format (.asc) and ascii text format (.glz);
- a metadata file that contains data sources, geographical extent, legal constraints and a brief summary of the building process, meeting the requirements of the INSPIRE Directive;
- the citation and an associated Digital Object Identifier (unique identifier used to cite scientific articles and datasets) to easily identify the future multiple uses of the DEM;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Future Improvements

Even if SHOM has elaborated the tools and the expertise needed to produce a nationwide coverage of bathymetric models, some improvements are foreseen. Tools still need to achieve a semi-automated deconfliction (Figure 4) of overlapping datasets. Deconfliction is presently performed manually for high-resolution DEM. Likewise, a methodology to update published DEM using new dataset is currently being evaluated and will be implemented in our production scheme. Moreover, an evaluation of the supplementary set of information needed for the data user to evaluate the accuracy and the representativeness of the DEM product is currently being carried out. The result will include an estimate of the uncertainty of the DEM from the relative precision of the sources data and the intrinsic evolving character of the seabed assessed by surface sediment records. More importantly, progress made in acquisition programs such as Litto3D® and improvements of the vertical reference surfaces at sea (BathyElli) will directly benefit coastal DEM enhancements.

Conclusion

Armed with a full range of expertise in marine geographic information, SHOM has elaborated multi-scales nested DEMs to support maritime and coastal public policies. Particular attention is brought to topo-bathymetric high-resolution DEMs in order to facilitate their use in most coastal environment issues. Such production requires all SHOM's modern and legacy data and knowledge in order to manage the different DEM development steps. It also takes advantage of a necessary collaboration between organisations at multiple levels (local, national and international) in order to elaborate robust and up-to-date grids. These DEMs meet a wide variety of needs thanks to their specifications and their availability on SHOM's portal. Presently, a national coverage at 100m resolution is available. Further improvements will be gained through the production of coastal DEM of other coastal zones at risk.

Acknowledgements

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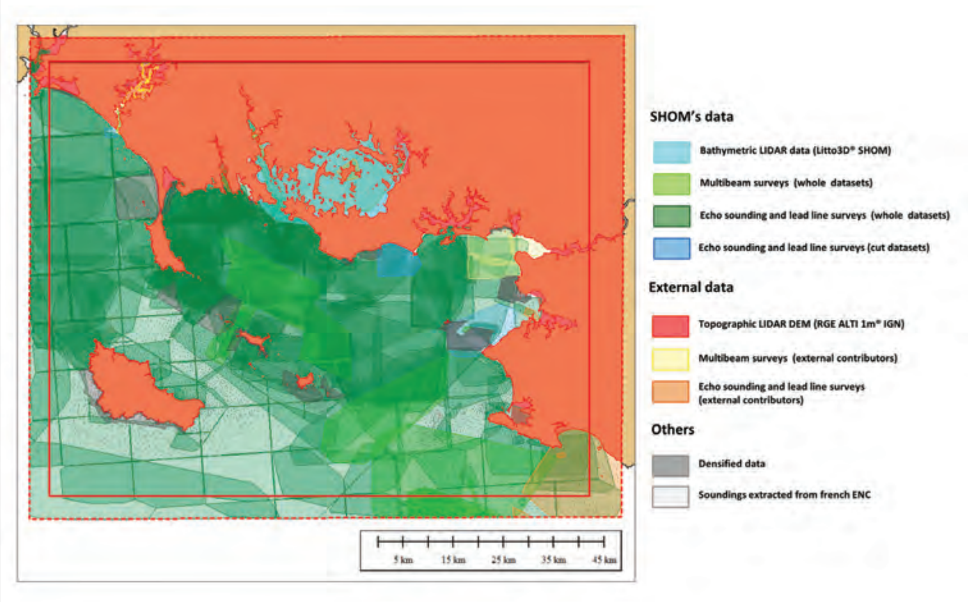

▲ *Figure 4: Source, type and coverage of selected datasets, on the extent of one coastal DEM (South Brittany local example). Red dash and solid lines respectively represent the extracted data area and the final DEM coverage. Similar data source evaluation is undertaken for each produced DEM.*

Laurie Biscara earned her PhD in Marine Geology from Bordeaux University in 2011. She has been working at SHOM since 2012 and has participated extensively in the implementation of the DEM production line in the scope of the HOMONIM project.

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Thierry Schmitt earned his PhD in Marine Geology from Cardiff University in 2005. Since then he has been working at CIDCO (Canada), Ifremer and SHOM (France) with the aim of developing techniques to elaborate bathymetric DEMs and facilitate their use.

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Bridging the Positioning Gap

Inertial Navigation Systems

Inertial Navigation Systems (INSs) are a great help in applications where either position stability is of great importance or where bridging (small) positioning gaps is a requirement. To understand INS imagine you are standing blindfolded in the centre of a long hallway. Then you start walking. You may proceed quickly at first, compensating as needed and covering ground with confidence. Eventually, however, you begin to lose your sense of alignment. This ability to successfully navigate when denied a visual frame of reference, even for a relatively short amount of time, represents our own basic human form of inertial navigation.

An INS is a relative positioning system. That is, it computes a position difference from a starting position (the centre of the hallway) using information about distance and direction. The combination of a 3 dimensional direction and a 3 dimensional acceleration / speed translates into a 3 dimensional position difference when computed over time. The direction and acceleration are determined from an Inertial Measurement Unit (IMU). A modern IMU is of the 'strap down' type and built around 3 accelerometers and three gyroscopes to provide rotation information. By using the 6 sensors from the IMU and combining them with the position information from, for example, a GNSS or a USBL system, a new position can be computed allowing the IMU to bridge a (small) gap in positioning information. This time, while travelling the same hallway blindfolded, a friend verbally directs you once per second. This greatly increases chances that you will proceed faster, never touch a wall, and will stop safely at the end.

Position and IMU Integration

A major hurdle that has to be overcome in an INS is the integration of all the readings on an exact time base; even small delays can cause significant errors in the final position. Also, in hydrography and navigation we are used to talking about heading when it comes to direction and the pitch, roll and heave movement of the vessel. These are all values that use a stable external reference; True North and the local vertical. An IMU does not measure heading, roll, pitch and heave, rather the information from the 6 'strapped down' sensors is converted using filtering algorithms into a heading, roll, pitch and heave value. The resulting accuracy depends on the type of sensors used but can, for the IMU alone, be better than 0.1° for the heading (on the

Figure 1: The INS concept (source: Applanix).

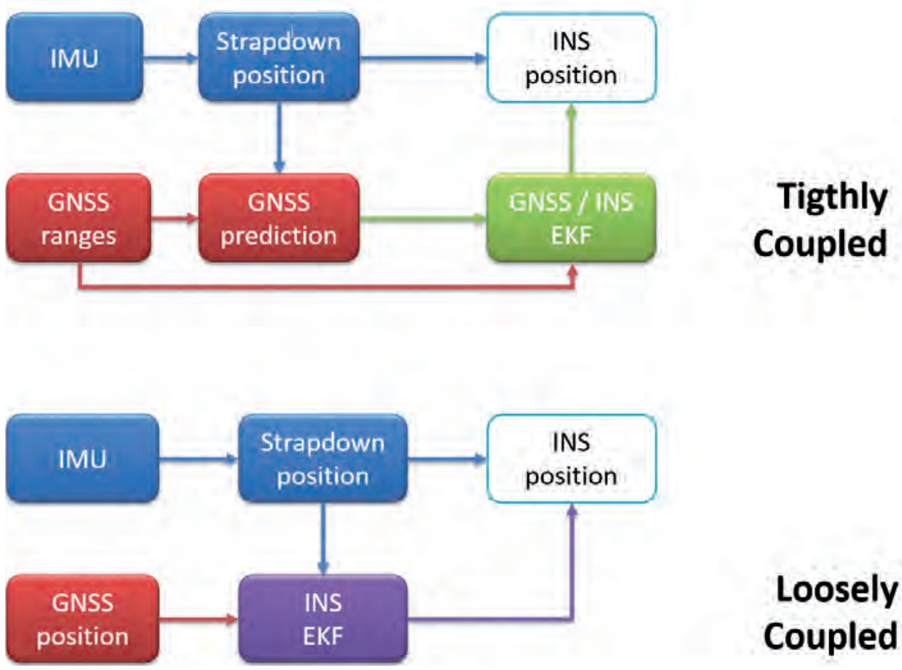


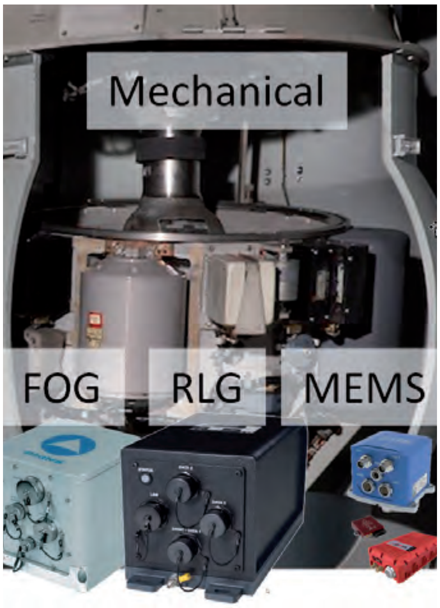
Figure 2: Loose and tightly coupled INS.

equator), 0.01° for roll and pitch and 0.05 cm or 5% of the heave motion.

If the positioning system has a lot of noise (as may happen with, for example, USBL in deepwater) a clever combination of the IMU data with the positioning system data allows smoothing of the position information, thereby improving the overall position accuracy and stability. The integration of the IMU and position data is commonly done using an Extended Kalman Filter (EKF). The EKF predicts a future position (and speed) based upon past position (and movement) information. With regular position updates the output of the EKF is generally better than any of the separate inputs. Depending on how the IMU and positioning system are integrated we talk about a 'tightly coupled' or 'loosely coupled' INS. A tightly coupled INS requires that all raw sensor information (including raw GNSS range information) is available and is relatively complicated to develop. When done correctly the

are small and are relatively cheap. MEMS are also found in smartphones to control, for example, screen orientation. When using MEMS technology, a modern IMU can be as small as a few centimetres cubed. The typical stability of a MEMS gyroscope is between 1° and 5° per hour with a few types significantly better and some significantly worse. A 1°/ hour heading error at a speed of 10 knots translates in a position error of over 5 metres after a minute without position updates. Because there are 3 gyroscopes (and 3 accelerometers), the IMU stand-alone position will normally be worse than the quoted 5 metres.

If better performance is required, an IMU with FOGs can be chosen. These typically have a stability of better than 0.1° per hour resulting in smaller position errors than the MEMS. The FOG uses the interference pattern created by two pulses of light travelling in opposite directions through long coils of optical fibre to measure the rate of turn.



▲ *Figure 3: Modern INS types (to scale; background detail of 1950s submarine INS.)*

An INS only provides a reliable position if it is properly aligned to the platform on which it is installed

tightly coupled INS is significantly better than the loosely coupled INS where the outputs from the GNSS (position, heading and speed) and IMU (heading, rotation and acceleration) are integrated externally.

IMU Sensors

As stated, the IMU has 3 accelerometers and 3 gyroscopes to measure along the X, Y and Z axis of the IMU (sometimes also called X1, X2 and X3 axis). Accelerometers are all essentially of the Micro Electro Mechanical Sensor (MEMS) type. There are different types of construction available (of which some are simply called solid state sensors) but all are built 'on a chip' and contain no moving parts in the classical sense. The accuracy of the accelerometer is determined by the quality of the sensor itself but also by local changes in the gravity field of the Earth. The quality of the sensor depends on the calibration procedures used as well as whether an advanced temperature stabilisation is employed within the device.

As to the gyroscope, three main different types exist; these can be roughly divided into MEMS, Fibre Optic Gyro's (FOG) and Ring Laser Gyro's (RLG). MEMS are the most common today; they

When even better accuracy is required, an IMU containing RLGs can be chosen. RLGs have drift rates of less than 0.002° per hour making them suitable for applications that either require very high accuracy or autonomous positioning performance over long timespans. The RLG has replaced the traditional (mechanical) gyroscope used in most military applications. As can be expected, an improved accuracy comes at a cost.

Sometimes an INS is aided by a Doppler Velocity Log (DVL), pressure sensor or magnetic compass, to provide additional information on movement and direction. The advantage of using, for example, a DVL is that a separate source of speed information is obtained against which the speed from the IMU can be checked. A RLG with DVL augmentation can obtain drift rates of less than 20 metres / hour.

Using an INS

An INS can achieve very high accuracies where heading, roll, pitch, heave and position information is concerned. The quoted accuracies are, however, those of the INS itself and are only achieved when the system has been properly set up. This requires knowledge of the various integration parameters according to the type of platform and its most probable behaviour (filter settings).

But even with the proper settings an INS only provides a reliable position if it is properly aligned to the platform on which it is installed. This means that the axis of the INS must be exactly aligned with the axis of the platform (vessel geometry). This is done by aligning the sensor as well as possible in a mechanical sense and then determining the remaining offset using a proper calibration procedure. When separate positioning sensors are used such as GNSS or a separate USBL, the relative position of the positioning sensor to the IMU must be determined accurately to achieve the advertised accuracy of the INS. To achieve this, an integrated unit with for example USBL + IMU may prove helpful as the offsets have already been modelled into the unit by the manufacturer requiring less set-up by the end-user. ◀

Huibert-Jan Lekkerkerk is a contributing editor and author of other publications on GNSS and Hydrography and principal Hydrography lecturer at Skilltrade. He is also a technical manager at the Dutch government. He has worked as client representative on projects such as Maasvlakte 2 and the Ketelmeer environmental dredging project
✉ info@hydrografie.info

The Neptune Oriental

The article below is reproduced from the Field Engineers Bulletin of the US Coast and Geodetic Survey for December 1936 with minor changes. Lieutenant Earle Deily (1900-1995), the author, was then a veteran of 13 years in the Survey having served on both coasts of the United States, Alaska, and the Philippine Islands. He was a scholar of the history of hydrography as well as being an outstanding hydrographer and geodesist. During the Second World War he served as an artillery surveyor with the Seventeenth Field Artillery Observation Battalion and saw action throughout France and Germany. He retired as a captain in 1954 but was advanced to the honorary rank of Rear Admiral based on his war combat experience.

▲ *Earle Deily, around 1930.*

Gold is where one finds it and one certainly finds things in the most unexpected places. While browsing around in an antique shop some months ago in search of copies of Blunts 'Coast Pilot' of which I am making a collection, I casually asked the manager of the store if he had any old maps. To my surprise he replied that he had a book of old maps that had been lying around there for some time and that he would gladly dispose of cheaply. He finally unearthed a large, dusty, canvas covered book from the bottom of a pile of seeming junk. Outwardly the volume appeared extremely ragged but the first chart I glanced at on opening the book bore a notation in the margin 'Published according to Act of Parliament by Alexander Dalrymple, December 10, 1771'.

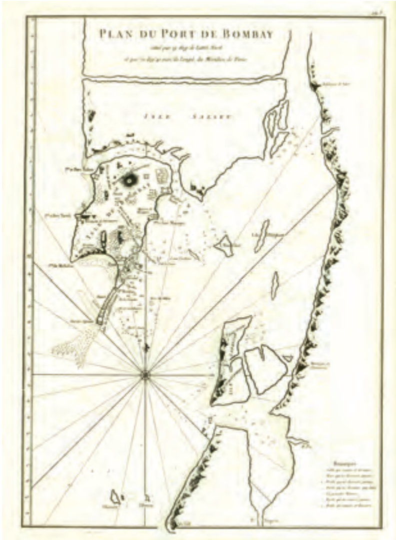
On stripping the temporary canvas cover from the volume I saw a fine leather binding and the words 'Neptune Oriental', which was enough information for me to quickly replace the canvas and attempt to conceal my excitement before calmly enquiring the small price of which he was continually speaking. It was so ridiculously small that I immediately paid it and, securing a receipt which said 'Book of old maps', dashed from the store with the book under my arm. To my surprise and great pleasure on a later careful examination I found it to be complete and all the charts well preserved.

The Neptune Oriental, a bound collection of nautical charts dating from 1730 to 1772, is probably less known to American hydrographers than the *Atlantic Neptune*. Compiled and first published by DeMannevillette in France in 1745, the *Neptune Oriental* should be of interest to Coast and Geodetic Survey officers because it included four charts of the Philippine Islands, more particularly of the Sulu archipelago, and undoubtedly suggested the name 'Atlantic Neptune' to the English atlas covering the east coast of North America, which was published some thirty years after the *Neptune Oriental*.

The *Neptune Oriental* consists of 69 charts and views embracing the coast of Europe from the English Channel to the Straits of Gibraltar, the coasts of Africa, Arabia and India, the Malay Peninsula with the islands of Sumatra, Java and Bali, Indo-china and the China Sea, the Sulu Archipelago, the Bay of Manila and two other charts of portions of the west coast of the Island of Luzon in the Philippines. Detailed charts of Port Louis and L'Orient in France, Tringuemalay (Trincomalee) in the island of Ceylon, and a Plan of the Bay and Port of Rio de Janeiro, dated 1730 and verified in 1751, are also included (Figure 2). All these were bound in one volume, 16 x 22 inches, which lacked title page, frontispieces and maps numbered 10 and 46.

This chart atlas was a product of the French due to the efforts of DeMannevillette, who, in 1762, became the director of the 'Depot des Cartes et Plans de la Navigation des Indes'. The results of thirty years effort, the first

▲ *Map of the Port of Rio de Janeiro.*



▲ *Map of the Port of Bombay (Mumbai).*

▲ *Map of the Port of Manila.*

edition, probably published in Paris, appeared in 1745, the second edition about 1775, and a supplement in 1781.

That the work of gathering and compiling the necessary data for such a monumental work and the correcting of such charts as were existing at such an early date must have been tremendous is self-evident, especially when one realises the possible sources of information concerning the East which, up to the l8th century, had been explored so little. It is amazing that so much was known at that time of many of the remote and even now comparatively little known portions of the globe.

That the French realised the value of a systematic gathering of nautical information for the use of their merchant marine as well as for the Navy so early is shown by the following portions of a 'sensible ordinance', of the date August l68l, concerning hydrography.

"Of the Professor of Hydrography

Art.1 .- We will, that in the most considerable maritime towns of our kingdom, there be Professors of Hydrography to teach publicly navigation.

Art.2 .- The Professors of Hydrography must draw, and instruct their scholars to make them capable of figuring the ports, coasts, mountains, trees, towers and other things serving for marks to harbors and roads, and to make Charts of the lands they discover.

Art.5 .- The Professors of Hydrography shall carefully examine the Journals of Voyages lodged with the Register of the Admiralty, of the place of their establishment, and correct them in preference of the Pilots, who had erred in their track."

The fact that the journals and charts of individual navigators must have been examined and the information recorded is evidenced by the numerous sailing tracks laid down on many of the charts of the *Neptune Oriental*. These tracks were transferred in such detail that the days' run of the vessel can be detected easily.

Chart No. 22d of 'The Islands and Dangers situated to the northeast of the Island of Madagascar' delineates a foul area and shows some 20 such tracks with the names of the vessels, commanders and the dates of sailing. These dates range from 1712 to 1776.

Chart No.52, 'A Chart of the China Sea', also shows many such tracks, particularly in that great unfrequented area in the China Sea lying westward of the island of Palawan. This chart shows the position of 'Scarboro Shoal' and contains the following note which may possibly be the first reference concerning that important danger lying to the west northwestward of Manila Bay - "This shoal is placed according to the Spanish Account, having been seen in 1755 by a ship bound to Manila from Macao."

Five of the charts in this collection are copies of the work of Alexander Dalrymple, the eminent British Hydrographer; laid down chiefly from his personal observations made in 1761, 1762, 1763 and 1764, and printed according to an Act of Parliament. These five charts are Charts 33, 52, 54, 55, and 56 titled respectively: Chart of the Northern Part of the Bay of Bengal; A Chart of the China Sea; A Map of part of Borneo and the Sooloo Archipelago; A Chart of Felicia and Plan of the Island of Balambangan; and The Sooloo Archipelago. As the *Neptune Oriental* is a French publication, the longitudes given were related to the Meridian of Paris and so noted on the plates. The charts are profusely illustrated with views of the various landmarks and ranges. Detailed sailing directions are included for entering harbours. Among the many views in this volume is a well executed one of the Harbour of Goa, the Portuguese capital of the Indies. The accompanying reproductions are particularly illustrative of the more detailed charts in the *Neptune Oriental*. It is interesting to note that these plates show how the Portolano lines were already evolving into the compass rose.

▲ *Jean-Baptiste Mannevilette, the early French Hydrographer who produced the* Atlantic Neptune.

▲ *Earle Deily, post World War II.*

The 'Plan De La Baye et Ville De Manille' is of especial interest to Coast and Geodetic Survey officers who have been on the Philippine station. That the area to the southward of Manila Bay is greatly distorted of course is self-evident. The wide opening into Laguna de Tual seems to be an attempt to show the Pansipit River. The passage between Golo and Mindoro is certainly wider than as remembered by anyone who has passed Cape Calivite.

Jean Baptiste Nicolas Denis d'Apres de Mannevillette (1707-1780), to whom the *Neptune Oriental* has been ascribed, studied mathematics at Paris. In 1726, he sailed along the north coast of San Domingo aboard the *Marechal d'Estrees*. With the aid of an octant and instruments invented by James Bradley, he corrected the latitudes of a number of points during a voyage to China. This happily suggested the task of correcting all the maps of India, the results of which appeared in the Neptune Oriental.

Alexander Dalrymple (1737-1808) was appointed a Writer in the service of the East India Company in 1752. On his first voyage to the East from India, Dalrymple visited Sulu and concluded a commercial treaty with the Sultan. This voyage was the means of giving the English a share in the spice trade, which was previously controlled by the Dutch. On his second voyage, in 1763, he obtained a grant for the company on the island of Balambangan and of the north end of Borneo and the south end of Palawan, with the intermediate islands. Thus began the holdings of the present British North Borneo Company.

From the time of his return to England in 1765 he was almost constantly engaged in collecting and arranging materials for a full exposition of the importance of the Eastern Islands and the South Seas. In 1779, he was appointed by the East India Company to examine their ships' journals and publish charts and nautical instruments which eventually amounted to 58 charts, 740 plans, 57 views of land and 50 nautical memoirs. These apparently were compiled from all known sources.

That he must have collaborated with DeMannevillette and borrowed from his work, as well as DeMannevillette borrowing from him, is particularly evidenced by the fact that one of the charts incorporated in the *Neptune Oriental* bears the following title: 'A CHART of the CHINA SEA Inscribed to Monsr. D'APRES de MANNEVILLETTE the ingenious Author of the NEPTUNE ORIENTAL As a TRIBUTE due to his LABOURS for the benefit of NAVIGATION And in acknowledgement of his many signal Favours to Dalrymple'.

Alexander Dalrymple was appointed Hydrographer to the Admiralty on the establishment of the office in 1795. He spent twelve years in this position. But little was accomplished as this period was spent in arranging documents, compiling charts and engraving plates. He apparently preferred to risk blame for lack of immediate show rather than be held responsible for the issue of charts that were incomplete and inaccurate. This necessary period of compilation was later repeated in the United States where an impatient Congress demanded of Ferdinand Hassler that charts be forthcoming immediately after the establishment of the Coast Survey. The British Admiralty also resented the non-productiveness in the way of printed charts and after an investigation Dalrymple was invited to resign. He never recovered from the humiliation of his enforced retirement and died within a few months.

CLIO Offshore

Proven Solutions for **Projects to 6,000 Metres**

CLIO Offshore provides recovery, ROV and survey solutions for subsea projects to 6,000 metres depth. Headquartered in Tampa, FL, USA, the company also maintains a marine base in Portland, UK.

▲ *Figure 1: Mark Gordon, OMEX and CLIO CEO and president.*

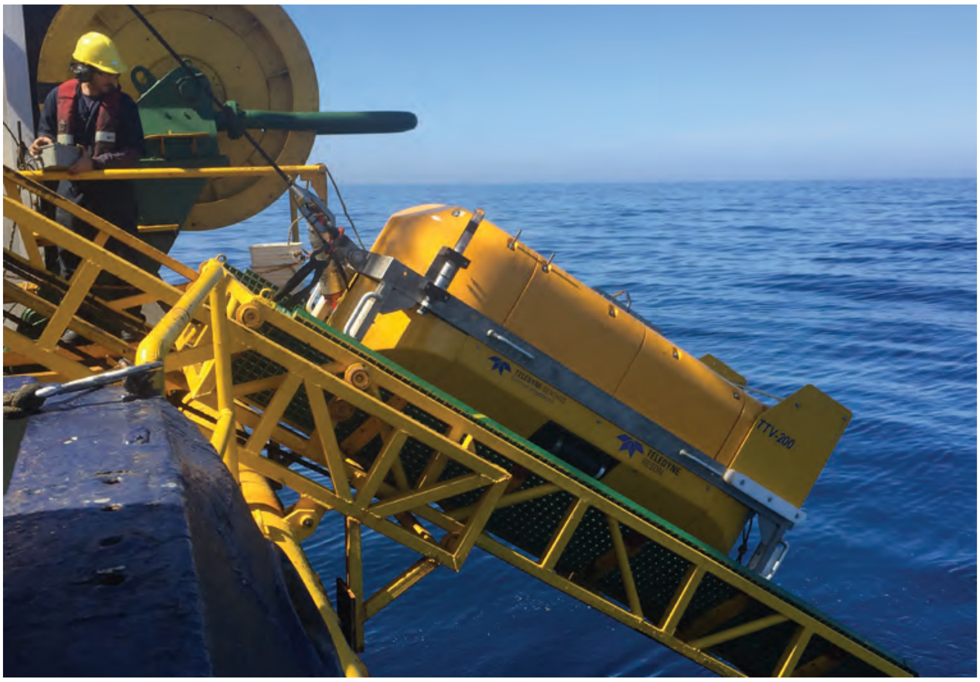
Officially launched in 2016, the team, tools and methods employed by CLIO have been honed for over 20 years by its parent company OMEX, a publicly-traded deep ocean exploration company.

“Traditionally, OMEX is known for its work in shipwreck exploration, but the vision for the company has always been much more robust. CLIO Offshore offers our wider-range of subsea capabilities to prospective clients that need cost-effective, efficient and proven project solutions,” said Mark Gordon OMEX and CLIO CEO. “The core competencies that we have developed working on our shipwreck and mineral projects can be applied to any marine-based project that requires survey, inspection or project planning. Our expert technical team has worked together over 15 years and achieves incredible results, an added benefit for companies that would like to benefit from their expertise.”

Ability to undertake Inverted USBL (iUSBL) tracking of tow fish over long laybacks

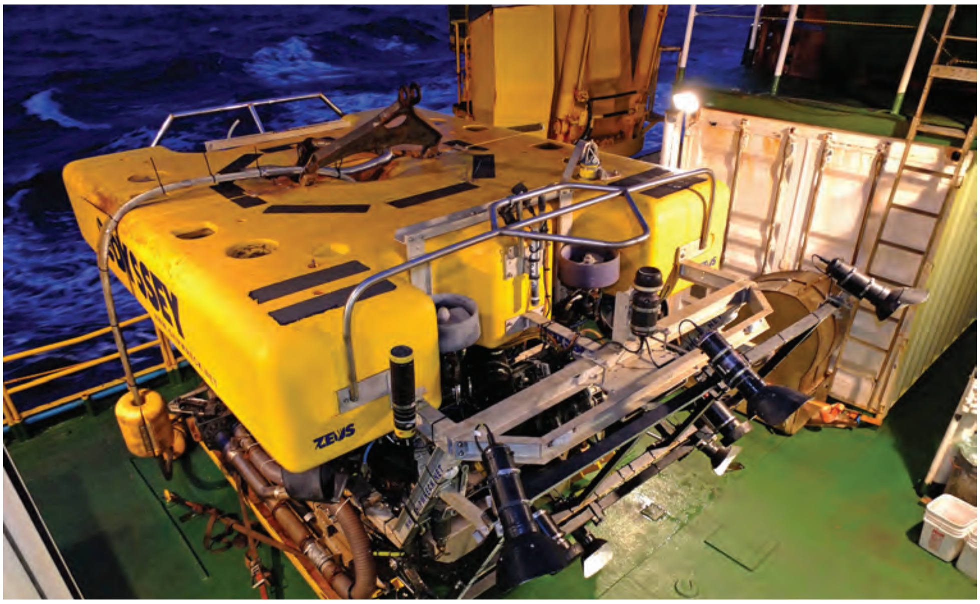
The four major toolkits currently offered by CLIO Offshore are the 6,000 metre *ARES* deep tow survey system; two WROVs, *ZEUS I* and *II*, rated to 2,500 metres depth, the 6,000 metre inspection and light survey-class *CLIO* ROV and a suite of ROV-actuated hydraulic cutting tools. All components are containerised allowing for fast and efficient mobilisation onto a client’s vessel or a vessel of opportunity. The company plans to add to this toolkit as it tests and proves additional technologies currently being acquired by OMEX.

CLIO’s service solutions may encompass a suite of individual tools and services to supplement



▲ *Figure 2:* ARES, *a 6,000 metre deep tow survey system that allows for the simultaneous collection of multibeam, side-scan and sub-bottom profiling data.*

▲ *Figure 3:* CLIO*, a 6,000m ROV configured to perform precision survey work or light work class ROV intervention tasks.*



▲ *Figure 4:* ZEUS II*, a 'heavy duty' WROV that is equipped with advanced acoustic positioning equipment and survey sensor packages and flyaway LARS package.*

Maintaining an incident-free, healthy work environment

existing operations or complete project delivery and management to meet a specific objective successfully. One key advantage offered by CLIO is the ability to work with an experienced and qualified technical crew that has been working together as a team on various deep ocean challenges for over 12 years. All of CLIO's work is underpinned by a track record in safety with a commitment to maintaining an incident-free, healthy work environment.

With employees and contractors based both on-shore and offshore, the company consists of over 120 specialists around the world. The US-based headquarters serve as the company lifeline for finance, logistics, business development and offshore support. Three project managers, led by the Marine Operations director, oversee the marine operations crew as well as the operations that occur offshore.

CLIO provides services to the global offshore oil & gas, telecommunications, and mineral exploration industries. In addition to the traditional site and route surveys for the offshore energy markets, CLIO Offshore's experience includes deep ocean natural resource exploration, ship and airplane wreck exploration, archaeological recovery and conservation, and insurance documentation. CLIO is actively engaging in discussions with a variety of clients from different markets and locations around the world.

The centrepieces to CLIO's kit is *ARES*, a 6,000 metre deep tow survey system, which allows for the simultaneous collection of multibeam, side-scan and sub-bottom profiling data. A proprietary feature is the ability to undertake Inverted USBL (iUSBL) tracking of tow fish over long laybacks. Rather than mounting the USBL transceiver on the vessel in the traditional manner, with iUSBL the transceiver is installed on the towed body itself providing a positioning solution for long layback tracking of the tow fish. This method eliminates the need for repeated system calibration, whilst the accuracy and repeatability of the acoustics is improved as the transceiver is located in a low noise, dynamically stable environment.

"As OMEX continues to develop its own projects requiring new technologies and unique project planning, CLIO will leverage this experience to benefit clients that are seeking to move their projects forward at fair and competitive rates. Every project has a unique set of requirements and we develop a customised project plan and budget to meet the specific needs of our clients. We integrate with our clients to assure the seamless delivery of data," said John Longley, chief operating officer for CLIO and OMEX.

CLIO will monitor new opportunities in emerging fields to take advantage of applying its unique set of capabilities. Multiple survey or recovery projects will be targeted within each calendar year. ◀

More information
www.cliooffshore.com

▲ *Figure 5: The grab that is part of the suite of hydraulic cutting tools, which allow for remote precision cuts to be conducted with surgical accuracy.*

The IHO's Role in Improving the **Charts of the Polar Regions**

The International Code for Ships Operating in Polar Waters, the 'Polar Code', recently adopted by the International Maritime Organization (IMO), warns that;

… *"In many areas, the chart coverage may not currently be adequate for coastal navigation. It is recognized even existing charts may be subject to unsurveyed and uncharted shoals"*

and

… *"navigational officers should … be familiar with the status of hydrographic surveys and … quality of chart information … and… aim to plan their route through charted areas and well clear of known shoal depths, following established routes whenever possible"*.

Against this background, the IHO is active in several international forums, seeking ways to address this unfortunate situation.

39th Antarctic Treaty Consultative Meeting (ATCM), Santiago, Chile, 23-27 May

In Santiago, the IHO, as an invited expert organisation, was represented by the Chilean Hydrographic Service that reported on the status of hydrographic surveys and nautical cartography in the Antarctic region. The contribution of the commercial sector, as represented by international organisations such as the International Association of Antarctic Tour Operators (IAATO), to support mapping and charting activities in Antarctica was highlighted. The IHO proposed that all vessels operating in Antarctic waters should be invited to gather depth data using their existing equipment, as active participants in the IHO's developing crowdsourced bathymetry initiative.

GEBCO Arctic-Antarctic Mapping Workshop, Monaco, 12-13 June

Ways to compile new editions of the authoritative GEBCO International Bathymetric Charts of the Arctic Ocean (IBCAO) and the Southern Ocean (IBCSO) were addressed by about 40 scientists, cartographers and hydrographers, who gathered at the IHO headquarters in Monaco in June. The Chairs of the Arctic Regional Hydrographic Commission (ARHC) and of the IHO Hydrographic Commission on Antarctica (HCA) both stressed the fact that additional data has been gathered over the years by many scientific cruises, but has not been made available. As a result, it is not currently reflected in the charts of the regions!

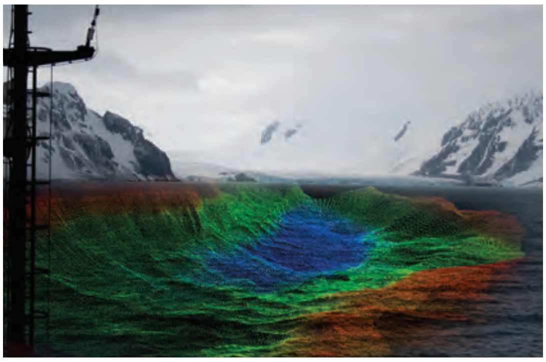
14th Conference of the IHO Hydrographic Commission on Antarctica, Tromsø, Norway, 28 June - 1 July

Discussions at the HCA Conference in Tromsø addressed both the need to obtain additional bathymetric data from all sources and observers in the region, and the need to establish a recognised and interoperable GIS-based data and metadata repository so that all existing data may be identified. A comprehensive analysis of the charting coverage in Antarctica was provided and compared against the statistics of recent vessel traffic patterns using both IAATO and AIS data. This enabled the verification of the maritime shipping routes that are currently the focus of charting priorities. Holding the meeting in Tromsø ensured that fruitful liaison was established with experts from the Norwegian Polar Institute involved in both Arctic and Antarctic research.

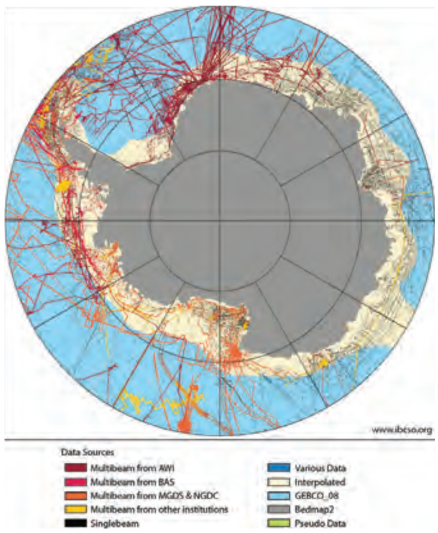
6th Conference of the Arctic Regional Hydrographic Commission, Iqaluit, Canada, 3 and 6 October

The forthcoming ARHC Conference will be held in the Canadian Arctic in conjunction with 'Ocean Innovation 2016 – Adapting to a Changing Circumpolar North'. The ARHC will bring together the national Hydrographers of Canada (Chair), Denmark, Finland, Iceland, Norway, Russian Federation and USA. They will meet to coordinate their charting activities and discuss, among other things, the development of an Arctic Voyage Planning Guide and an Arctic Marine Spatial Data Infrastructure. ◂

▲ *Figure 1: Sjokartverket survey vessel* Hydrograf *in the Arctic with polar bear. Image courtesy: Norwegian Hydrographic Service.*



▲ *Figure 2 : Bathymetry overlaid on an image. Image courtesy : Instituto Hidrografico de la Marina, Spain.*



▲ *Figure 3: Data sources available for Antarctic mapping and charting.*

SEPTEMBER

Offshore Site Investigation & Geotechnics (OSIG)
London, UK
→ 12-14 September
www.sut.org/event/osig2017

Echoview Training Course
Halifax. Canada
→ 12-16 September
www.echoview.com/products-services/training-and-events

European Dredging Summit
Hamburg, Germany
→ 14-15 September
www.wplgroup.com/aci/event/dredging-summit-europe

EIVA Days Denmark
Skanderborg, Denmark
→ 14-15 September
www.eiva.com/about/events/eiva-days-denmark-2016

MTS/IEEE Oceans '16
Monterey, USA
→ 19-23 September
www.oceans16mtsieeemonterey.org

India Clean Seas 2016
Goa, India
→ 22-24 September
www.cleanseas.in

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

OCTOBER

Inmartech 2016
Bergen, Norway
→ 4-6 October
inmartech2016.imr.no

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

International conference on Marine Data and Information Systems (IMDIS)
Gdansk, Poland
→ 11-13 October
imdis2016.seadatanet.org

Flood Expo
London, UK
→ 12-13 October
www.thefloodexpo.co.uk

Unmanned Maritime Systems
Washington, DC, USA
→ 17-19 October
www.unmannedmaritimesystems.com

Euro Naval
Paris, France
→ 17-21 October
bit.ly/10anvm1

Iranimex
Kish, Iran
→ 18-21 October
www.europort.nl/about-europort/europort-exports/iranimex

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

Danish Maritime Fair
Copenhagen, Denmark
→ 25-28 October
www.danishmaritimefair.dk/

NOVEMBER

Trimble Dimensions
Las Vegas, USA
→ 7-9 November
www.trimbledimensions.com

North Sea Open Science Conference
Ostend, Belgium
→ 7-10 November
www.northseaconference.be

Ocean Energy Europe 2016
Brussels, Belgium
→ 8-9 November
http://www.oceanenergy-europe.eu/oee-2016

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

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

European Autumn Gas Conference
The Hague, The Netherlands
→ 14-16 November
www.theeagc.com

UK Marine Technology Show
Southampton, UK
→ 14-18 November
conference.noc.ac.uk/matshowcase

Asia-Pacific Dredging Summit
Singapore
→ 23-24 November
bit.ly/10aoD9n

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

WOC Sustainable Ocean Summit
Rotterdam, The Netherlands
→ 30 November – 2 December
www.oceancouncil.org

JANUARY 2017

HYPACK 2017 Training Event
New Orleans, USA
→ 9-12 January
hypack.com

Least Squares Adjustment for Offshore Survey
Newcastle Upon Tyne, UK
→ 16-18 January
bit.ly/2aLJVJG

FEBRUARY

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

MARCH

US Hydro 2017
Galveston, USA
→ 20-23 March
www.ushydro2017.com

APRIL

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

Gastech
Chiba-City, Japan
→ 4-7 April
www.gastechevent.com

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

SMI Annual Conference 2017
Dartmouth, UK
→ 26-27 April
www.maritimeindustries.org/SMI-Annual-Conference

JUNE

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

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

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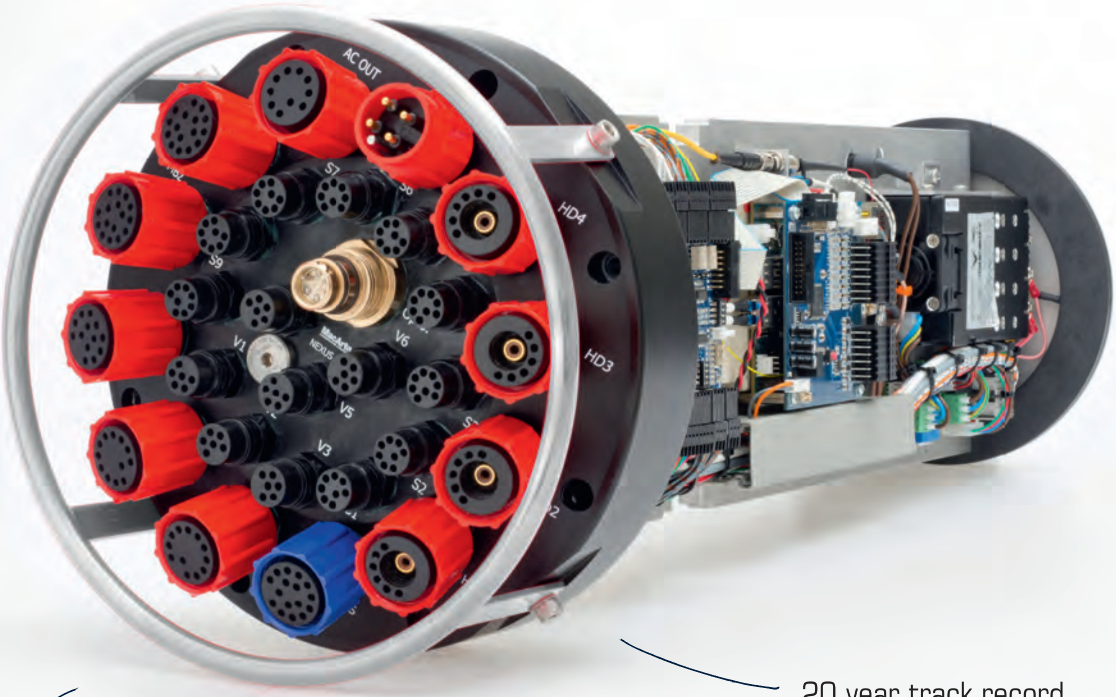

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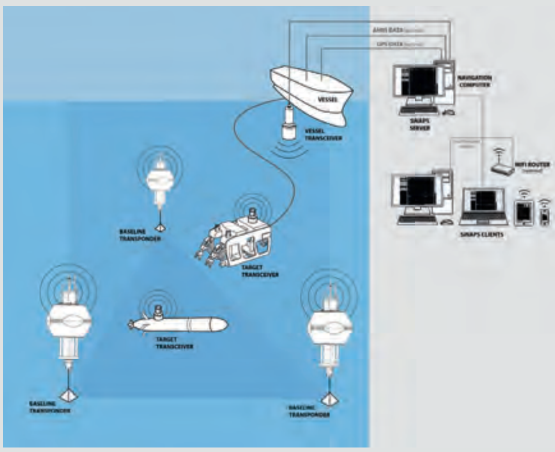

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