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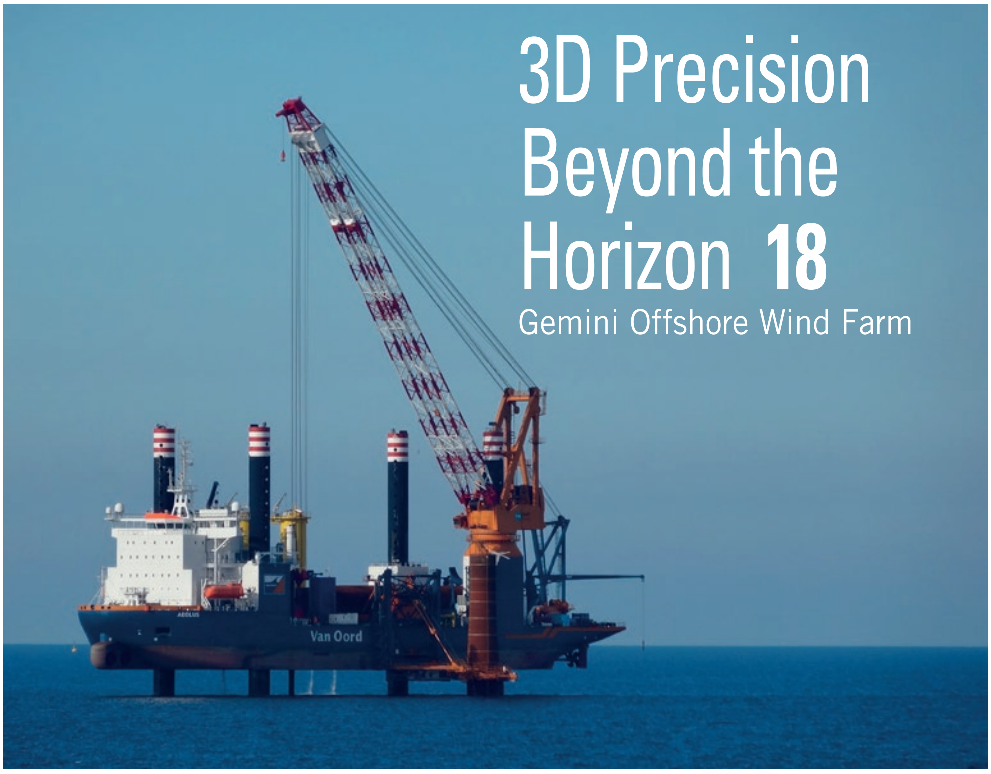
Hydro INTERNATIONAL 20th ANNIVERSARY

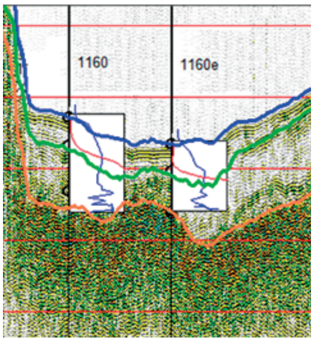
Developments and Trends in Multibeam Echo Sounders

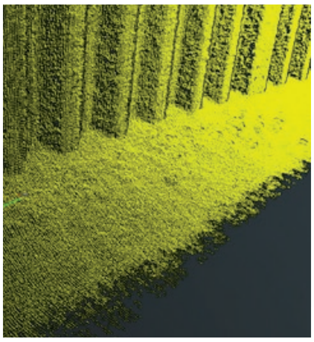
UNMANNED SURFACE VEHICLE AS AID FOR LBL POSITIONING

3D Precision Beyond the Horizon

GEMINI OFFSHORE WIND FARM







January-February 2016
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Van Oord's offshore installation vessel Aeolus *installing a monopile at the Gemini Offshore Wind Park. Image courtesy: Flying Focus.*

HYDRO ALPHABETICAL LIST OF ADVERTISERS

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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Silver and Gold

Maybe you had already noticed the silver rosette on the cover of this first 2016 issue of *Hydro International* when it landed on your desk. The rosette marks 20 years of *Hydro International*. An expert in anniversary colours might argue that silver belongs to the 25th and gold to the 50th anniversary, but we prefer silver to the emerald green that officially denotes a 20th anniversary. We're not that picky, but still proud that we've reached the respectable age of 20 years. That's quite remarkable in this day and age for a business-to-business magazine and we think it's worth celebrating. I believe that the strength of *Hydro International* has been and is its strong reputation for content together with the ability to bind a global community through news on businesses, products, organisations and hydrographic societies, developments with universities and companies and updates on state of the art techniques in feature articles. In this very issue you will find an overview article on the state of the art of multibeam echo sounders. Our product focus in this issue is MBES and Ole Kristensen wrote the article Developments and Trends in Multibeam Echo Sounders (can be found on page 30). In addition, there is a feature article on positioning at the Gemini Wind Farm in the North Sea written by Wim Kanneworff on page 18 and Maria Pleskach updates our readers on the possibilities of putting unmanned surface vehicles in place as aids for LBL positioning on page 22. Coen Werner looks at a flexible high-resolution seismic method for qualification of the seabed on page 26. Dr. John Hall sheds a little light on the possibilities to map the 88 percent of the ocean that is literally uncharted and the IHO gives an update on further development towards S-100 framework. Furthermore, Joost Boers and Wim van Wegen, managing editors at Geomares, interviewed Steven Xu, CEO of a Chinese (hydrographic) surveying equipment manufacturer. He looks far beyond the horizon, from the Far East, on page 14 of this issue. It's my not intention to just tell you what is featured in this issue of *Hydro International* as I am sure you will read this for yourself; looking for your favourite columnist or topic and then reading the rest or the other way around: keeping the best for last. But the fact is that we've tried to provide you with a mix of authors from all corners of the hydrographic community for the last 20 years and we plan to continue doing so for a long time to come. You will notice that this issue of *Hydro International* is thicker and more luxurious than usual. It's not all good news unfortunately. We have had to say goodbye to two of our valued contributing editors recently. Both Leendert Dorst and Ronald Koomans have left the editorial board after years of guiding the magazine on the right course! I would like to thank them very much for all of their contributions, not just in print, but also during many inspiring editorial meetings and I wish them both all the best for the future. I am sure they will keep an eye on *Hydro International*, and we'll keep an eye on them. Nevertheless, this is the silver start of the year 2016 and together with you we want strive towards gold in the years to come!

Durk Haarsma durk.haarsma@geomares.nl

What about **the other 88%?**

Despite the last decade's flurry of UNCLOS ECS mapping, the amount of the oceans surveyed remains around 12%. The continuing search for the MH370 wreckage emphasises our scant knowledge of the actual deep ocean seafloor despite the apparently detailed overall picture derived from satellite altimetry's synthetic bathymetry.

Just eight years ago, from this 'bully pulpit', I wrote about GOMaP, a 1999 proposal to devote USD8-16 billion over 20-30 years to swath map all the oceans deeper than 500m. I concluded 'Unfortunately GOMaP lacked the sex appeal of placing humans on Mars or fulfilling other dreams'.
One year ago, Larry Mayer presented 'What Difference a Swath Makes' when GEBCO's Science Day was held at the AGU Fall Meeting in San Francisco. After comparing awesome full-resolution swath to GEBCO or SRTM_30PLUS 0.5 min grids, he computed the proportions of seafloor between 150m and 1km and then over 1km intervals, using the latest GEBCO 2014 grid. Operating at 10kts, with swaths of 4x water depth, he showed 65,246 days were needed. Using a USD52k/day rate the cost (for mapping only) totals approximately USD3.4bn.

Few people question the value of our oceans. Bordering 153 of the world's 194 countries, they are a heat and CO_2 sink, protein provider for 3 billion people, the source of our worst weather, and the pathways for most of our commerce. Despite annually generating USD3tn, they are actually a dwindling USD24tn asset taken mostly for granted.

Web searches show primary concern about the upper photic layer, scarcely 1% of the average depth. But the ocean seafloor is too important to ignore. While all but one of the known animal phyla are found in the sea, almost half are exclusively marine. The >100,000 seamounts >1km high and mid-ocean ridges and trenches produce the varying habitats that harbour these mostly unknown life forms, while their steep critical slopes provide the mixing that prevents a stratified and dying water mass.

The revised budget is amazingly small. Assuming ~60 deep ocean ships with modern sonar, only three years are required to map the world's oceans. A period of 10-15 years is more likely, costing about one Boeing 787-10 Dreamliner per year. For mapping the vast areas beyond sovereignty claims, one solution might come from rapidly improving deepwater swath equipped AUVs. Imagine a large mother ship with crew and workshops for the care of perhaps 50 HUGIN 3000 and 6000 AUVs, each capable of 60 hours endurance at 4kts. Assuming 6 hours for recovery, data downloading, battery swapping, route programming, and launching of one HUGIN, each could, at a depth of 2km above the bottom, accomplish up to 3,500 km^2 of mapping every 66 hours. All 50 could do 175,000 km^2 in that period. The daily logistics and maintenance load would amount to about two AUV turnarounds per hour, probably only possible with specially designed moon-pool. Monthly data acquisition could approach 1.9m km^2 (compared to UNH-CCOM-JHC's UNCLOS mapping of 2.29m km^2 from 2003 to 2012). Operational areas would change as 100% coverage was completed, with locations chosen for their benign weather.

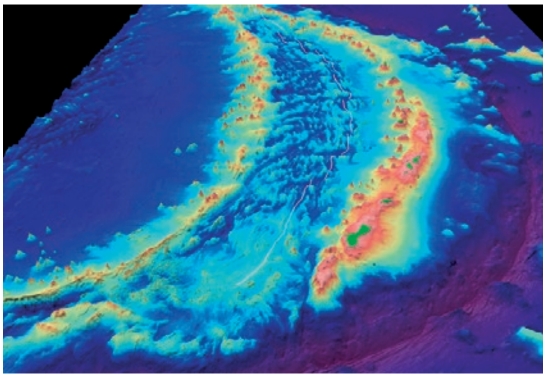
Acquisition of such a ship and AUVs would probably be around USD250m, with annual operational costs of some USD60m. This would be similar to the IODP budget for operating the JOIDES Resolution. The recent Ocean XPrize might kick start this giant step forward.

More information
http://oceandiscovery.xprize.org/about/overview

Deep-sea Vents and Volcanic Activity Discovered

By the time of their return from a 28-day expedition on board R/V *Falkor* in mid-December 2015, a team of scientists had more than doubled the number of known hydrothermal vent sites in the Mariana Back-arc region. This area, west of the Mariana Trench, is where plate spreading and submarine volcanism are concentrated. Several momentous findings were made, including the discovery of one of the deepest vents ever found plus volcanic activity.

▸ ***bit.ly/1PGOm3U***



Bathymetry of the Mariana back-arc.

Busy Year ahead for British Wind Farms

RenewableUK is predicting a busy year of construction activity in offshore wind in 2016, bringing massive economic benefits across the UK. Construction activity is currently underway on six offshore wind projects, with onshore substations being built and cables being laid. These projects have a combined capacity of more than 2.6GW.

▸ ***bit.ly/1PGOT5F***

Survey vessel Bibby Tethra *operating in a wind farm.*

Geo-matching.com Adds DVLs

Geo-matching.com has recently added Doppler Velocity Logs (DVLs) to its product categories. In addition to general specifications, detailed information is given about operation characteristics, acoustic specifications and water velocity. Sonardyne is the first supplier in this category with the Syrinx DVL. To see the DVLs category, go to geo-matching.com/category/id106-dvls-doppler-velocity-log-.html

▸ ***bit.ly/1PGP6Gc***

Most Shared

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

Deep-sea Vents and Volcanic Activity Discovered - bit.ly/1PGOm3U
OpenSeaMap – the Free Nautical Chart - bit.ly/1PGOv7d
Introducing GIS to Support Maritime Accessibility - bit.ly/1PGOwIz
Underwater Electromagnetic Propagation - bit.ly/1PxDKt2
Guidelines for GNSS Positioning - bit.ly/1PGOGj5

Rob Spillard.

Rob Spillard Bibby HydroMap's Technical Director

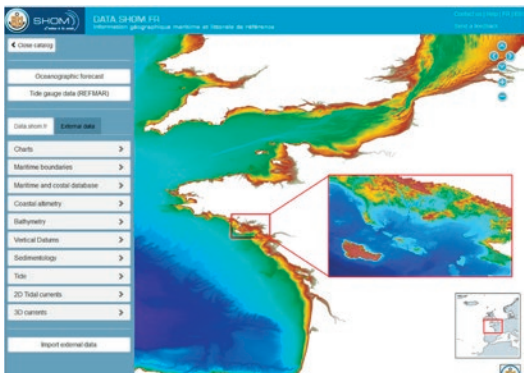
UK-based seabed survey company Bibby HydroMap continues to strengthen its executive board with the appointment of Rob Spillard as technical director. As part of the company's focus on efficiency, the newly created role has followed a restructuring of the senior management team which previously saw the appointment of Mick Slater as operations director.

▸ ***bit.ly/1PGPd4w***

High-resolution DEM Released for French Waters

SHOM has recently produced nested multi-purpose digital elevation models (DEMs). The resolution ranges from down to 10 metres for topo-bathymetric coastal DEMs to 100 metres for regional bathymetric DEMs in the North East Atlantic and the Mediterranean Sea.

▸ ***bit.ly/1PGONLz***



SHOM bathymetric digital elevation model.

AUV Survey Contract for Deepwater Development

Fugro has been awarded a contract by Esso Exploration and Production Guyana Limited, an ExxonMobil affiliate, for survey services at a deepwater field development offshore Guyana. The contract provides for autonomous underwater vehicle (AUV) geophysical survey and an environmental baseline survey, along with shallow geohazard and geotechnical coring.

▸ *bit.ly/1PGPpAE*

Heat Loss from the Earth's Crust Solved

The first discovery by the National Oceanography Centre (NOC, UK) and the University of Southampton of a new type of hydrothermal vent system in a decade helps explain the long observed disconnect between the theoretical rate at which the Earth's crust is cooling at seafloor spreading ridge flanks, and actual observations. They used a combination of AUVs and ROVs operated by the NOC. It could also help scientists interpret the evidence for past global climates more accurately.

▸ *bit.ly/1PGR0q6*

New Name: Klein Marine Systems

As of 1 January 2016, USA-based L-3 Communications Klein Associates, Inc. has been acquired by Mitcham Industries, Inc. Following this, the business has been renamed 'Klein Marine Systems, Inc.'

▸ *bit.ly/1PGPOmH*

Helcom Discusses Underwater Noise

Country delegates of HELCOM have made decisions on issues concerning the Baltic Sea and the protection of its marine environment. The agenda included the approval of the Roadmap on underwater noise and the Recommendation on sustainable aquaculture and follow-up on the protection of threatened and endangered species.

▸ *bit.ly/1PGR9dm*

Geraint West Global Business Manager for Oceanography at Sonardyne

Geraint West.

Sonardyne International, UK, has appointed Geraint West as its Global Business manager for Oceanography. Geraint joins Sonardyne with immediate effect and brings with him extensive experience gained over 32 years with the Royal Navy, Fugro and most recently, the National Oceanography Centre (NOC).

▸ *bit.ly/1PGPww9*

Charts Based on Satellite Images

Western entrance of Yukon River, chart based on satellite imagery.

NOAA Coast Survey has issued unique provisional charts based solely on satellite images for barge operators and others traversing Alaska's challenging Yukon River. The electronic navigational charts (ENCs) display shoreline and shoals (shallow areas) only, with no depth soundings. These charts, the first to be created from satellite imagery alone, will give the mariners annually updated information to help them navigate along the changeable river.

▸ *bit.ly/1PGPW5N*

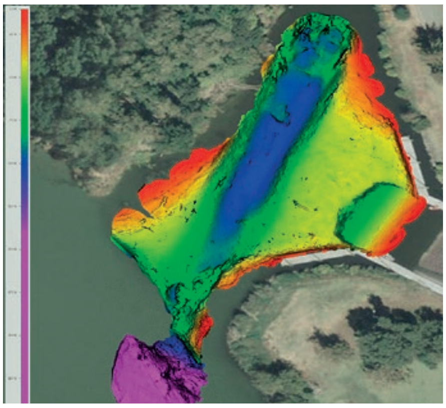
Large-scale Mapping Completed in Bay of Bothnia

Overview of the surveyed area in the Bay of Bothnia.

Swedish survey company Clinton Marine Survey has completed the large-scale hydrographic mapping project called BBROK2015. A total of 1,311 square kilometres of multibeam data have been acquired between June and November 2015. The water depth has varied from 5.5 metres to 95 metres and a total of 5,500GB of raw data has been collected during this period.

▸ *bit.ly/1PGQ3y8*

Echoboat-RCV Integration with Norbit



Survey map of the surveyed area.

Seafloor Systems has successfully integrated and tested the Norbit iWBMSc (Integrated Wideband Multibeam Sonar, Compact) echo sounder system with the EchoBoat-RCV remotely controlled survey vehicle.

In addition to its ultra-compact form factor, the Norbit system features an integrated INS and sound velocity sensors, thus eliminating the need to install separate devices while greatly reducing calibration and offset measurements.

▸ ***bit.ly/1PGQhVS***

NOAA and Cuban Chartmakers to Improve Chart Coverage

The Cuban delegation spent time on the NOAA survey vessel.

Following up on Coast Survey's visit to Havana, Cuba, spring 2015, Cuban hydrographic officials travelled to Maryland, USA on 15-17 December 2015, to meet with NOAA National Ocean Service (NOS) leaders for discussions about potential future collaboration. High on the agenda for Coast Survey was improving nautical charts for maritime traffic transiting the increasingly busy Straits of Florida.

▸ ***bit.ly/1PGQsRg***

Explanatory Video of the IHO S-100 Standard

The International Hydrographic Organization (Monaco) has launched a video explaining the S-100 hydrographic standard. The 8-minute video outlines elements and features of the standard, as well as the history leading towards it. It is also useful for professionals working with product specifications of hydrographic surveys leading to the end product, nautical charts.

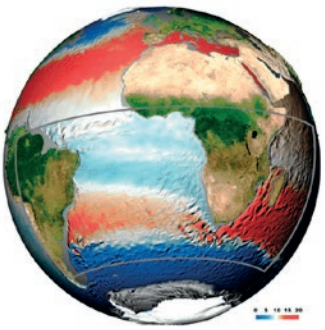
▸ ***bit.ly/1PGQAQG***

Top 5 Geo-Matching.com

Geo-matching.com The right choice

Inertial Navigation Systems	
Applanix POS MV WaveMaster II	bit.ly/wavemasterII
NovAtel SPAN-IGM-A1	bit.ly/spanigma1
Applanix POS MV Elite	bit.ly/posmvelite
SBG Systems Apogee N	bit.ly/apogeen
Advanced Navigation Spatial Dual	bit.ly/spatialdual

Reconstruction of Ocean Current Behaviour around the Cape of Good Hope



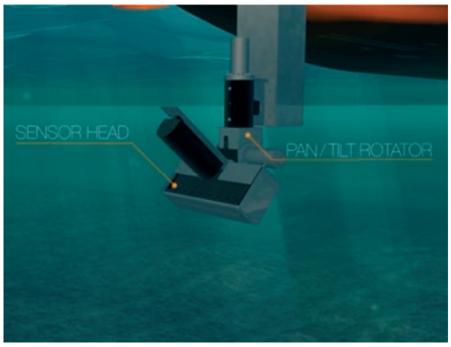
Simulation of temperature (shading in °C) and currents in 250-400m depth in an ocean model. Image courtesy: Geomar.

The Agulhas Current near the Cape of Good Hope at the southern tip of Africa plays a key role in the system of global ocean currents. For the first time, using a combination of various computer models and existing observations, oceanographers at GEOMAR Helmholtz Centre for Ocean Research Kiel have been able to reconstruct the behaviour of the Agulhas Current since 1870. The study appears in the international journal 'Nature Communications'.

▸ ***bit.ly/1PGReO9***

Intensive Collaboration ECE Offshore and Stema Systems

Stema Systems and ECE Offshore sealed their cooperation in November 2015, formalising their collaboration in the shape of a strategic cooperation agreement. Reinier Nagtegaal of ECE Offshore and Pepijn Peter of Stema Systems signed the official cooperation agreement. The cooperation between ECE Offshore and Stema Systems started around one and half years ago, due to a demand for real-time monitoring of the installation of the HCAC/HVDC cables, flexibles & umbilicals at sea.



OASYS Cable Touch Down and Installation system.

▸ ***bit.ly/1PGQPvc***

International Workshop on Tsunami Inundation Mapping

Hydrographic Offices Embark on **Tsunami Disaster**

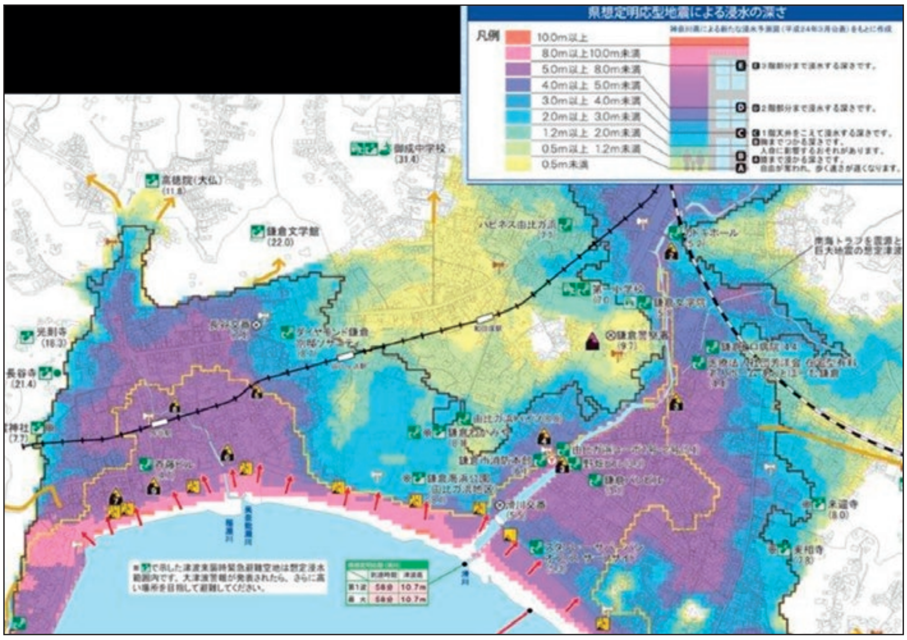


Figure 1: Example of Tsunami Inundation Map developed by Kamakura city in Japan.

The International Workshop on Tsunami Inundation Mapping was held in Tokyo, Japan on 25-26 November 2015. It aimed to improve the capacity of Hydrographic Offices (HOs) in East Asian countries on Tsunami Inundation Map (TIM). TIM is an important tool for increasing public awareness and making counter measurement plans for an estimated tsunami disaster. HOs are expected to contribute to developing TIM in their own state, because bathymetric information is essential in doing so. This event was a first for the hydrographic community worldwide.

A Tsunami inundation map (TIM) is an important tool for increasing public awareness and for developing counter measure plans for stakeholders involved in tsunami disasters. A TIM maps inundation areas, evacuation sites and evacuation routes and includes other useful information. Techniques and knowledge to develop TIM can be applicable to other marine disasters related to sea level rise, such as a storm surge.

International Workshop

The International Workshop on Tsunami Inundation Mapping was held by JHOD in cooperation with UNESCO/ International Oceanographic Commission (IOC) Tsunami Programme and Port and Airport Research Institute (PARI), Japan, as part of the 2015 East Asia Hydrographic Commission (EAHC) Capacity Building Programme using the International Hydrographic Organization (IHO) Capacity Building fund.
The objectives of workshop were to improve the capacity of Hos, mainly in the East Asian states, for development and utilisation of TIM and to discuss the way forward to achieve this by sharing the latest technology, knowledge, experiences and challenges among the participants.

bit.ly/1Z1E6gH

Figure 2: Discussion at the International Workshop on Tsunami Inundation Mapping.

HYPACK 2016 Training Event

The HYPACK 2016 Training Event was held from 4-7 January 2016 in Tampa, FL, USA. This event was attended by over 325 people representing over 25 countries, had 26 of the industry's leading companies exhibiting, and hundreds of viewers tuning in to watch selected training sessions remotely.

The proceedings commenced with the unveiling of HYPACK's newest version, HYPACK version 2016. This new version has been enhanced with several new features. These features include: high-density laser data acquisition, multi-detect multibeam support, multi-day acquisition and processing, post-processed positioning (PPK) in HYSCAN, SBET editing tool, many new exported reports to PDF, Support 4-channel magnetometers, dual head water column logging, sound velocity interpolation by position in MBMAX, TIN MODEL volumes features, new 64bit single beam editor and new marine search software package, just to list a few.

Figure 1: Delegates in the opening session.

The HYPACK Training Event offered a forum for attendees to receive essential instruction in HYPACK hydrographic and dredging applications; it provides an opportunity for them to network with others and view exhibits from the industry's leaders of hardware, equipment resellers and service providers.

Figure 2: Harold Orlinsky and Lourdes Evans at the HYPACK information stand.

Spanish

For the first time, HYPACK added three training sessions presented in Spanish. This gave our Spanish speaking users the ability to have a more comprehensive training. HYPACK is also pleased to announce that for the third year in a row, the HYPACK Training Event was streamed live on Ustream.tv. For those who missed this broadcast, the presentation videos from the General Room have been posted on the HYPACK website for future viewing. It provides viewers with 16 hours of HYPACK® training. The HYPACK organisers extend a special thank you to all the attendees and exhibitors who came to Tampa and made HYPACK 2016 a memorable and exciting event. They enjoyed all the positive feedback and can't wait for HYPACK 2017. For more information on upcoming trainings and seminars in 2016, please go to HYPACK's website.

▸ *bit.ly/1PGRBZO*

More Information
www.hypack.com

German Hydrographic Society to Stage Hydro 2016

The International Federation of Hydrographic Societies' (IFHS) 24th symposium and exhibition will be held in Rostock-Warnemunde, Germany, from 8-10 November 2016. Abstracts of papers for presentation at this major three-day event may now be submitted to the organisers, the German Hydrographic Society (DHyG).

▸ *bit.ly/1PGOLmF*

Registration Now Live for OI 2016

Oceanology International 2016 (OI) being held at ExCeL London, UK, from 15-17 March 2016, is set to be a record breaker according to the organisers. It has already matched the size of OI 2014 and, with hundreds of additional metres on reserve and due to be confirmed soon, the 2016 event will be the biggest OI of all time. Registration is now available online.

▸ *bit.ly/1PGQoAY*

Hydro International Interviews Steven Xu, CEO, Hi-Target

Looking **Far Beyond** the Horizon

These are exciting times in the geomatics and hydrographic industry. Innovative solutions are being developed, integration is the main keyword and the big players are acquiring smaller companies that add a new dimension to their portfolio. Europe, Japan and North America are traditional strongholds of geomatics, but several very ambitious companies from China are doing their utmost to catch up with the frontrunners. Steven Xu, CEO of Hi-Target, was more than happy to share his thoughts and expectations with *Hydro International*.

Hi-Target was established in Guangzhou, China, in 1999. What were its ambitions in the early years?

Hi-Target started out as a small company. The chairman, Mr Liao Dinghai, founded the company after he graduated from Dalian University. Mr Liao served in the national navy as a hydrographic surveyor for a period before Hi-Target was founded. At that time he had the opportunity to take part in some big hydrographic survey projects in China but the equipment they used for surveying was very old and difficult to operate, even dangerous at times. Slowly and surely Mr Liao realised it was his ambition to manufacture more advanced equipment on his own to change surveying conditions in China, but it remained a dream for a while. He then received a chance to work on another big project, this time for Nansha island exploration. The Chinese government spent lots of money importing GPS devices for this project. Mr Liao was one of the first people to use GPS for surveying. He quickly learnt how GPS devices work and took every opportunity to attend industry events to help him develop advanced surveying technology. Mr Liao established Hi-Target in 1999. Today, Hi-Target successfully promotes the implementation of RTK production localisation and is a leader in China.

What are your present ambitions, both nationally and internationally?

Now that's what you call a big question! But I would like to put it simply: in our domestic market we want to be the number one. There is a unique opportunity as the Chinese market is huge and has an enormous potential. We are currently making great strides so things look very promising for Hi-Target in China.

When it comes to the international market, our ambition is to become one of the most respected premium brands. We dream of being mentioned in the same breath as Trimble and Leica Geosystems. When people think of 'Made in China' they traditionally associate it with copies, low quality or even worse. But this is clearly changing nowadays. Many Chinese companies already have their own core technology. But I am keen to stress that we also believe the international market offers a lot of potential for Chinese software. Without linguistic and cultural barriers, software developed by Chinese companies will be increasingly widely used in different countries. Therefore, we think there are great opportunities on the horizon in the survey industry.

Hydrographic survey and nautical charting is important in Asia/Pacific for various purposes: offshore construction, navigation, EEZ surveying and Oil & Gas. Will Hi-Target further expand the focus on ocean research and mapping? How?

Hi-Target had been focused on Marine technology R&D and innovation since the company was established. In 2003, the first domestic digital echo sounder was launched by Hi-Target, which significantly promoted the Chinese marine surveying development. In the following decade, Hi-Target marine business developed and expanded very fast; the specific team grew from 10 people to more than 600 people now. In 2014, Jiangsu Hi-Target Marine Information Technology Co.,Ltd, a subsidiary of Hi-Target for marine business, was established in Nanjing, Jiangsu province.

After Jiangsu Hi-Target Marine Information Technology Co.,Ltd was established, the company kept developing its technical strength in acoustic research, signal processing and transducer performing. To cooperate with the acoustics institute of Chinese academy of sciences, Hi-Target has already mastered the absolute competitive advantages in marine technology R&D, production, marketing and so on.

At present, the company is increasing efforts on R&D and the industrialisation of high-end marine detection equipment, including the multibeam echo sounder, underwater acoustic positioning equipment. And in the next five years, the company plans to achieve the production and complement of multibeam sounding systems, underwater positioning systems, underwater robots and ADCP products, etc. for marine surveying and mapping services, marine environmental monitoring, marine engineering, marine geophysical prospecting, marine biology, marine renewable energy, underwater archaeological salvage, inland waterway transport, water conservancy engineering, hydrological monitoring, maritime surveillance and other fields.

▲ *Steven Xu.*

What major developments do you foresee in GNSS technology and what are the implications of these developments on the surveying profession in general and the manufacturers of receivers in particular?
Future GNSS technology should be developed to be more compatible, easier to use and more cost-efficient. In view of the global growth of satellites, GNSS technology should be highly compatible with various satellite systems. Furthermore, satellite-enhanced signal acquisition should become increasingly convenient and popularised so that people can get enhanced signals in different accuracies through various channels. It is also essential to improve cost-efficiency in order to promote the use of satellite navigation technology – and especially high-precision technology – in more industries.

In terms of the implications of these developments on the surveying profession, I expect high-precision GNSS surveying data to gain in popularity. At the same time, GNSS will be combined with other surveying technology and information technology, such as geographic information technology, total stations, 3D laser, UAV and so on. The use of mass data for surveying will lower the barriers to market entry for high-precision data. And for the manufacturers of receivers, the implications are actually quite simple: there are chances but also challenges for us. GNSS technology will be used in other industries and the market demands will increase rapidly. We, the manufacturers, have to conduct research into core technology and promote our applications to more fields, beyond just surveying – otherwise we may be out of the game.

Technology and societal needs are rapidly changing. What are your thoughts on how surveyors around the world should adapt to these changes?
Surveying used to be a relatively isolated industry but it now combines with other industries. It has become easier to enter the market for professional surveying in the open air, and some manual survey activities have been replaced by unmanned aerial vehicles, 3D laser scanning, etc. However, the working standard of data processing is higher. Therefore, surveyors should adapt by moving from front stage to backstage. In other words, surveyors should learn to use high-end equipment like unmanned aerial vehicles, better understand the demand for industry applications and improve their ability to analyse data for industry solutions.

How does your company keep pace with – or even stay ahead of – changing technology and societal needs, particularly in terms of R&D?
Hi-Target is a company relying on technological innovation for long-term development. Since becoming listed, Hi-Target has been focused on speeding up the layout of the R&D team, promoting and developing technology innovation constantly with the aid of capital strength. In fact, the annual investment in R&D is more than 11% of our total revenue, we have more than 1,600 staff, more than 30% of whom are R&D engineers, and over 10% are professors or hold PhDs. In recent years we established several research institutes and even overseas R&D centres to study the international advanced technology and achieve successful breakthroughs in technical challenges. We have already mastered the core technology in satellite navigation, high-end marine and 3D laser

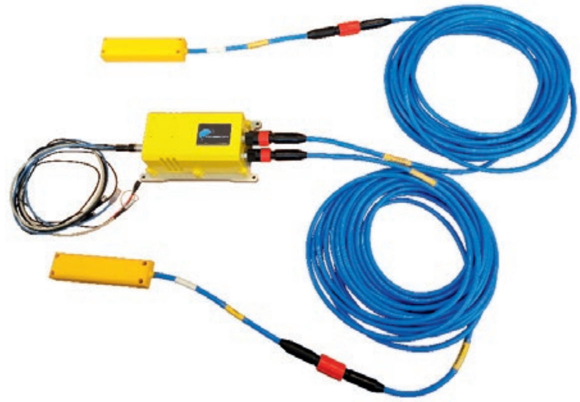
Geo-matching.com

The world's largest product database for surveying, navigation and machine guidance

Multibeam Echosounders on Geo-matching.com

Bathyswath-2-STD

– ITER Systems



Bathyswath provides depth and sidescan over very wide swath widths, especially in shallow water. It meets accuracy requirements at a price lower than similar products. The STD option includes a compact, robust, splash-proof low-power deck unit that is ideal for RIBs, and small survey vessels.

▸ ***http://bit.ly/Bathyswath2STD***
Product brochure: http://bit.ly/1WNm8tw

HYDROCHART 3500

– Klein Marine Systems

The Klein HydroChart 3500 Side Scan Swath Bathymetry Sonar System comes complete and pre-calibrated with pitch, roll, heave, heading, and sound velocity compensation from sensors mounted within the faired pole-mountable Sonar Head Unit (SHU).

▸ ***http://bit.ly/HYDROCHART-3500***
Product brochure: http://bit.ly/1QrvEzU

Seabed Portable Lightweight Multibeam Set (SPLMS) *– Seabed*

The Seabed lightweight multibeam set, including GPS, motion sensor, SV profiler and antennas, offers high resolution bathymetry, weighs only 23kg and can be transported as check-in luggage with any airline. The SPLMS is ideal for projects where rapid mobilization is required and where logistical challenges are taken into account due to the simple deployment.

▸ ***http://bit.ly/SeabedSPLMS***
Product brochure: http://bit.ly/1SiGQ3U

iWBMS

– NORBIT Subsea

NORBIT-Subsea manufacture wideband curved-array multibeam sonar sensors for bathymetry, NORBIT's multi-sensing concept combines multiple integrated sensors into one hardware platform with a single LAN connection to survey laptop. Supported sensors include any combination of bathymetric multibeam echo-sounder, forward looking sonar and LiDAR.

▸ ***http://bit.ly/NorbitiWBMS***
Product brochure: http://bit.ly/1NzJz2x

On Geo-matching.com you can find 48 multibeam echosounders from 14 suppliers. Visit Geo-matching.com for specs, videos, case studies & brochures.

scanning industry, established a specialised R&D team and subsidiaries for those high-end businesses and launched more and more high-end products with proprietary intellectual property rights, like multibeam echo sounders, 3D laser scanners, mobile mapping systems, etc. In this way, Hi-Target keeps seeking technology innovation and promoting R&D strength to keep pace with the technological developments and societal needs.

Looking ahead at the geomatics industry in general, do you foresee any 'rising stars' that will significantly change the hydrographic industry, such as marine autonomous systems (MAS), much like AUVs and USVs have done over the past years?

In our opinion, the products for further marine marketing should be portable, highly accurate, easily operated and highly efficient.

Are you working with universities to develop maritime solutions through scientific research?

In China, there are many famous universities with rich scientific research technology and theoretical accumulation in marine application. Jiangsu Hi-Target Marine Information Technology Co.,Ltd has already cooperated with several universities for ADCP, underwater robots and software development.

Some people say that high precision is no longer the privilege of surveyors and that today's GNSS advances, smartphones and other low-cost equipment mean that decimetre accuracy is available to people without qualifications and specialist knowledge. What's your reaction to this? How should the profession adapt?

The key thing is to keep pace with industry developments relating to geography and location information services. What we suggest is firstly applying new technology, addressing the market demand with rapid low-cost access to information, updating data, mastering the real measurement technology and trying to develop the highest-grade technology possible. Secondly, in the near future the surveying and mapping operation will become increasingly simple. The current mode of working will be replaced by the mode of quickly acquiring large amounts of data. Therefore, measuring personnel should focus more on the data processing and application side of things rather than how to survey in the field.

▲ *Hi-Target's head office.*

There are many different manufacturers of survey equipment in China today. Western countries have seen a process of consolidation over recent decades. Is the situation similar in China? In other words, are manufacturers looking to join forces or merge with other companies, either in China or abroad?

I would say yes, the current industry in China can be likened to what Western countries have gone through in the past decades; China is experiencing a process of integration. After becoming listed on the stock market in 2011, Hi-Target merged with many businesses to expand its product lines and research abilities, such as 3D laser, indoor positioning, total stations and ocean survey. Today, we're also interested in cooperating with research centres and universities abroad, perhaps even merging with a research team.

Your company operates worldwide. What is your business model in terms of dealer and service networks around the globe?

Yes, we are active worldwide. We mainly export surveying devices through our authorised dealers in the various countries around the world, and most of the dealers work on the basis of an exclusive or non-exclusive model. Hi-Target currently has more than 100 dealers in 70 countries. To improve our after-sales service, we have set up a maintenance centre in Hong Kong to provide services for Southeast Asian countries, and in Europe we have just opened a Czech maintenance centre. At the end of this year, we will launch a maintenance centre in America to provide better services for customers in both North and South America.

What type of company will Hi-Target become over the next five years in terms of products, services and customer base?

Over the next five years, Hi-Target will evolve and specialise in devices, system integration, data services and suchlike, providing what we call 'comprehensive industry solutions' including product hardware, industry application software and support services. Examples are entire and various solutions from devices to services for 3D laser scanning, high-end sounding and positioning marine applications, and BDS applications for precision agriculture, etc. ◀

More information
www.hi-target.com.cn/en/

Steven Xu is CEO of Hi-Target Surveying Instrument. He graduated from Wuhan University, Surveying and Mapping Institute, having mastered the basic theory and key technology of geodesy, engineering surveying, satellite positioning and navigation. With more than 15 years' experience in GNSS, GIS, 3D laser scanning and marine technology research, Steven remains committed to the satellite navigation and positioning industry. Under his leadership, Hi-Target achieves numerous technological breakthroughs, overcomes technical difficulties and successfully offers solutions for a wide range of industries. Steven also serves as director of the Chinese national satellite positioning technology association, is director of Wuhan University's Surveying and Mapping Institute (Guangdong alumni branch) and director of the Chinese national instrument industry association (surveying and mapping instruments branch).

Gemini Offshore Wind Farm

3D Precision Beyond the Horizon

The Gemini Offshore Wind Farm in the North Sea is located 85km north of Groningen, The Netherlands. Van Oord, a leading Dredging and Marine Contractor, started the offshore construction work in January 2015. Gemini consists of two separate areas called 'ZeeEnergie' and 'BuitenGaats', both with 75 4MW Siemens turbines. Gemini will be the 2nd largest offshore wind farm in the world upon completion in 2016, providing power to 785,000 households, equivalent to 1,500,000 people.

Gemini is privately owned by Northland Power (60%), Siemens (20 %), Van Oord (10%) and HVC (10%), and with costs expected to be EUR2.8 billion, Gemini is the largest ever offshore wind farm financed on a project basis.

Project Preparations

The requirements and tolerances for the construction of the Gemini Offshore Wind Farm are described in the 'Employer Requirements', used as the baseline document for the preparation of the survey method statements and procedures, which started in January 2014 (Table 1). The tolerance for the position of the foundations, consisting of monopile and transition pieces, was the leading factor in the process of selecting the most suitable method of positioning. Other considerations were: accurate 3D positioning in real-time, hence no need for the post-processing of positioning data and cost efficiency.

▲ *Figure 1:* Aeolus *during monopole installation.*

By reducing the tolerance for the monopile installation position to 1m radius, the amount of rock to be placed for seabed stabilisation prior to monopile installation could be reduced significantly, thus saving cost and time.
In order to meet the requirements above and in particular the requirement for the Transition Piece flange level, three options were considered, namely GNSS with corrections service such as Fugro G2 or Veripos, seabed tide gauge and the extension of the 06-GPS RTK network to cover the project area.
The feasibility of the network extension was discussed with 06-GPS; by using two offshore platforms as additional reference stations centimetre accuracy could be achieved.
An onshore station in use for subsidence monitoring on the Island of Schiermonnikoog was also to be added to the network.
The Geo++ software used by 06-GPS to calculate and provide GNSS corrections uses the data from the reference stations in the network to model the correction data, providing homogenous accuracy within the network, even if the reference stations are over 40km apart.
Unknown at the time was the influence of platform movements due to wind and waves, as well as the delay in the connection over the internet to the 06-GPS server and then to the user offshore.

Millimetre Accuracy

The Schiermonnikoog station, used by an oil and gas company as a reference for subsidence measurements with mm-accuracy

▲ *Figure 2:* Geo Focus *and* HAM602 *during inter array cable installation.*

in the Waddenzee area, was added first.
The platform to the east of the project area, Fino-1, a meteo platform for scientific purposes is owned by the German Authorities. Having contacted the operator of the Fino-1 platform, it became clear that a GPS station was already established on Fino-1 and operated by the German RTK corrections provider SAPOS. After upgrading the GPS receiver to include the GLONASS satellites and an upgrade of the connection to shore, the Fino-1 GNSS data were available for use from July 2014.
The platform to the west of the project area, G17d-A, a gas production platform is operated by GDF-Suez. After several meetings with the GDF-Suez personnel responsible for the platform, plans were made to install a GNSS reference station on G17d-A. After installation of the GNSS receiver in September 2014, the network extension was complete.
All coordinates of the new stations are computed using GNSS post-processing software. The system used is ETRS89 and the stations are positioned relative to the first order stations of Active GNSS Reference System (AGRS), maintained by the government of the Netherlands. The platform based reference stations showed some more movement than traditional onshore reference stations, but not more than +/- 1cm, which is acceptable for both the network processing as well as the desired RTK accuracy. The locations of the antennas on the two platform based stations are not as good as on normal onshore stations. Both locations have obstacles like masts and stacks, resulting in fewer available satellites and a more challenging multipath environment than normal. The delays in the connections over the internet were typically smaller than one second and thus within the three second limit for the network software.

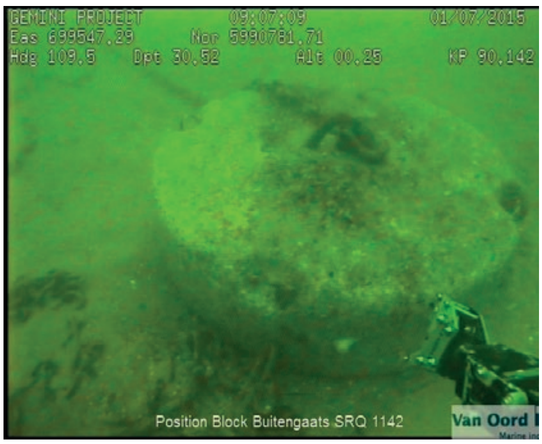
On 6 November, interference from an unknown source was experienced at the G17d-A station. Investigations eventually pointed to a connection from the platform to another platform, activated around that time. The interference problem was mitigated by replacing the GNSS antenna by another type in December 2014.

Hydrographic Survey and Installation Operations

For the execution of the survey scope of work on the Gemini project, a charter was arranged with GeoPlus for the *Geo Focus*, a 35m hybrid survey / ROV support vessel. Mobilised with POS-MV and SeaBat 7125 through the moon-pool and using PDS survey software, survey operations commenced on 5 January with the in-survey of the export cable corridor. The depths were referenced to LAT in the survey software by using the GEONZ97 Geoid model combined with the MSL to LAT model (2006).
In-survey operations continued up to the end of March, combined with trench dredging progress surveys as well as other types of surveys. The correlation between surveys executed over a period of time showed that the repeatability of the positioning was typically better than 5-10cm in X,Y and Z. This could be seen when comparing surveys over seabed features like boulders and gulleys.

In February 2015, two concrete position check blocks, Ø 180cm and 60cm high, were placed on the seabed in the wind farm. The purpose of the blocks was to provide a bench mark for the rock installation vessel coming from Norway, eliminating the need to come to shore for a position check. The comparison of the position check objects' coordinates established by the *Geo Focus* by means of a multibeam survey and the coordinates measured with the Fall Pipe ROV systems were carried out prior to every rock installation trip to verify the proper functioning of the vessel's survey systems.
A ROV was mobilised on the *Geo Focus* for ROV video and cable burial surveys at the same time. During the first ROV position check on one of the two objects, it was confirmed that there was a bundle of chain on top, which was later removed. The position check objects were also used for checking third party ROV positioning as well as side-scan sonar checks.

Monopile installation was only permitted after 1 July, at the end of the porpoise breeding season, when the porpoises and their young have left the area. For this installation operation, the jack-up installation vessel moves into the desired jack-up position whilst in 'Dynamic positioning' mode. It then jacks up, i.e. elevates the vessel out of the water while standing on the 'legs'. Once all the load tests are completed, a monopile is picked up and



▲ *Figure 3: Reference block offshore.*

Figure 4: Nexus *during inter array cable installation.*

inserted into the 'Gripper'. Using the 'Gripper', the monopile is moved exactly into the design position. Three systems are used to measure the verticality during the installation process, Inclinometers in the hammer, one or two total stations and Fugro InclinoCam. The combination of the three systems resulted in accurate and efficient installation of the 150 monopiles. The installation level of the monopile is measured and monitored using a total station, set up on a known offset, which was dynamically coordinated using the GNSS-RTK system. All stations to monitor the installation process were set up on rigid pillars welded on deck. All the stations were referenced to a pre-installed prisms. Almost all of the small movements were compensated by the total station compensator. The hammering of the pile had to stop for the measurements to take place.

As soon as the monopile installation started, a back-up reference station was mobilised on one of the central monopiles in both 'ZeeEnergie' and 'BuitenGaats'. Powered by solar power, they transmit corrections via telemetry radio.

Results

In our mode of operation, the Virtual Reference Station (VRS) corrections were optimised for the first position update to the 06-GPS server. The position of the VRS remains the same until the connection is reset and re-initialised. Having found out that the data quality was better when operating close to the VRS position, the surveyor was instructed to reset the VRS connection regularly. In order to remind the surveyor of this, the BPQ (Base Position Quality) message from the Trimble receiver was interfaced to the survey software in order to calculate a distance between the vessel and the VRS position.

Description	Tolerance
Horizontal position of Monopile (Employer requirement)	3m radius
Horizontal position of Monopile (Contractor requirement)	1m radius
Transition Piece Flange level (LAT)	0.25m
Verticality of Monopile	**0.25°**
Orientation	**± 5°**

Table 1: Tolerances for monopile positioning.

When the distance exceeded 10km, an alarm was generated, prompting the surveyor to take action. Re-initialising the GNSS receiver was typically finished in the time required for taking a sound velocity profile, this then became the standard operating procedure.

The position check objects have been used regularly to check the Multibeam system(s) and the ROV positioning. A trend has been visible in the data, the blocks are slightly deeper than when placed, possibly due to erosion and/or settlement.

A comparison was carried out on the offshore installation vessel *Aeolus* whilst it was jacked up. One receiver was set to static measuring mode, the other one to dynamic, both receivers using the VRS corrections. In static mode, the antenna is assumed not to be moving, providing some improvement in accuracy compared to dynamic mode.

The comparison showed the noise present in the Z component of the measurements, but also shows that there is horizontal movement when jacked up caused by wave action on to the legs.

Another comparison was carried out on the *Aeolus*, whilst it was jacked up, comparing positions derived by using VRS corrections and positions derived by using local base station corrections (Table 2). The average of the two is within a centimetre, however, the position derived with local base station corrections is

Aeolus - Receiver in Dynamic mode				*Aeolus* - Receiver in Static mode			
	Easting	Northing	Altitude		Easting	Northing	Altitude
Average position	698272.828	5993052.033	18.635	Average position	698272.846	5993052.023	18.641
Standard deviation	0.0795	0.0489	0.0133	Standard deviation	0.0876	0.0499	0.0035

Aeolus - 06-GPS VRS corrections				*Aeolus* - Local base station corrections			
	Easting	Northing	Altitude		Easting	Northing	Altitude
Average position	691309.133	5991547.264	16.034	Average position	691309.134	5991547.258	16.043
Standard deviation	0.0111	0.0167	0.0289	Standard deviation	0.0060	0.0089	0.0107

Aeolus - Installation results Difference to design for 77 locations				*Pacific Osprey* - Installation results Difference to design for 73 locations			
	Δ Easting	Δ Northing	Δ Distance		Δ Easting	Δ Northing	Δ Distance
Average	0.25	0.27	0.40	Average	0.20	0.17	0.31
Standard deviation	0.16	0.19	0.18	Standard deviation	0.15	0.19	0.18

	Δ Orientation	Δ Inclination	Δ Height		Δ Orientation	Δ Inclination	Δ Height
Average	0.98	0.04	0.01	Average	1.33	0.06	0.04
Standard deviation	0.71	0.03	0.01	Standard deviation	0.81	0.04	0.09

▲ *Table 2: Installation deviations.*

more stable, as is shown in the standard deviation.

All monopiles were installed well within planning and within the required tolerance, except for one, which was installed lower than the design due to an offset not being applied.

Conclusions

The positioning using the VRS corrections worked very well, there was no downtime due to the positioning accuracy or 06-GPS server failure. The real-time position was accurate and repeatable, shown time and again in the checks and progress surveys. Overall performance of the network extension is illustrated by comparing the RTK positioning results using the RTK network with those from a local reference station placed on a monopile nearby. Because of the large distance between the platform stations, but mainly because of the obstacles on the platforms themselves, the RTK results from the RTK network solution are less accurate than the results from using the nearby reference station. But results were still acceptable and within the specifications for the survey and installation work.

Due to the use of the vessel internet infrastructure and onboard GNSS receivers, it has been cost effective. Once a local reference station is installed and used, it provides a more stable position in the immediate area of the reference station. ◀

▲ *Figure 5:* Geo Focus *during survey.*

More information

www.vanoord.com/activities/gemini-offshore-wind-park
www.06-gps.nl
www.geoplus.nl
geminiwindpark.nl
www.youtube.com/watch?v=Q65mgPeygC8

Wim Kanneworff, studied Hydrography in Amsterdam in 1987, and has been working as a Hydrographic Surveyor for Van Oord since. He has been involved in many projects as chief surveyor, including Subsea Rock Installation, Dredging & Reclamation, Pipeline Installation and currently Offshore Wind Farm construction.
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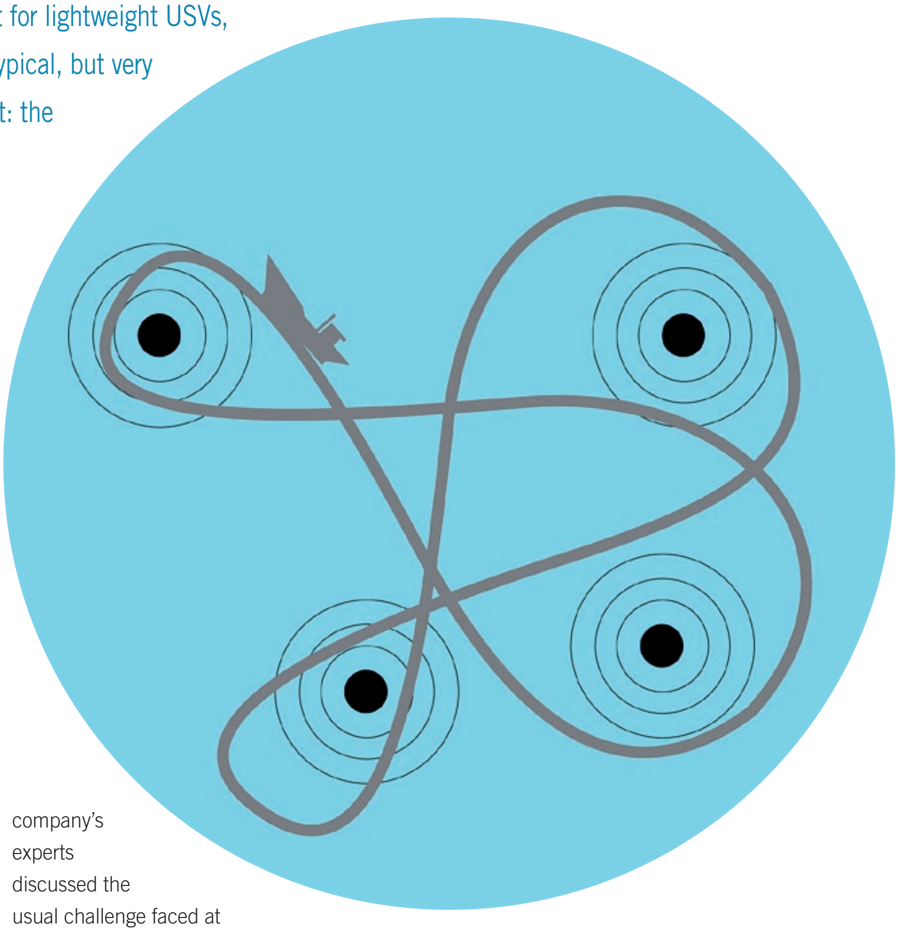
EvoLogics Explores New Applications for its Sonobot USV

Unmanned Surface Vehicle as **Aid for LBL Positioning**

The market of unmanned surface vehicles (USVs) is expanding, with more and more remotely controlled and autonomous USVs becoming available as commercial products. While environmental monitoring and data collection remain the primary target for lightweight USVs, EvoLogics recently tried out a rather untypical, but very promising approach for using its Sonobot: the vehicle turned out to be well suited for calibration and testing of long-baseline (LBL) positioning systems, opening a wide range of new applications.



▲ *Figure 1: A typical vessel route for calibration of a LBL positioning system.*

A typical LBL underwater acoustic positioning system uses an array of at least three seafloor-mounted transponders that form the system's baseline. Before putting the system into operation, these baseline nodes are carefully located in absolute coordinates. When the system is operational, baseline transponders respond to acoustic interrogation signals from the target transceiver, which then calculates distances between itself and each transponder of the baseline array to derive its position.

LBL positioning systems offer great accuracy, independent of depth, but require the extra steps of deploying the baseline around the work site and performing system calibration to establish absolute coordinates of the baseline nodes. The calibration procedure involves sailing a vessel with an acoustic transceiver and a DGPS receiver over the deployed baseline array to test acoustic connection to baseline transponders and establish their positions on the seabed - which can turn out to be too time-consuming and costly for some applications (see Figure 1).

As EvoLogics from Berlin, Germany, was preparing for demo-sessions of its LBL positioning system at MTS/IEEE OCEANS'15 Conference and Exhibition in Genoa, Italy, the company's experts discussed the usual challenge faced at an industry event: the equipment had to be deployed and set up as quickly and efficiently as possible. System deployment, calibration, testing and demonstration - all had to be performed within two hours. This is when the idea was born to use the company's Sonobot USV, primarily intended for bathymetric service providers, to perform some of the tasks involved in LBL system demonstration.

The site at the Genoa harbour was well-sized to try out the new system configuration, and existing components of the EvoLogics LBL system and the Sonobot vehicle required only minor modifications, so the team decided to go through with the idea.

Main Considerations

The main concept of using a USV as aid for an LBL acoustic positioning system is to streamline, simplify and automate the logistics

Figure 2: EvoLogics Sonobot USV system.

involved with calibration and testing the system before putting it into operation.

Deployment of baseline nodes does require a vessel to transport them to the work site and sink the transponders around the perimeter. After deployment, the vessel is needed again, as system calibration requires another trip around the perimeter, this time circling around and across the work site to establish acoustic communication with baseline transponders and locate them in absolute coordinates.

For calibration of an LBL system, the vessel must be equipped with a highly-accurate DGPS receiver to ensure most accurate calibration results and, hence, the LBL system's future performance. An acoustic transceiver, compatible with deployed baseline array, must be installed on the vessel to establish acoustic communication to the baseline nodes and calculate the distances between these and the transceiver. The DGPS system and an acoustic transceiver on board the vessel must be interfaced with a PC running positioning software that performs data fusion and calculates geographic positions of the baseline nodes.

Basically any vessel of appropriate size is suitable for deployment of the baseline array. However, in many cases, the vessel used for deployment is not outfitted with the equipment necessary for calibration of the system.

EvoLogics engineers came to the idea, that testing and calibration of the baseline array is exactly where an USV can 'step in', taking over most of the tasks from the vessel, which would no longer require additional equipment installations and all the extra manoeuvring involved in LBL calibration.

Testing and calibration of the baseline array is exactly where an USV can 'step in', taking over most of the tasks from the vessel

USV for Calibration of LBL Systems

The Sonobot, a stable twin-hull catamaran craft, already met most technical requirements to perform calibration of an LBL system: the vehicle was initially developed as a lightweight solution for hydrographic surveys. It is designed to deliver geo-referenced bathymetric data, as well as provide a real-time wireless connection to the station onshore for data acquisition on-the-go as depicted in Figure 2. The Sonobot is equipped with a DGPS receiver and can operate either over remote control or autopilot, following a survey grid programmed with the vehicle's control software.

The team decided to undertake as few modifications as possible to incorporate the USV into the LBL system: they added an acoustic transceiver to be towed behind the Sonobot, and over its WLAN, configured the wireless connection between the transceiver and a PC running positioning software (SiNAPS), see Figure 3.

We used a small inflatable boat to deploy four baseline nodes and returned to the shore to initialise the software and launch the Sonobot. The vehicle was steered towards the 'work site' and made a run to each transponder

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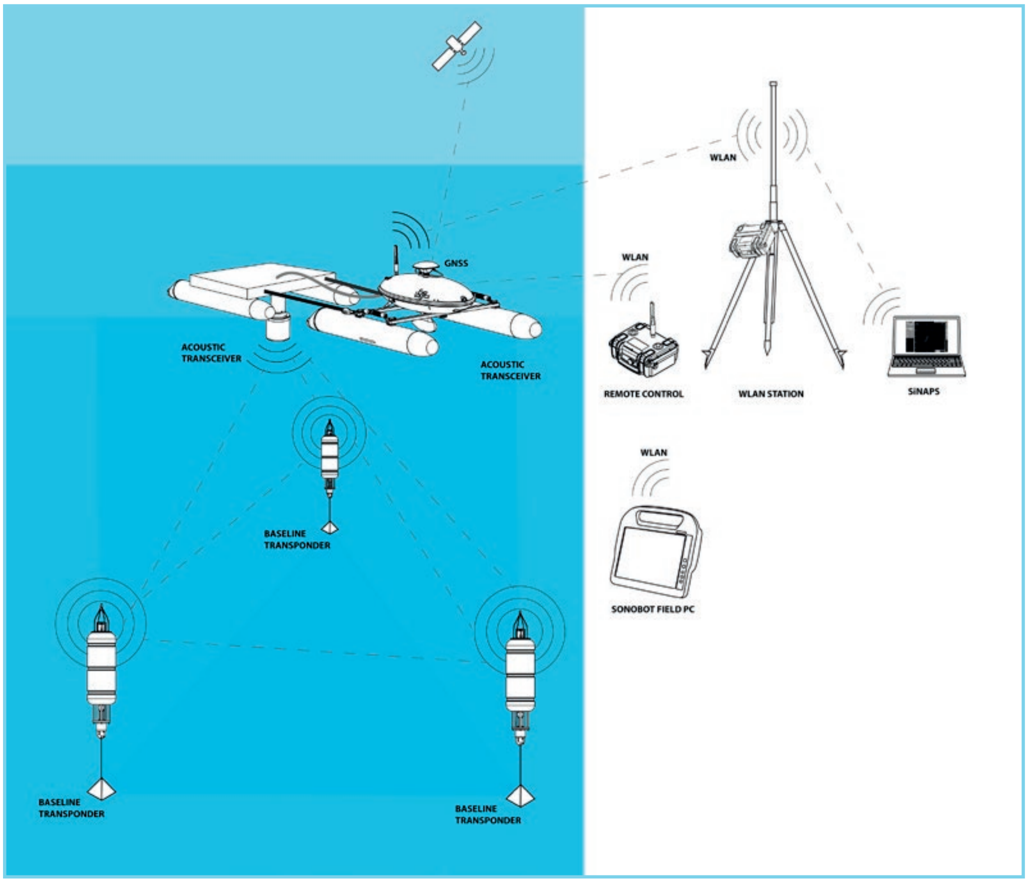

Figure 3: Sonobot USV for calibration of a LBL positioning system.

performing a quick acoustic communication test. For subsequent calibration, the USV, again on remote control, travelled along a path around and between the deployed transponders while the team observed the progress onscreen, as data was transferred from the USV over WLAN. Figure 4 shows this setting.

After calibration, the team demonstrated the LBL system's performance using the USV as a mobile target, again manually steering the vehicle within the area: for visual comparison, the software displayed position fixes, estimated by the LBL system, along with data from the DGPS receiver.

During the session, conditions were very favourable (1-2Bft) with calm waters and an occasional light breeze. Maximum limits of wave and wind conditions for USV-aided LBL calibration would require further investigation.

Future Prospects

Using a USV within the infrastructure of a LBL positioning system proved to be a very promising application of the vehicle. During the demo-sessions in Genoa, the team was able to save time and cost, only using a large vessel to deploy the system and retrieve the transponders after the mission. The USV could perform calibration and testing of LBL systems, deployed at larger work sites in open water, as it can be launched from the support vessel and operate for over 10 hours on one battery charge.

Looking at potential commercial applications, we plan to work on better integration of the hardware to incorporate an underwater acoustic modem into the Sonobot and perform further testing on automating LBL calibration by using the Sonobot's autopilot. Software integration would potentially allow planning the route and executing a Sonobot mission within the LBL positioning software environment.

Figure 4: Sonobot USV during LBL calibration in Genoa, Italy.

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Used for Qualification of the Seabed

Flexible High-resolution **Seismic Method**

Traditionally, the upper part of the shallow seabed is investigated using low frequency echo sounders to enable safe navigation, and even lower frequency profilers for seabed structure mapping. However, the results of these systems often lack accuracy and, as a consequence, seabed properties are not known. A more accurate method, which results in seabed parameters, is obtained by the addition of the ultra-high resolution seismic sub-bottom system package Silas. It will be shown that Silas can be added to any echo sounding or profiling system. High-quality data acquisition is possible with only minor changes to standard survey practices. The data output to the survey software can range from a high-quality seabed depth to a calibrated output of seabed density parameters. Moreover, integrated verification of multibeam, side-scan, cone penetration and borehole data is also possible.

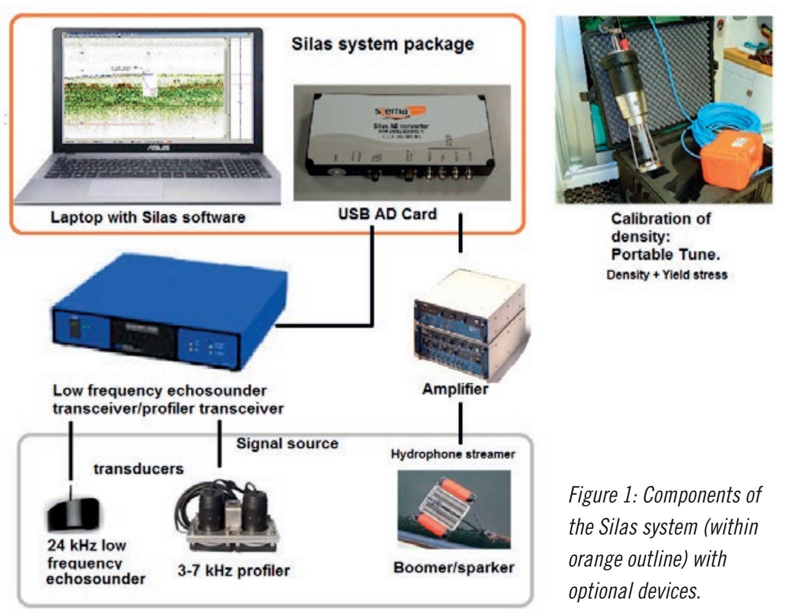


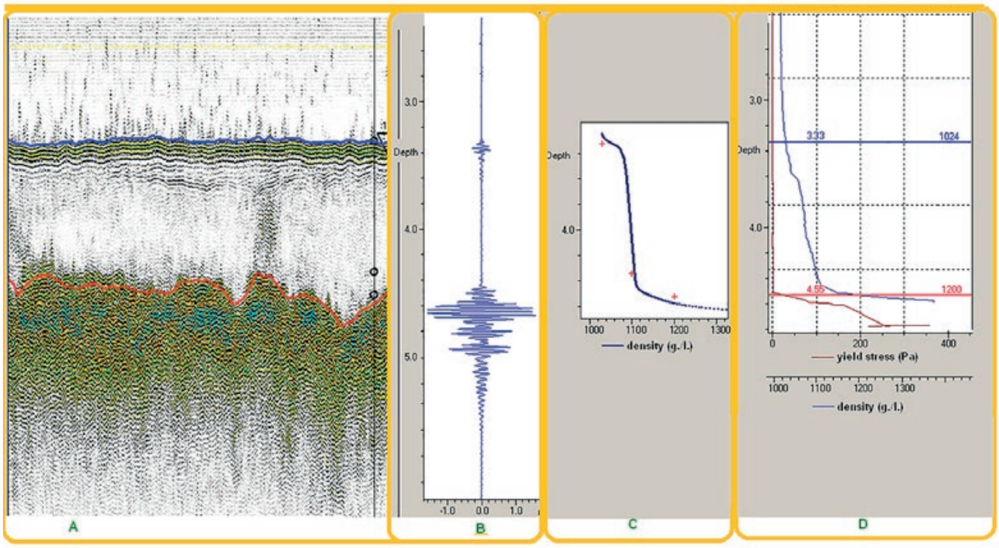
Figure 1: Components of the Silas system (within orange outline) with optional devices.

In order to achieve high accuracies, the Silas system records the full returned signal of a low frequency echo sounder with ultra-high sampling speed and accuracy. The system (Figure 1) consists of the recently developed Analog to Digital converter (USB AD Card), a laptop with the Silas software, and a standard transmitting and receiving unit (transceiver) with a signal source. A geophysical density meter can be added to the system, to enable a calibrated density level output. This can be any vertical geophysical density device, however a Tune system is recommended (Figure 1). Such a system utilises the environmentally friendly Tuning fork method, and produces density and material strength (yield stress).

The signal source consists of a transducer that is attached to a pole, mounted over the side of the survey vessel. For deeper applications, the transceiving unit can be replaced by a dedicated amplifier. Such a set-up is used to receive signals of heavier towed seismic sources for sub-bottom registration, such as boomers and sparkers.

System Operation and Survey Method

During a survey, several cross sections (lines) are sailed. During those lines, the transceiver sends a signal to the sound source. This is executed at a rapid rate, depending on the signal source. The signal travels through the water column and is reflected by the seabed and the strata underneath. The reflected signal is recorded using the AD converter and the laptop with Silas software, which also facilitates interfacing with all required positioning, vertical referencing and motion correction data.



◀ *Figure 2: Procedure of density calibration of high-resolution seismics as applied by Silas. A: Seismic registration (24kHz); B: Received signal at calibration point; C: Synthetic density profile derived from seismics at calibration point; D: Results of geophysical point measurement (RheoTune).*

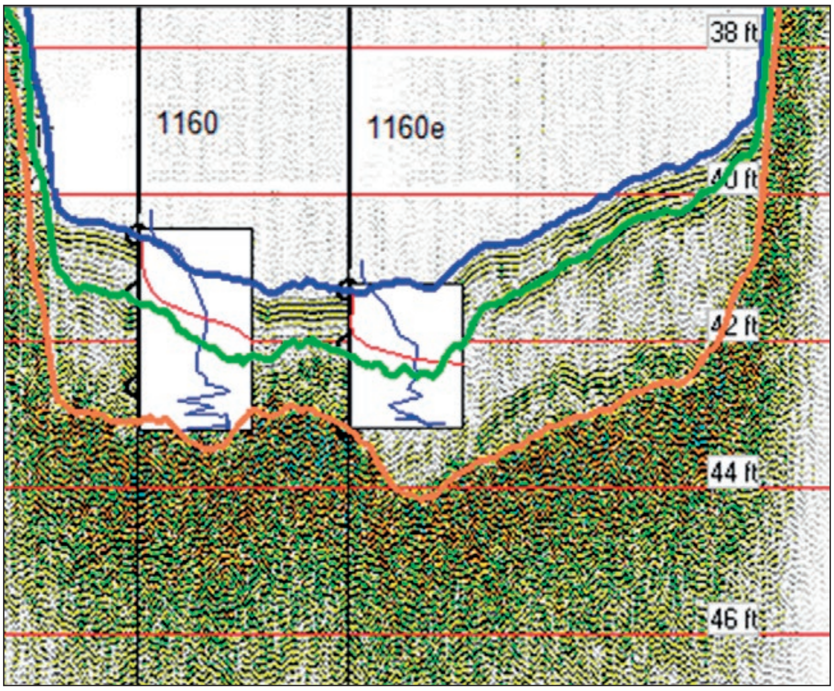
Bathymetric surveys with the Silas system can either produce a standard digitisation level or a calibrated output of density levels. The method of depth digitising does not differ from the standard digitising set-up of an echo sounder, except that there are more options to optimise the digitising settings. These settings are related to the threshold limits for detection of the upper seabed layer and the top of the more consolidated layer underneath.

Density levels are produced in real-time, performing the traditional echo sounding survey procedure

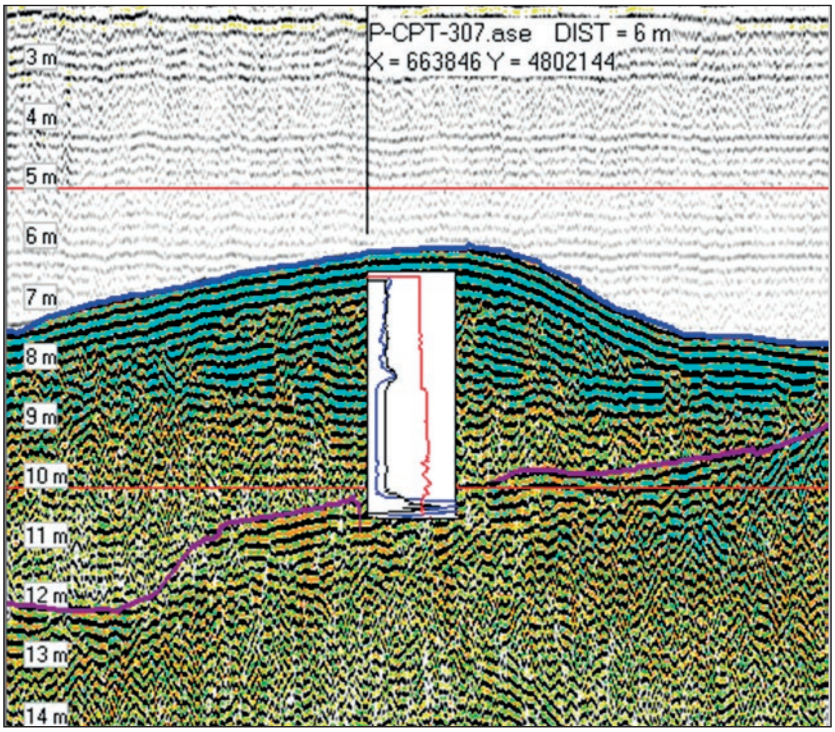
The method of calibrated density level requires a calibration survey in advance, using a Silas line and a number of vertical geophysical density measurements. After this calibration, density levels are produced in real-time, performing the traditional echo sounding survey procedure. The calibration consists of an automated iterative estimate of the arriving signal power just above the seabed (Figure 2), calculating the least squares difference between synthetic seismic and true density profiles (for an explanation of this method, see C. Werner, 2012 in the More Information section). For both the standard digitising and the density level options, the later processing and validation is possible, because the full reflected signal has been recorded

Results and Accuracy

The high-resolution seismics produce detailed and highly sensitive results for the upper seabed, depending on seabed composition and connected acoustical source. It is concluded that, using a 24kHz echo sounder with Silas, density changes above or equal to 0.4g/l/cm are detected. The accuracy of the density level option of the high-resolution Silas system, connected



▲ *Figure 3: Example of 33kHz seismic recording in area with lack of current and minor dredging activity. Blue line: top of Silt (Lutocline). Green line: 1,200g/l density level according to Silas (preliminary proposed nautical level). Orange line: 1,250g/l level. Circles: location of density levels according to RheoTune, from top to bottom: 1,030g/l, 1,200g/l and 1,250g/l. Vertical profiles: results of RheoTune drops with blue = density (horizontal scale min. 990g/l, max. 1,400g/l) , red = yield stress (horizontal scale min 0 Pascal, max 50 Pascal). Please note that yield stress (red line) increases rapidly just at the 1,200g/l level (green line). Also note that here the Tune does not penetrate further than the 1,250g/l level (orange line) because of the high yield stress in the sediment.*



▲ *Figure 4: Example of 5kHz seismic profiler recording with projected results of cone penetration tests (CPT). Blue line: seabed; Purple line: layer with cone resistance larger than 20 Mega Pascal; Graph: location of CPT, with blue = cone resistance (horizontal scale min -2.0MPa, max 20MPa), black = sleeve friction (horizontal scale min -0.1MPa , max 0.4MPa), and red = porewater pressure (horizontal scale min -0.5MPa , max 0.5MPa).*

to a low frequency echo sounder, has a standard deviation of around 0.12m, compared to the density level measured by the geophysical point measurement. Moreover, an additional study by Deltares, (a hydraulic institute from the Netherlands) reveals that the accuracy of the density level of Silas is of the same magnitude as the accuracy of the point measurements used for calibration.

New Insights and Influence of Seabed Strength

The new Silas echo sounder data indicate that the clear reflector underneath the seabed which is often visible in a fluid sediment situation, does not always correspond to the nautical depth. This often occurs in areas with a lack of current and minor dredging activity (Figure 3). Hence,

Ultra-high resolution seismic data and seabed parametrisation

these areas show a higher seabed strength (yield stress) of the upper (semi-) fluid sediment. Here, the critical density level calculated by Silas is often located at considerable distance above the most significant reflector, with good correspondence to the point measurements and without loss of accuracy. This also illustrates that in these situations the 'hard layer detection method' used by echo sounders does not indicate the bathymetric depth. Moreover, such a situation emphasises the importance of the yield stress for assessment of the navigable depth and it also emphasises how the yield stress values measured by the Tune help to assess a critical density level for a certain area.

Validation of Deeper Data

Deeper Silas data of consolidated sediments and rock, often acquired with lower frequency sources such as a profiler, boomer (Figure 5D) or sparker, can be validated against another measure for the seabed strength, namely the cone penetration test (CPT). During this test, a cone is driven into the seabed while all parameters, such as the cone resistance, are measured. The Silas system enables complete validation of the deeper layers with full CPT (Figure 4) and borehole results (Figure 5C).

New Features

The Silas package has been upgraded with a new ultra fast USB AD Card, which results in seismic records with up to 4 times more detail compared to previous versions of the Silas programme. The USB interface also makes the system more portable. Another innovation is a lighter version of the optional calibration tool (Portable Tune instead of the RheoTune), allowing for easier deployment by hand. Since the beginning of 2013, the Silas software has been extended with numerous options. The most important ones are a new user interface for the Silas density calibration, the integration with Multibeam data, CPT and Borehole information and the import and export options for the universal seismic exchange format (SEGY).

Conclusions

The Silas system can be connected to a large number of seismic sources, ranging from low frequency linear and parametric echo sounders for bathymetric surveys to lower frequency profilers, boomers and sparkers for deeper seabed characterisation.
The added value consists of ultra-high resolution seismic data and seabed parametrisation, such as density and nautical levels. Density and nautical levels are produced after calibration with geophysical

More information

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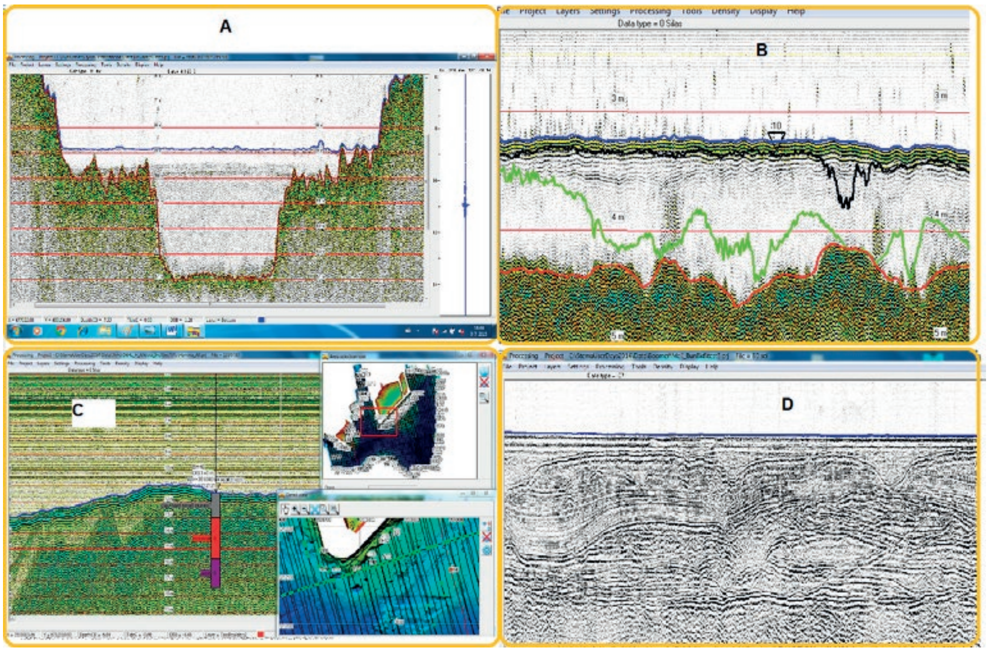

▲ *Figure 5: Summary of Silas data and validation applications: A: result of standard depth digitising of Silas with high-resolution recorded 33kHz data on background with blue line= seabed, brown line= digitised 'hard' layer; B: results of validation of projected multibeam data of different moments (black and green line) with 1200g/l density level from Silas (red line), on background 24kHz high-resolution data; C: example of Silas validation display with high-resolution 5kHz profiler data (left) with integrated multibeam (plan view on the right). Please note the boulder outcrops in both datasets; D: example of boomer data (1-5kHz) recorded with Silas.*

point measurements, such as Tune sensors. Application of the Silas system with a Tune sensor also shows that a clear sub-seabed reflector does not always correspond to the nautical depth, if the silt is more consolidated and has a higher yield stress. The high flexibility to all types of sub-bottom data and extensive integration with multibeam, side-scan, CPT and borehole data makes Silas a valuable tool for further seabed classification of the shallow seabed.◀

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Developments and **Trends** in **Multibeam Echo Sounders**

The multibeam echo sounders available on the market are constantly evolving as technology advances and as sonar producers seek new ways of refining and utilising the products. In this article we will provide a snapshot of current products and trends from the dominant (high-end) sonar producers focused on survey-grade products.

Trend #1 – Resolution

The neverending trend of getting higher resolution sonar systems is battling the physics of acoustics.

Over the past several years, the battle for best-in-class multibeam for medium water depth has been between the Teledyne RESON SeaBat 7125, the Kongsberg EM 2040/2040C and the R2Sonic Sonic 2024. Each has its own strengths, benefits and loyal followers, and all offer similar resolutions of around 0.5×1.0 degrees – all three are great sonar systems.

These sonar models are still being further developed, with new options becoming available. R2Sonic has just released their 2026 Sonic model, which offers 0.5×0.5-degree resolution (i.e. a better along-track resolution). We have not seen data from the sonar yet, but it seems interesting.

Race for broader coverage is resulting in multi-transducer multibeam products

For very short range detection, there are several high-resolution options. One worth mentioning is the Teledyne BlueView BV5000, which is a sonar operating at high frequencies 1350-2250 kHz compared to the typical 400-700kHz. The BV5000 is focused on close-up scans (10–20-metre range) of structures.

Trend #2 – Size and Portability

Many multibeam echo sounders are being used in short, shallow water surveys of harbours, waterways, etc., where easy mobilisation is very important, and several of the producers have focused development on exactly this – units that are as portable as possible and 'all-in-one' when it comes to GNSS (GPS) and motion sensor.

NORBIT offers the WMBS/iWBMS, which has an exceptional small form factor while still offering 0.9×1.9-degree resolution. The WMBS is available with built-in high-end GNSS and INS (Applanix POS MV), so mobilisation is very quick, with no complex offsets or angles to measure.

The Teledyne RESON SeaBat T20-P was introduced a couple of years ago and has been very popular as a portable sonar. The recently released SeaBat T50-P offers a portable package with specs (0.5×1 degrees) nearing those of the SeaBat 7125. Both the SeaBat T20-P and the SeaBat T50-P are also available with integrated GNSS and IMU, making mobilisation simple.

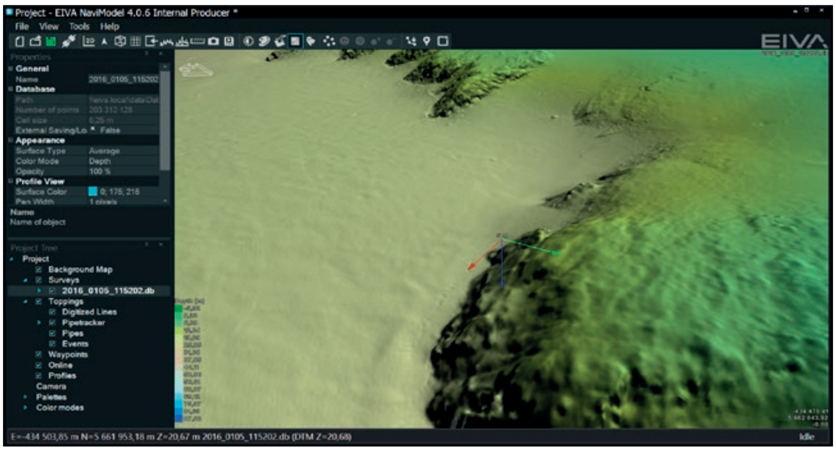
From R2Sonic, the Sonic 2020 (2×2 degrees) is a very small form factor sonar offering good results, and the Sonic 2022 (1×1 degree) is also among the smaller sonars in the market. Both are available with built-in INS.

Kongsberg's M3 is another IHO S-44-grade multibeam, which performed very well at the 2015 Shallow Survey conference in Plymouth, UK. The M3 is both an imaging sonar and a bathymetric/profiling sonar and offers 3-degree beam for point cloud generation.

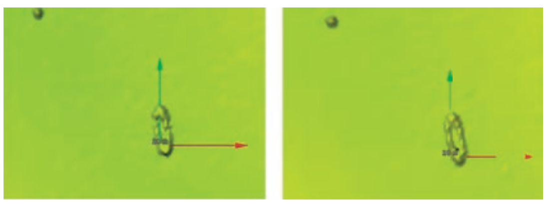
Another highly portable 2×2-degree sonar with the option for built-in IMU and GNSS is the Teledyne Odom Hydrographic MB2. We have not yet seen data from the MB2.

Trend #3 – Combination Products

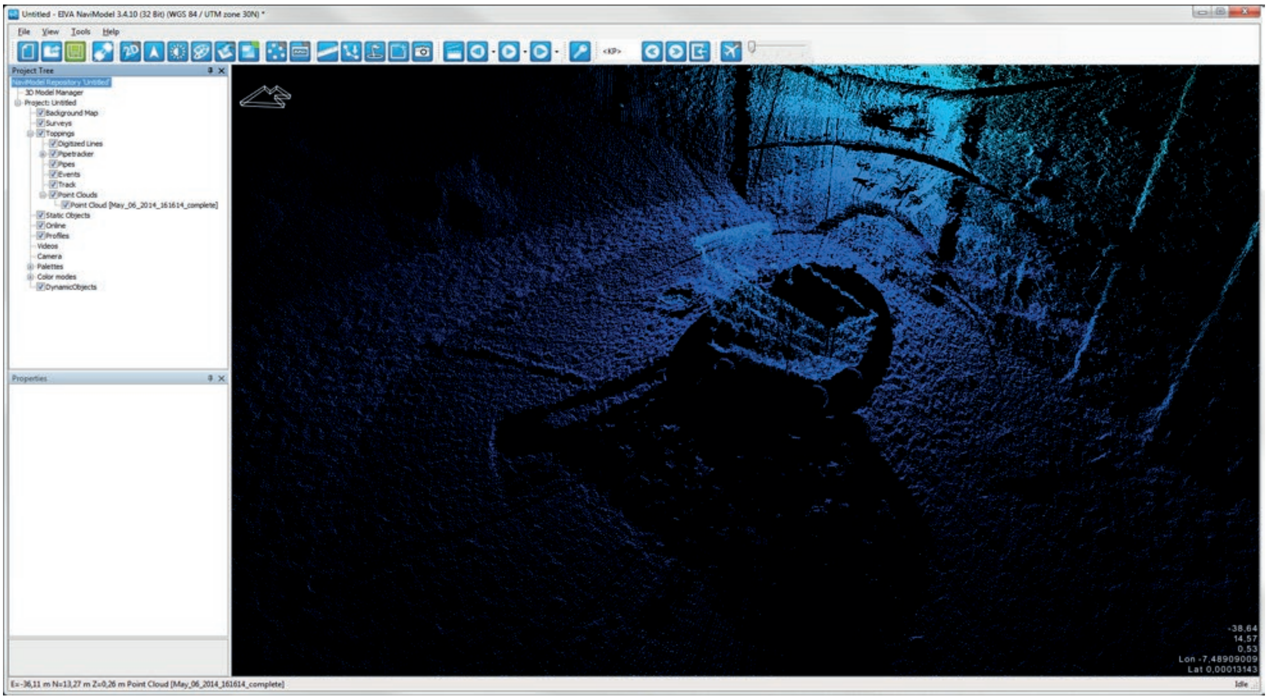
The different technology applied for a side-scan sonar and a multibeam echo



▲ *Figure 1: Teledyne RESON 7125 high-quality scan of Plymouth harbour, 25cm grid (data from Shallow Water Survey).*

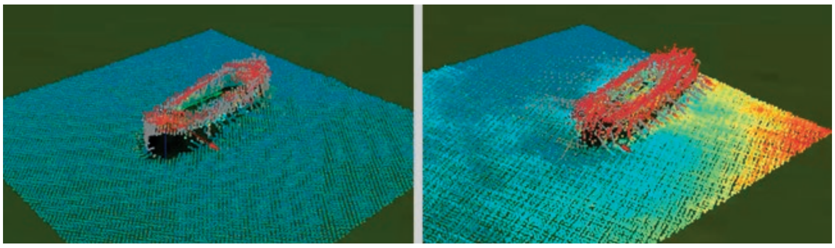


▲ *Figure 2: Identical feature scanned as part of the Shallow Water Survey UK, Teledyne RESON 7125 left and KONGSBERG 2040C right.*

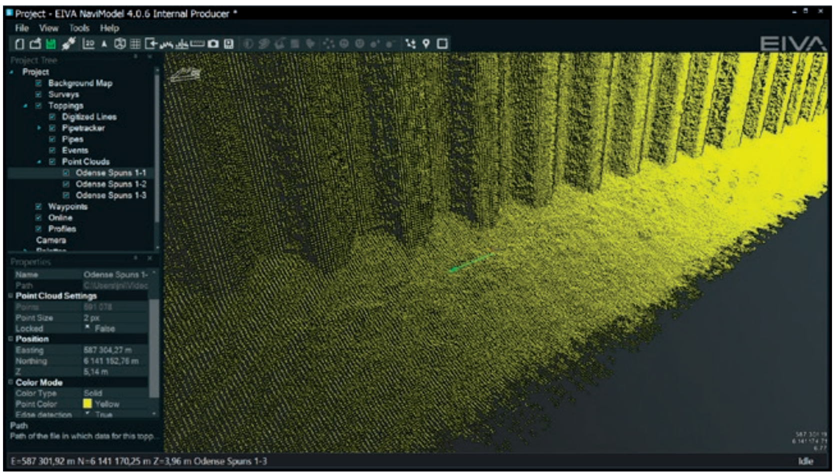


▲ *Figure 5: Harbour scan in NaviModel with a shopping trolley taken with a BlueView 1.35Mhz.*

sounder means that for truly great data you need both a good side-scan sonar and a good multibeam – but the combination of getting bathymetry (depths) and intensity data (image) from a single instrument is of course a focus of development for both the traditional multibeam manufacturers and the side-scan sonar manufacturers.
Multibeam producers call this 'backscatter', and you can find it in most of the Teledyne RESON, R2Sonic, NORBIT and Kongsberg products, where it has been offered for several years alongside its related feature, 'snippets'. Backscatter data are not of side-scan sonar quality, but are still useful for, for example, seabed classification, i.e. identifying the type of seabed (sand, rock, etc.).
New products come from the high-end side-scan sonar producers – Klein Marine Systems HydroChart 3500 and EdgeTech 6205 are both combination products that offer a great side-scan sonar image with a useful bathymetric data output. These are definitely interesting products because of their very high swath (8–12 times water depth) and therefore have a much faster survey area coverage than pure multibeam. This makes the products ideal for river surveys or just large area surveys – as long as you do not expect bathy data comparable to data from the best multibeam echo sounders.
Not strictly speaking about multibeams, the GeoSwath and Bathyswath products also offer very high swath up to 12 times depth. These are typically used for river/channel surveys.



▲ *Figure 3: Raw accepted and deleted soundings on the same feature, RESON 7125 left, Kongsberg 2040C right.*

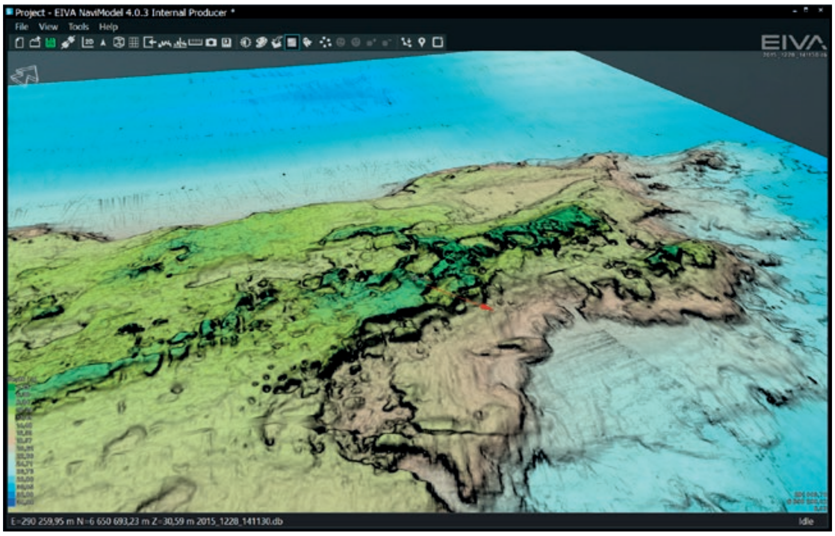


▲ *Figure 4: Scan of a harbour wall from small boat with R2SONIC 2024 700kHz.*

Trend #4 – Multi-head

The race for broader coverage (swath) is resulting in multi-transducer multibeam products.

- Two heads – Having two transducers (heads) simply gives double the coverage by angling the heads for better swath/ coverage or inwards for higher point density e.g. each side of the vessel/ROV pointing slightly inwards for scanning of both sides of a pipeline.
- Three heads – For pipeline inspection jobs, it is often seen that two heads are used to



▲ *Figure 6: WASSP used for mapping the Aliwal Shoal off Durban, South Africa (50cm point grid in NaviModel).*

cover the seabed to the sides, and a higher frequency sonar (or subsea laser) is used to cover the centre (i.e. the pipe in great detail).
- Four heads – Yes, we have seen this as well. For example, the Kongsberg EM 2040C comes in a quad-head configuration, where the TX and RX arrays are separated for optimal performance/placement (so actually, a 2 × dual head sonar).

Trend #5 – Detecting More

All the producers are looking for new ways to use the equipment, and there are always new buzz words.

- Water column: Multibeam echo sounders for bathymetric surveys are interested in the hardest return signal (i.e. the seabed), so traditionally, the return signals in the water column have been considered as noise. In many cases, it is just that (i.e. noise), but for some applications, it is useful data. Examples are plumes of gas and fish (fishing sonar systems are mainly water column sonar systems). Water column data are huge, so it is not something you simply record on every survey without needing to. Deployment for water column data recording is also often a challenge – mounting a moving sonar to cover an area for gas leaks requires a tripod, pan, etc. Water column data are typically not used for ROV inspections – there is rarely anything in the water column in the short distance from the ROV to the pipe.
- Multi-detect: Being able to return more than a single point from a ping is actually useful when, for example, surveying an area with fish in the water column and still needing to get a return from the seabed, or when surveying a wreck with protruding masts, where a single point would generate a spike in the data rather than water column data.
- Pipe detection / pipe tracker: Being able to detect a pipeline directly in the sonar and return top of pipe track. This is of course only useful when the pipe is exposed, in which case the multibeam points themselves give a much better representation of the pipe with higher density – and when the pipe is buried, a pipe tracker is needed anyway.

Trend #6 – Price

The general trend is 'you get what you pay for', and when talking about multibeam echo sounders, you will not regret spending the extra money if budgets allow.
There are a number of producers worth mentioning in this perspective:

- NORBIT - have a series of mid-high range products that are different from the norm.
- Imagenex - have been in the mid-range sonar beam market for a long time and have a variety of very special sonar systems for special purposes.
- Tritech - have just announced the Gemini 620p (1×1 degree) 620kHz sonar.
- WASSP - produce a huge number of lower-priced sonars for yachting/fishing and have launched their new 224-beam IHO 1a-compliant sonar at a very affordable price. We are beginning to see the first datasets from this sonar (see Figure 6) and it suggests a sonar suitable for low-cost area survey.

Getting bathymetry and intensity data from a single instrument

Trend #7 – Lidar and Laser

What? That is not sonar! True, but looking at the ROV-based inspection surveys for pipelines, rig foundations, etc. in particular, the use of subsea laser / Lidar is rapidly increasing.
Products like the 2G Robotics or Cathx Ocean subsea laser scanners can be used just like a multibeam – the technology is different, though. Both products will build a relative point cloud (range/bearing) in ultra-high (millimetre) resolution – much higher than any acoustics-based product. The challenge is range and conditions – subsea Lidar / lasers require visibility (i.e. clear water) – if you can see it, you can scan it. So do not consider a laser for dredging operations or scanning murky river/harbour water. Use it for clear water (deep, tropical, or Nordic winters etc.), where the results are fantastic.

EIVA has been involved in multibeam technology since the early days of commercially available multibeam echo sounders, with the first acquisition software made by EIVA for the Teledyne RESON SeaBat 9001 back in 1993. Since then, EIVA has been offering sonar acquisition and processing software independently of, but in close collaboration with, the different sonar producers, thus having a unique insight into most of the available products and ongoing developments. ◂

More information
www.bit.ly/Multibeam

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From **Longitude by Fowl** to Three-Point **Sextant Fix**

Prior to the development of modern navigation methods and modern charts, the mariner was left to his own devices both in approaching unknown and known coasts. Although Lucas Janszoon Waghenaer invented the nautical chart in the late sixteenth century, his charts and the charts produced over the next two centuries were relatively crude affairs made with primitive methods. Accurate methods of positioning a vessel and confidently determining longitude were virtually unknown until the late eighteenth century. What could be called modern nautical charting methods were also not developed until that time.

Early navigators relied as much on faith, instinct and luck as solid hydrographic knowledge. Examples of this can be found in early maritime literature. An account by Master Jackman on Sir Martin Frobisher's return voyage to England in 1578 described using an armed lead (a sounding plummet having a recessed socket filled with wax or tallow to pick up bottom samples) to determine bottom characteristics. He "sounded and had 70 faddems, oosy sand, whereby we judged us to be northwards of Scilly, and afterward sailed south east all that night". The ship rounded Lands End safely, and in three days "had sight of the Start, 5 leags off, God be praysed!" Few mariners today would trust their lives to "oosy sand."

Figure 1: Observing three-point sextant fix in 1916.

During this time many pilot guides were being published such as William Bourne's, who wrote in 1574 "Also it behoueth him to be a good coaster, that is to say, to knowe every place by the sight thereof". Rutters also included information (sometimes ad nauseam) on the character of the bottom. A typical passage in the earliest English sailing directions refer to "sandy wose and black fishey stonys .... redd sande and black stonys and white shellis .... grete stremy grounde with white shellis ... the grounde is redd sonde and white shellis amonge .... the grounde is white sonde and white shellis". That there were fine arguments as to which white "shellis" were which is corroborated by an account of the *Ship Hopewell* from Newfoundland bound for London in August 1587 "drawing neere the coast of England" sounded and found seventy fathom, but nobody could agree on interpreting what the lead brought up; so through "evil marinership were fain to dance the hay foure days together' running northeast, southeast, east, and east northeast" until finally sighting a known point on land. (To dance the hay refers to a folk dance in which the participants moved in circles).

Although in deepwater there were fewer opportunities for disaster as compared to sailing in close proximity to land, the problem of longitude determination bedeviled the deep-sea sailor. On 2 June 1699, William

Few mariners today would trust their lives to "oosy sand"

Dampier described his uncertainty while approaching the Cape of Good Hope: "I saw a large black Fowl, with a whitish flat Bill, fly by us; and took great Notice of it, because in the East India Waggoner, or Pilot-Book, there is mention made of large Fowls, as big as Ravens, with white flat Bills and black Feathers, that fly not above 30 Leagues from the Cape … My Reckoning made me then think myself above 90 Leagues from the Cape, according to the Longitude which the Cape hath in the common Sea-Chart: So that I was in some doubt , whether these were the right Fowls spoken of in the Waggoner or whether those Fowls might fly further off Shore than is there mentioned… I found, soon after, that I was not then above 25 or 30 leagues at most from the Cape…." Although reduced to navigating by fowl, Dampier, showing complete understanding of the navigational problems of his day, went on: "Whether the fault were in the Charts laying down the Cape too much to the East …, or were rather in our Reckoning, I could not tell: But our Reckonings are liable to such Uncertainties from Steerage, Log, Currents, Half-Minute Glasses, and sometimes want of Care, as in so long a Run often cause a difference of many leagues in the whole Account."

Over the next century a revolution occurred in both the ability of the mariner to position himself at sea and in the techniques for producing accurate nautical charts for use in approaching land and harbours. The convergence of three factors led directly to success in determining longitude: 1) invention of the octant by John Hadley in 1731 and then sextant by Captain John Campbell RN in 1757; 2) the invention of the chronometer, generally attributed to John Harrison, although there were a number of forerunners of this technology; and 3) development of the lunar distance method of longitude determination coupled with the publication of *The British Mariner's Guide* in 1763. This guide, produced by Nevil Maskelyne who became the fifth British Astronomer Royal in 1765, led to the publication, beginning in 1767, of yearly

Figure 2: Using octant for observing astronomic bodies, circa 1750.

nautical almanacs with predictions of the positions of various astronomical bodies expressly for the purpose of determining longitude at sea.

Paralleling the evolution of technologies and methods for longitude determination, was the development of improved systems and methods for surveying the coastlines of the world. A pioneer in this endeavour was Murdoch Mackenzie. In 1747, he began a survey of the Orkney Islands. Of this survey and its published charts, he wrote: "Having previously acquired a competent knowledge of the islands, and planned the future procedure in my mind, I caused beacons, or landmarks, to be built on the summits of all the remarkable hills and eminences; and, catching the opportunity of a very hard frost I pitched on the north-most branch of the Loch of Stenhouse…" for measurement of a 3 and ¾ mile base line. Mackenzie goes on: "The direction of this base line having been exactly

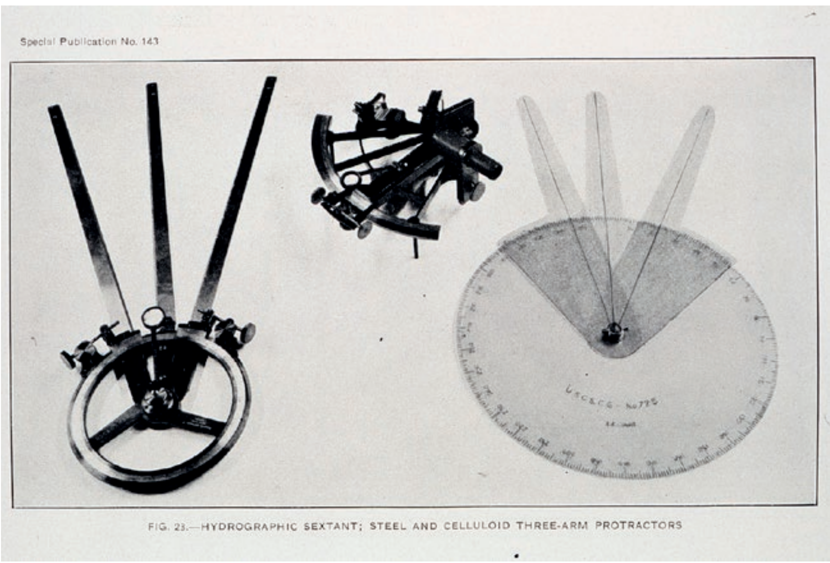
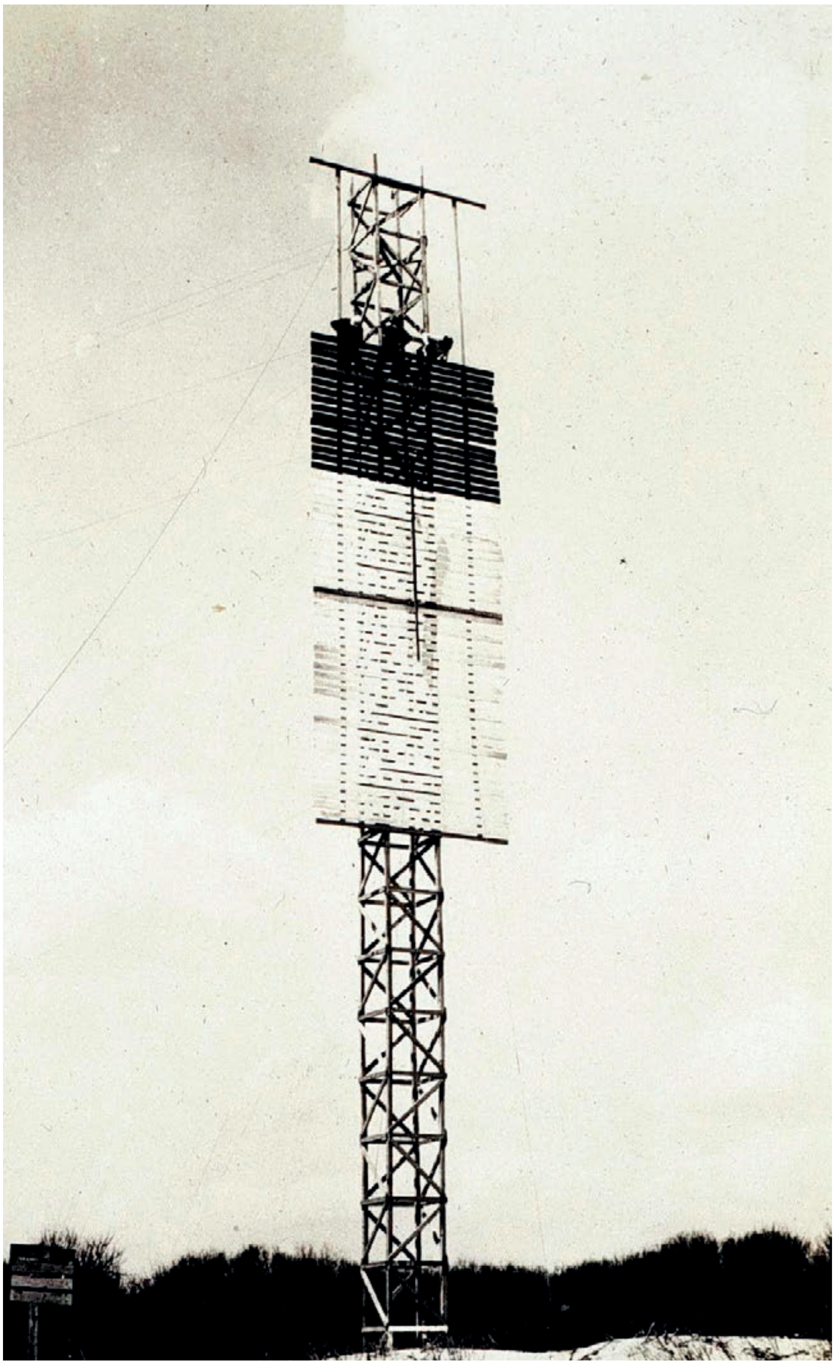


Figure 3: Metal old style station pointer (three-arm protractor), newer plastic model, and sextant in 1931.

No instrument was available to plot the resulting fix

taken with a magnetic needle, from each of its extremities, with a good theodolite, the angles were observed, contained between the base and the visual rays connecting the beacons; from which their distances from the station and from one another, were calculated trigonometrically and protracted on paper in their proper bearings…"

The purpose of the survey of terrestrial points prior to conducting the hydrographic survey was to establish a geographic framework in which the accurate location of soundings could be determined by either intersecting bearings or by three-point sextant fix. The accuracy of MacKenzie's surveys were degraded by using intersecting bearings observed by magnetic compass during his hydrographic surveys.
MacKenzie was aware of the concept of the three-point sextant fix but no instrument was available to plot the resulting fix. This led him to publish a suggestion for design of a station pointer (also called a three-arm protractor) in 1774. This instrument was meant to easily and rapidly plot three-point horizontal sextant fixes.



▲ *Figure 4: Building signal for visual sextant hydrography. Circa 1935.*

Although the history of production of this instrument is murky, it seems that the surveyor Graeme Spence developed and used the first station pointer by 1784. The benefits of this new technology and methodology were immediately apparent in both the increased accuracy of plotted soundings and the ability to maintain straight, well-controlled survey lines. The station pointer also facilitated rapid plotting of ship and sounding boat positions while outlining shoals or running shoreline. In spite of these advantages, the slow dispersion of information through the ranks of marine surveyors is highlighted by the fact that Captain Thomas Hurd, while visiting the British Hydrographic Office in 1806, saw a station pointer for the first time and ordered one for his own use. Two years later he was appointed Hydrographer of the British Navy. He was progressive in his views and within ten years the British East India Company hydrographer James Horsburgh stated that the station pointer was a common piece of surveying equipment. And so it and the technique of measuring horizontal sextant angles for a three-point fix remained so for over 150 years. The accuracy of positioning by this technique (3-5 metres in a rigid geodetic framework) was not exceeded in normal surveying practice until the advent of the global positioning system.

Besides leading the hydrographers of the world into the modern era, Murdoch MacKenzie left a legacy of moral guidance to those who survey the seas: "The lives and fortunes of sea-faring persons, in great measure, depend on the accuracy of their charts. Whoever, therefore, publishes any draughts of the sea-coast is bound in conscience, to give a faithful account of the manner and grounds of the performance, impartially pointing out what parts are perfect, what are defective, and in what respects each are so; that the public may be enabled to judge … how far the draughts are to be relied on." ◀

Shell Ocean Discovery XPRIZE

Getting to the Bottom of Our Ocean

Two-thirds of our planet surface is covered by water and yet what lies underneath is a mystery to us. We know the ocean controls our weather and climate and is home to an estimated half of all species on Earth. However, 95% of the ocean still remains unexplored. We have higher resolution maps of the Moon and the surface of Mars than we do of our seafloor [1].

Exploring the ocean has long been a challenging endeavour. Historically, access to the deep ocean has been limited for many reasons such as the extraordinary physical challenges presented by the opaque, corrosive medium of salt water and operating under crushing pressures, the high financial costs of exploring this extreme environment, and limited technological advancements. Today's ocean exploration technologies have not yet achieved the scales necessary to gather the detailed data and imaging needed to understand and protect our ocean resources in more expansive, sustainable and affordable ways.

We need a new era of ocean exploration.

Shell Ocean Discovery XPRIZE

For over a decade, the XPRIZE Foundation has been the global leader in incentivised prize competitions. Founded in 1995, XPRIZE is a non-profit organisation that solves the world's Grand Challenges by creating and managing large-scale, high-profile competitions that drive innovation and inspire the belief that we can create a better future through breakthrough technological solutions. To address the Grand Challenge of deep ocean exploration and discovery, XPRIZE has launched the USD7 Million Shell Ocean Discovery XPRIZE [2] - a three-year competition challenging teams to advance breakthrough technologies that, through shore or air deployments, will result in rapid, unmanned and high-resolution deep ocean exploration. Embedded within this is a USD1 Million National Oceanic and Atmospheric Administration (NOAA) bonus prize, which will be awarded to teams that demonstrate that their technology can also detect and identify a specified object in the ocean through its biological or chemical signal. Such underwater smart sniffers would be pioneering technology that would allow us to better respond to emergencies, and discover and monitor new marine life and underwater communities in a way that never existed before.

▲ *Figure 1: Jyotika I. Virmani, PhD, senior director, XPRIZE*

This competition is part of the XPRIZE Ocean Initiative – our commitment to launch five multi-million dollar prizes over 10 years. Collectively, these XPRIZEs address critical ocean challenges and inspire innovation that helps ensure that the world's oceans are healthy, valued and understood. The first two prizes were the Wendy Schmidt Oil Spill Clean-Up XChallenge (awarded in 2012, [3]), to develop efficient oil spill cleanup technologies, and the Wendy Schmidt Ocean Health XPRIZE (awarded in 2015, [4]), to develop robust, affordable and accurate pH sensors to detect changes in ocean acidification.

Competition Details

Team registration for the Shell Ocean Discovery XPRIZE opened in December 2015, with a registration deadline of 30 June 2016. Late registrations will be accepted until 30 September 2016. Teams will be required to submit technical details to the Judging Panel in December 2016, and up to 25 teams will move forward to the testing. The teams will compete during two rounds of progressively difficult challenges and the winners will be announced at the end of 2018.

During the first round, in 2017, teams will be required to produce bathymetric maps of at least $100km^2$ of the seafloor at 2,000m depths at a minimum horizontal resolution of 5m (0.5m vertical resolution) in less than 8 hours. Teams will also have to capture a high-resolution digital image of a specified object at 2,000m, and an additional 5 high-resolution digital images of archeological, biological, or geological features from any depth. Testing for the NOAA Bonus prize will take place during this round. If no team wins the bonus prize, another opportunity to compete for this USD1 Million will be offered during the second round of testing. At the conclusion of the first round of tests, up to the top ten performing teams will share a USD1 Million milestone prize and move forward to the next round of testing.

The second and final round of testing will take place in 2018. Teams will be required to produce bathymetric maps of at least $250km^2$ of the seafloor at 4,000m depths at a minimum horizontal resolution of 5m (0.5 m vertical resolution) in less than 15 hours. Teams will also have to capture a high-resolution digital image of a specified object at 4,000m, and an additional 10 high-resolution digital images of archeological, biological, or geological features from any depth.

Further details are available in the Competition Guidelines (available at ◄ [2]), which are currently open for Public Comment until 31 January 2016.

Impacts

The small fraction of the ocean we have explored has already yielded a number of fascinating and beneficial discoveries for the benefit of humanity. For example, potential treatments and drugs for cancer, Alzheimer's and AIDS have been identified ◄ [5], and an estimated 3 million shipwrecks ◄ [6] lie on the seafloor, waiting to provide insights into human history and culture.

We have barely scratched the surface of one of the most fascinating and critical places in the universe. The Shell Ocean Discovery XPRIZE aims to usher in a new, unprecedented era of ocean exploration and provide a pathway for tomorrow's discoveries. By accelerating innovation for the rapid and unmanned exploration of the unchartered deep sea, this XPRIZE will catalyse new markets in deep ocean exploration and sustainable resource development and protection.

The technologies needed to win this XPRIZE may span many areas of innovation - engineering, oceanography, robotics, imaging, data visualisation, nanotechnology, material science, computing and chemical sensing, to name a few. We invite teams around the world to join us on this exciting adventure and help shape the future technologies of deep-sea exploration and discovery.

Together, we can get to the bottom of our ocean. ◄

▲ *Figure 2: There are challenges to mapping the ocean floor.*

More information

1. https://theconversation.com/just-how-little-do-we-know-about-the-ocean-floor-32751
2. http://oceandiscovery.xprize.org/
3. http://oilcleanup.xprize.org/
4. http://oceanhealth.xprize.org/
5. http://www.noaa.gov/features/economic_0309/medicines.html
6. http://www.ioc-unesco.org/index.php?option=com_content&view=article&id=83:underwater-cultural-heritage&catid=14&Itemid=100063

Achievements in 2015 Important for ECDIS and e-Navigation

Significant Progress for IHO Technical **Standards**

The main driver for the establishment in 1921 of the precursor of what is today the International Hydrographic Organization (IHO) was to standardise the presentation of information on nautical charts and publications. Standardisation has been a core activity of the IHO ever since. The IHO currently maintains 15 standards and 10 related guidelines. This article highlights some of the recent achievements in relation to the maintenance of existing standards as well as the development of new standards.

A major achievement in 2015 was the completion of a coherent set of revised editions of the key standards underpinning Electronic Chart Display and Information Systems (ECDIS). This activity required close coordination between the IHO and the International Electrotechnical Commission (IEC). The IHO's contribution includes Edition 6.1 of Publication S-52 - *Specifications for Chart Content and Display Aspects of ECDIS*, Edition 4.0 of S-52 Annex A - *IHO Presentation Library for ECDIS*, Edition 3.0 of Publication S-64 - *IHO Test Data Sets for ECDIS* and Edition 1.2.0 of Publication S-63 - *IHO ENC Data Protection Scheme*. These standards were reviewed and updated to reflect lessons learned from earlier reports of unexpected chart behaviour in some ECDIS. The revised editions are a significant contribution by the IHO to supporting navigational safety by ensuring that all identified ambiguities and inconsistencies relating to the display of Electronic Navigational Charts (ENCs) in ECDIS have been resolved. Following the publication of the 4th Edition of IEC 61174 - *Maritime Navigation and Radiocommunication Equipment and Systems - Electronic Chart Display and Information System (ECDIS) - Operational and Performance Requirements, Methods of Testing and Required Test Results* in August 2015, the revised editions are now the normative IHO references for the type approval of all new ECDIS equipment.

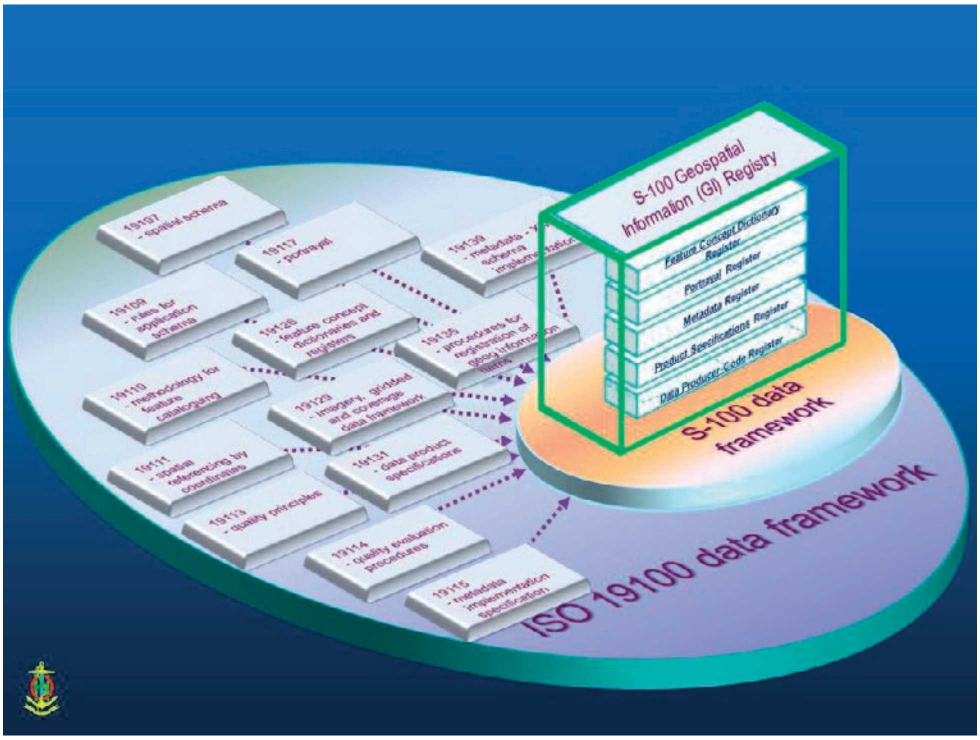
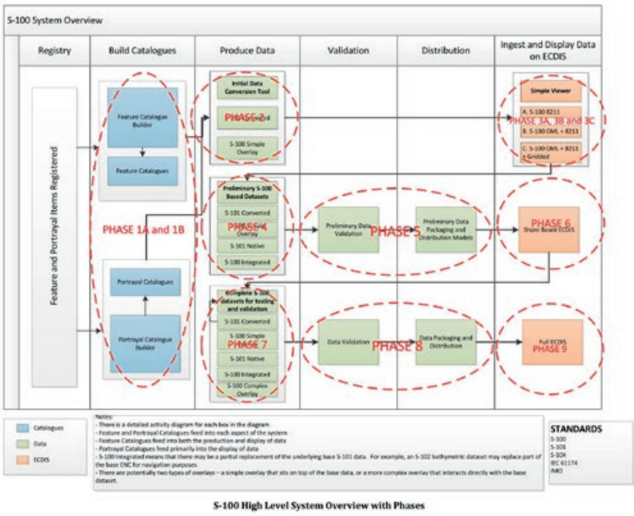


Figure 1: S-100 is based on ISO conceptual standards.

In parallel, the IHO was actively preparing the next generation of standards to support the e-Navigation strategy and implementation plan adopted by the International Maritime Organization as well as supporting the growth in maritime spatial data infrastructures that promote the wider availability of core geospatial data, such as hydrography. An enhanced Edition 2.0.0 of the underpinning standard, Publication S-100 - *Universal Hydrographic Data Model*, was issued in 2015. The changes introduced in the new edition improve the usability of S-100 for the developers of product specifications by providing for a portrayal model, an additional encoding format - Geographic Markup Language (GML), and the ability to maintain lists of information that are common across different domains. A number of S-100 based product specifications developed by the IHO or by other organisations are also now ready for implementation or for validation tests.

Another significant outcome of the efficient coordination with the other standardisation organisations was the adoption in August 2015, by the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), of a *Guide to the Role of Standards in Geospatial Information Management* and an associated *Technical Compendium* as the UN-endorsed international geospatial standards best practice for spatial data infrastructure. These documents resulted from a collaborative endeavour between the IHO, the Open Geospatial Consortium (OGC) and Technical Committee 211 of the International Organization for Standardization (ISO).

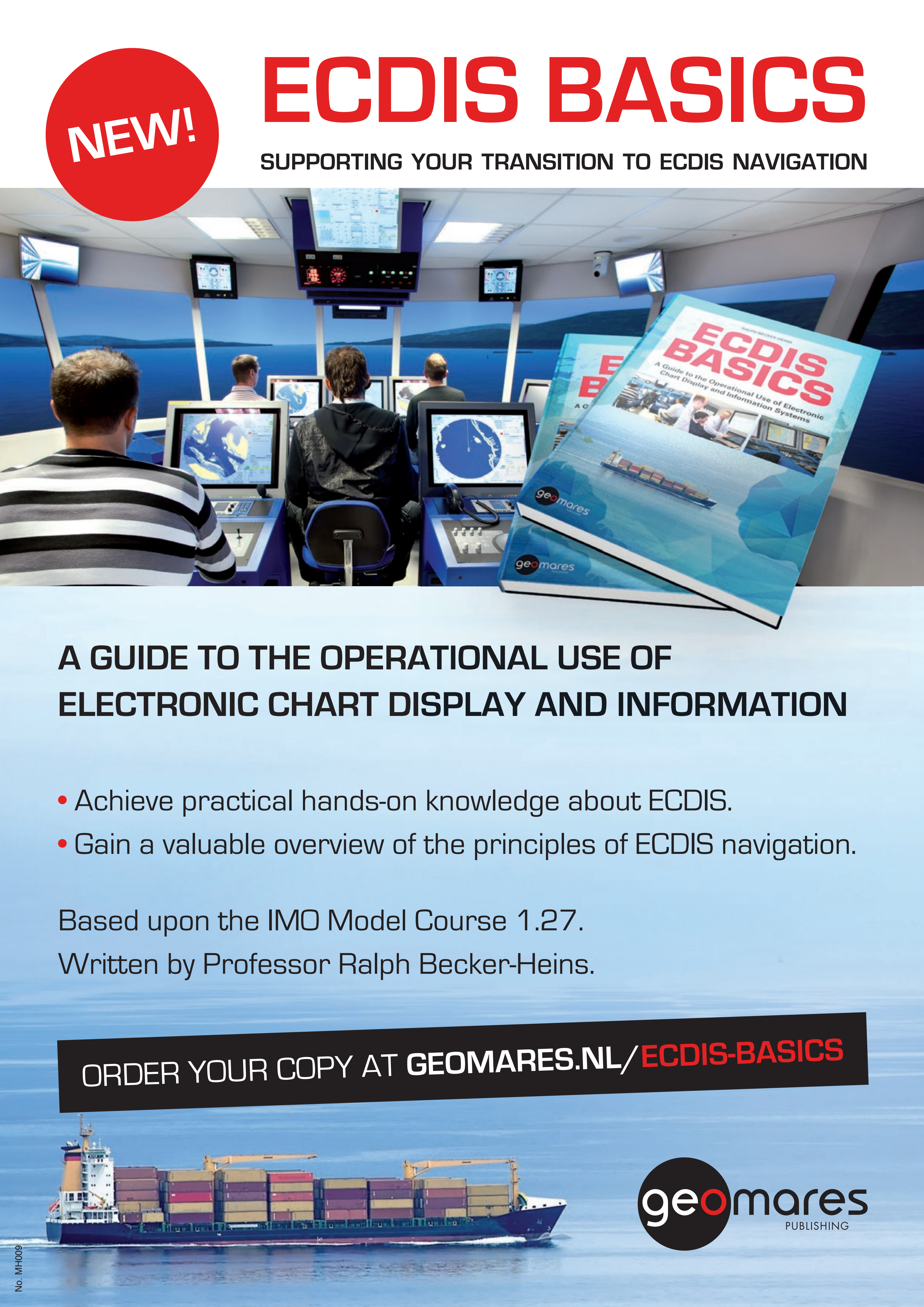


▲ *Figure 2: S-100 Test Strategy.*

2016 will see the IHO's technical programme continue work on developing the S-100 framework and monitoring the implementation of the revised ECDIS standards.

Most IHO standards are made freely available on the IHO website. ◀

More information
www.iho.int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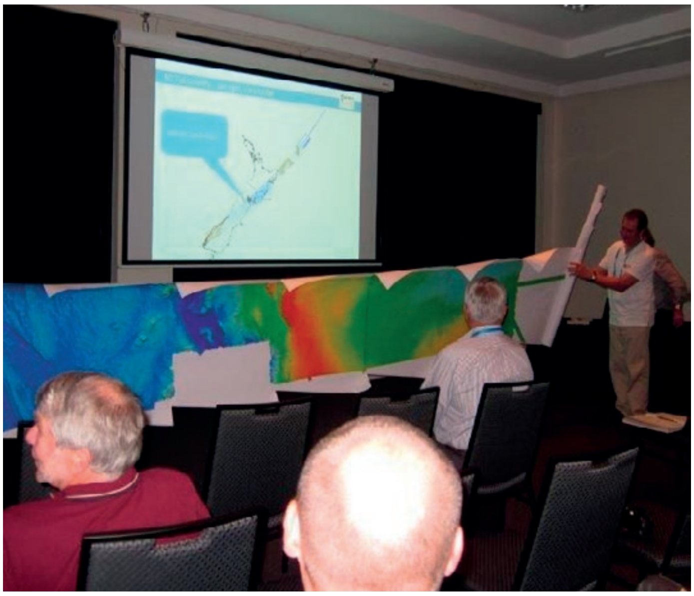

▲ *Figure 1: MH370 search area comparison and swath output.*

Fugro Australasian Hydrographic Symposium Report

The Fugro Australasian Hydrographic Symposium 2015 & Trade Exhibition was held in early November 2015 in Cairns, Australia. The Symposium had 117 attendees, mostly from Australia, with a small contingent of welcome oversees visitors as well as 9 exhibitors. The Symposium was ably chaired by CAPT John Maschke, RANR with generous support from sponsors such as Fugro, Kongsberg, Precision Hydrographic Services, QPS, IXSurvey, Hydro and Cadastral Survey, Acoustic Imaging, SBG Systems and a very small team of volunteers.

The presentations were of a high standard covering many aspects of hydrography. Some of the key discussion areas were the use of autonomous vessels, Lidar, data processing and future vessels capable of undertaking multiple roles for hydrography and oceanography data collection. A standout presentation was Fugro's work in the search for MH370. Apart from the difficulty of finding the wreckage in a very large area of the Indian Ocean, the operating conditions are extreme – 6 days to sail (rock and roll) out to the search site on a 42 day rotation. In one particular weather event, a 17m wave was recorded. It was reiterated several times that the heroes of the search effort are the men and women on the ship working in difficult physical conditions. The picture shows a comparison of the length of the search area to New Zealand and the swath paper plot stretched across the width of the conference room (one third shown in the picture).

A copy of the presentations will be available soon from the AHS website: www.ahs.asn.au/AHS.html

During the Symposium, the AHS held their AGM with several changes to key personnel within the various regional executive teams.

The AHS was also saddened with the passing of one of its foundation members and stalwarts CMDR Edward Ronald Whitmore, RAN (Rtd) on 11 November 2015.

FEBRUARY

2016 Ocean Sciences Meeting
New Orleans, USA
→ 21-26 February
osm.agu.org/2016/

Underwater Intervention
New Orleans, USA
→ 23-25 February
www.underwaterintervention.com

Flood & Coast
Telford, UK
→ 23-25 February
www.floodandcoast.com

International Conference on Ocean Energy (ICOE)
Edinburgh, UK
→ 23-26 February
bit.ly/ICOE2016

Waves and Wave Modelling Using SWAN
Oxfordshire, UK
→ 24-25 February
bit.ly/1ZB53TB

MARCH

Coastal Process and Management Course
Oxfordshire, UK
→ 1-2 March
bit.ly/1ZB5jli

Coda Octopus Breakwater Construction Webinar
Online
→ 2 March
sales@codaoctopus.com

57th Marine Measurement Forum
Wallingford, UK
→ 3 March
For more information:
www.mmf-uk.org

ECORD Training Course 2016
Bremen, Germany
→ 7-11 March
www.marum.de/en/ECORD_Training_Course_2016.html

International Geomatics Congress
Havana, Cuba
→ 14-18 March
www.informaticahabana.cu/es/eventos/show/91

Oceanology International
London, UK
→ 15-17 March
For more information:
www.oceanologyinternational.com

APRIL

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

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

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

MAY

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

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

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

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

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

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

JUNE

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

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

SEPTEMBER

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

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

OCTOBER

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

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

NOVEMBER

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

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

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

FEBRUARY 2017

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

APRIL

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

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

JUNE

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

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

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