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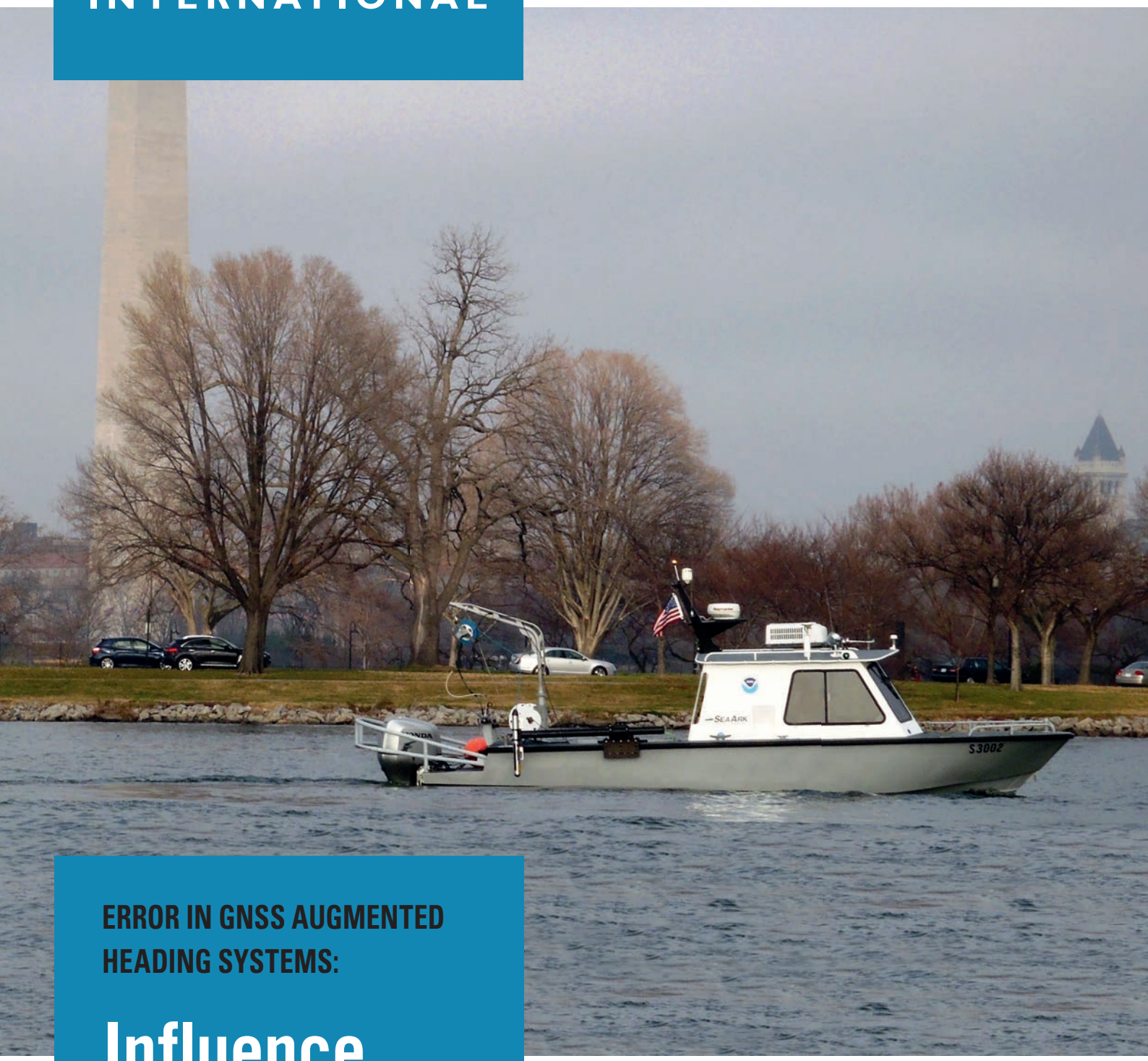

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S-101

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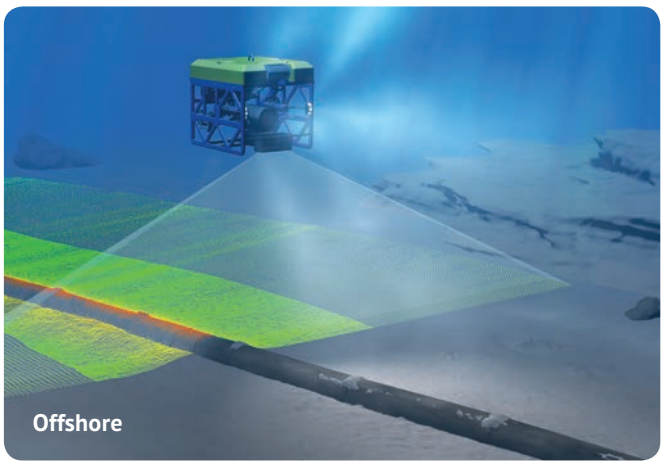

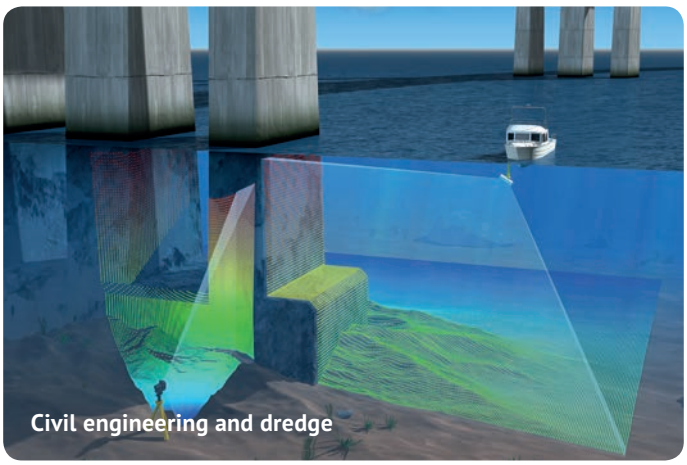

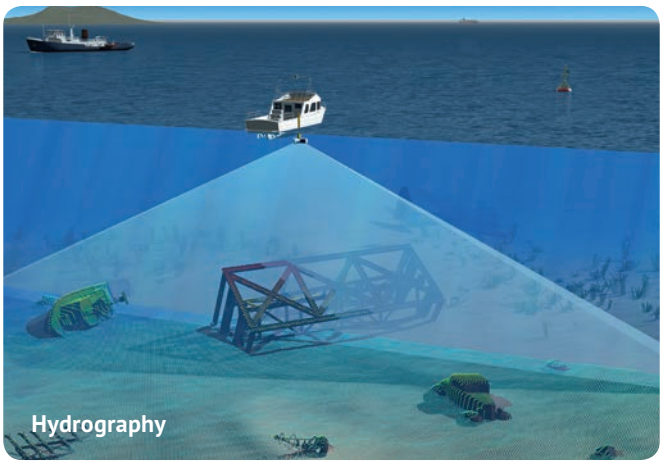

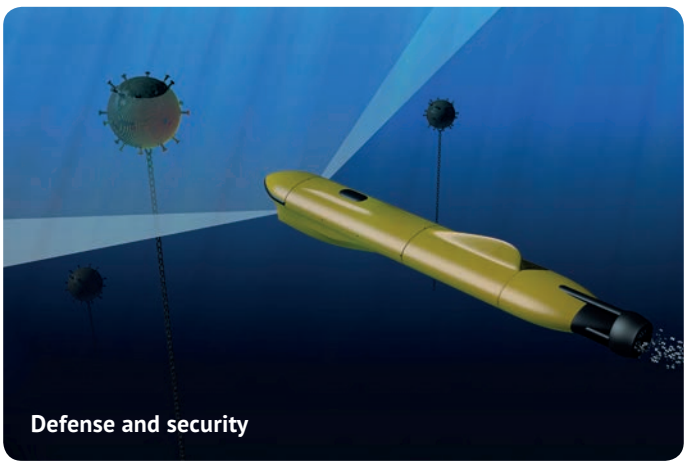

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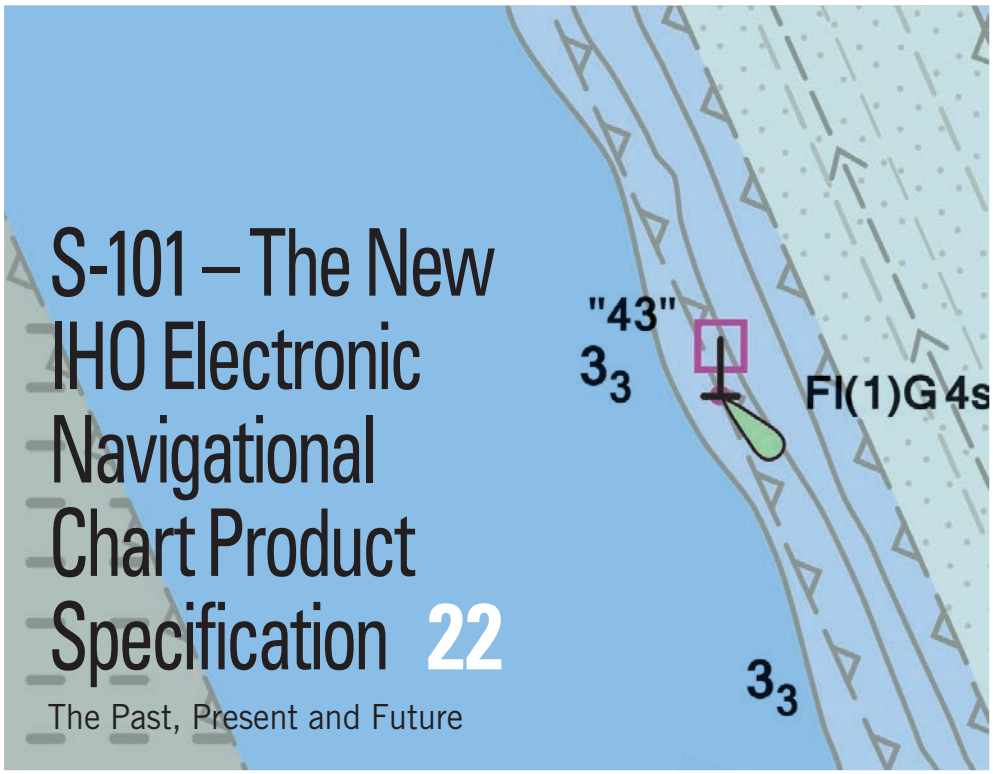

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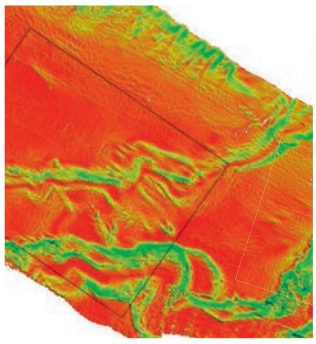

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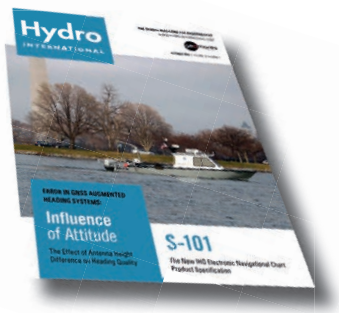

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NRT-5 surveying the Potomac River security zone in preparation for the 2013 USA Presidential Inaugural. A programme to replace the boats has been initiated. Image courtesy: NOAA.

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PHOTOGRAPHY: ARIE BRUINSMA (WWW.ARIEBRUINSMA.NL)

Centre of gravity

Convincing colleagues in adjacent fields of the importance of hydrographic data is one of the hot topics that comes up every time I talk to policy and decision makers in hydrography: 'We need to make ourselves visible and show the world that everything we do underpins the work at sea in many different aspects: safe navigation at sea, building of offshore wind farms, search and exploration of oil & gas, development of ports & harbours, and coastal zone management.' One of the main reasons behind this is that hydrography as a field wants (and maybe needs) to prove its right of existence, with the occasional fear that the work of hydrographers is being taken over by professionals that are less or differently skilled – ending up in the one-button-hydrography. This would make highly educated professionals obsolete. Another and more justified fear is that the world around us is making mistakes in obtaining, analysing and interpreting bathymetric data, and trained hydrographers do not point out these mistakes, which leads to, among others, accidents at sea, wrongly placed infrastructural projects, and way too much or way too little dredging.
There is another way of convincing the world and establishing hydrography as a profession that will count in many more countries across the globe for decades to come: capacity building. Going to conferences and tradeshows all over the world, it needs to be said that hydrography has a few geographical centres of gravity: in all countries bordering the North Sea, the United States and Australia hydrography and hydrographers are well represented and to be honest the majority of delegates at shows all over the world come from these countries. It would be good for capacity building to once again become more prominent on the agenda. Because there is a lot of room for growth – not just vertically in all the topics I mentioned: coastal zone management, offshore energy and tourism, but also horizontally in areas that are developing fast – South East Asia, China, Africa and Latin America. Imagine if hydrography was to be as well established in all these regions, in the public and private sector, at educational institutes and in local or regional hydrographic societies as in the centres of gravity. It would certainly help hydrography as a whole grow, with benefits for all those other sectors in the Blue Economy. There are two major events this month. One in that other centre of gravity Monaco where the IHO will meet at the 5th Extraordinary International Hydrographic Conference from 6-10 October and the other in Aberdeen, UK, where the International Federation of Hydrographic Societies holds its 22nd Hydro conference from 28-30 October. Capacity building should be on the official and unofficial agenda at both conferences to ensure a career in hydrography and the future of the profession of the hydrographer and the field of hydrography across the world.

PS We are introducing a refreshed layout in this edition of *Hydro International*: one of the most important features of this new design is that it will enable us to provide you with even more information in every issue from now on! I look forward to hearing what you think of it.

Durk Haarsma durk.haarsma@geomares.nl

Rear Admiral Gerd Glang, director, NOAA Office of Coast Survey

Re-thinking **Nautical** Charts

The maritime world is evolving and the tools we use to make decisions are changing. At NOAA, we are re-thinking the nautical chart, improving the content and format to best meet the challenges of timeliness and fitness-for-use for tomorrow's navigation.

We all know the stereotypical picture of the master mariner climbing up the ladder of his vessel, with the chart rolled up under his arm. That paper chart, as the only representation of what that mariner sees, is increasingly one for the history books. There is no question that electronic display systems and mobile apps are the digital wave of the future.

NOAA recently transformed chart production processes from manipulating raster images to building the digital database. This lets us release corrected charts within the week – instead of within a year or two or ten, as under the previous system where we waited to release most changes on periodic new editions. This change alone has the potential to reduce 'update latency' by 80 percent, for both paper charts and digital charts.

NOAA is also developing chart distribution formats and systems to more readily deliver charts and other relevant coastal environmental information to modern navigation systems. For example, we are reformatting our thousand charts into millions of tiles, for quicker and easier uptakes by mobile apps, chart plotters and other electronic systems.

Rear Admiral Gerd Glang inspects nautical charts with Ann Kinner of Seabreeze.

In ports, ships regularly manoeuver within a few metres of each other, of the seafloor, and of shoal water and shoreline. In a trial project in Long Beach, NOAA data will support commercial navigation systems enabling pilots and ship captains to better manage underkeel clearance risk and optimise the efficiency of operations in ports. In addition to tide and current station observations, NOAA will maintain and distribute high-resolution depth models, tide and current models and other types of environmental information — all in formats that are compatible with portable pilot units. They will also be able to customise the display of chart data, using a spectrum of tools, to set their own safety contours and plan cargo loads.

NOAA is also taking advantage of the recent growth in availability of geospatial data, much of it freely available. We take our responsibility for maintaining the accuracy of our charts very seriously, and will use the best available data to that end. While we will not make significant changes to our charts based on unreliable data, we also cannot afford to ignore this data in evaluating the quality of our charts and prioritising our own surveys. In this mode of operation, we are using bathymetry and shoreline data from many new sources, such as public source photogrammetry, satellite derived bathymetry and crowdsourced navigation hazard data.

Einstein once gave us the secret to his success: "Logic will get you from A to B. Imagination will take you everywhere." Thanks to what we hear from the people in the ports and harbours and marinas around the country, NOAA is re-thinking and re-doing navigation. I think mariners will be happy with where it takes us.

Navigation Response Boats to be Replaced

Lake Assault Boats of Superior, Wisconsin, USA will build two small vessels for the NOAA Office of Coast Survey's navigation response programme, part of a plan to eventually replace all six of the programme's small survey boats. The combined cost of both 28-foot vessels is USD538,200. All of the navigation response team survey boats are nearing or have exceeded their designed service life, according to Russ Proctor, division chief of Coast Survey's Navigation Services Division.

▸ *http://bit.ly/1ql2EOa*

NOAA NRT survey boat.

AUV Pioneer Receives Award

Bjørn Jalving, executive vice president Subsea at Kongsberg Maritime (Norway) has been given the Compass Distinguished Achievement Award from the Marine Technology Society. The award ceremony took place on 16 September 2014 at the OCEANS 2014 MTS/IEEE conference in St. John's, Newfoundland, Canada. This award is presented to an individual whose work has had significant impact on the fields of marine science and technology.

▸ *http://bit.ly/1sl7Cy7*

Bjørn Jalving.

Most Shared

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

New Seamount Discovered During ECS Mapping - http://bit.ly/1sl8fYt
Teledyne RESON Acquires Business From ATLAS HYDROGRAPHIC - http://bit.ly/1sl8vXt
Bay of Bengal Maritime Boundary Arbitration Awarded - http://bit.ly/1uG4aLm
In Situ Mud Density Measurement System - http://bit.ly/1sl8Qcs
Brazil Expands Network to 10 AXYS 3-metre Buoys - http://bit.ly/1sl8V01

European Lidar Mapping Forum Presents Programme

The European Lidar Mapping Forum (ELMF) 2014 conference programme has been posted online. The event will take place from 8-10 December 2014 at the Passenger Terminal Amsterdam (PTA) in Amsterdam, the Netherlands. There are two 'blocks' dedicated to topographic and bathymetric Lidar survey.

▸ ***http://bit.ly/1slamvh***

Fran Rowe Recognised

Fran Rowe, technical advisor of Rowe Technologies, recently received the Lockheed Martin Award for Ocean Science and Engineering at the Oceans 2014 MTS/IEEE conference in St. John's Newfoundland, Canada. The Lockheed Martin sponsored award is presented to an individual who has demonstrated the highest degree of technical accomplishment in the field of marine science, engineering or technology.

▸ ***http://bit.ly/1sl7Cy7***

Subserv Pro Welcomes Atlas Professionals

As Subserv Pro enters its tenth year, the company has agreed an initial 25% equity investment by Atlas Services Group Energy Limited. Control of the companies (Subserv Pro and its subsidiary ORCA Offshore) will not change, however, the agreement will see Marcel Burghouwt, managing director of Atlas Professionals, take up a non-executive position on the board of directors.

▸ ***http://bit.ly/1slatHl***

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Bathyswath V2 117kHz	Multibeam Echo sounders	bit.ly/YXEz6R
Seatronics Predator Inspection-Class ROV	ROVs - Remotely Operated Underwater Vehicles	bit.ly/1AUn7LS

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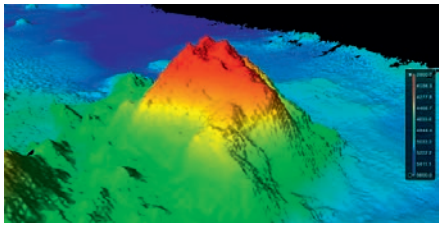
New Seamount Discovered During ECS Mapping

A discovery has come out of the US Extended Continental Shelf (ECS) Task Force mapping efforts in an area of the Pacific Ocean that is one of the least explored of the Earth's oceans. On 13 August 2014, University of New Hampshire (UNH) Joint Hydrographic Centre (JHC) scientists aboard the R/V *Kilo Moana*, discovered a new seamount in the Pacific Ocean using a 12kHz multibeam echo sounder. The seamount, estimated to be more than 1,100 metres high, was discovered in the midst of a feature-rich stretch of seafloor approximately 5,100 metres deep.

http://bit.ly/1sI8fYt



The discovered seamount.

Side-scan Sonar Finds 170-Year-Old Wreck

One of the two ships of the Arctic expedition of Sir John Franklin has been found and imaged using technology including Klein Side-scan Sonar. The Prime Minister of Canada, Stephen Harper, said in a statement that Franklin's ships are an important part of Canadian history given that his expedition, which took place nearly 170 years ago, laid the foundations of Canada's Arctic sovereignty.

http://bit.ly/1sI9JBU

Teledyne RESON Acquires Business from ATLAS HYDROGRAPHIC

Left: the future general manager of Teledyne RESON GmbH, Carsten Park Andreasen. Right: Kim Lehmann, president of the Teledyne Marine Acoustic Imaging Group and Teledyne RESON group.

Teledyne RESON A/S from Denmark has announced that its German subsidiary, Teledyne RESON GmbH, has acquired assets of ATLAS HYDROGRAPHIC, Germany, and that the business, product lines and a number of employees from ATLAS HYDROGRAPHIC GmbH are now part of the Teledyne Marine Acoustics Imaging group.

http://bit.ly/1sI8vXt

Offshore Survey 2015: Call for Papers

Offshore Survey, which takes place from 15-16 April 2015 alongside Ocean Business at the National Oceanography Centre in Southampton, UK, has announced a call for papers. The committee welcomes submissions suitable for sessions on: Subsea Positioning, Advanced Survey Techniques, Survey Operations, Data Processing and Visualisation, and Industry and Professional Issues. All papers will be evaluated by a technical committee of experts from industry and academia. Abstracts can be submitted online before 3 November 2014. The organisers of Ocean Business also published that the stands at the tradeshow are sold out.

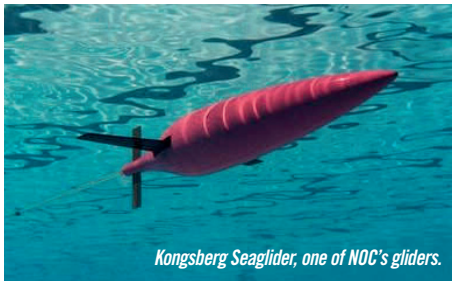
▸ ***http://bit.ly/1slbzTf***

N-Sea Offshore Moves to New UK Premises

N-Sea Offshore Ltd is to move into new premises as its Aberdeen-based business continues to grow. The subsea IMR provider has outgrown its current offices in Dyce and is adding additional office space to accommodate an increase in staff numbers as it expands operations both in the UK and internationally. The new office facility at Salvesen Tower will accommodate N-Sea's expansion of Aberdeen-based staff and is to house an enlarged project management and engineering department. Since early 2014, N-Sea has added 15 UK staff allowing the company to expand its service offering.

▸ ***http://bit.ly/1slaSti***

NOC Glider Fleet to Integrate SeeTrack



Kongsberg Seaglider, one of NOC's gliders.

SeeByte, UK, is working together with the National Oceanography Centre Southampton (NOC, UK). The agreement will see SeeByte develop tools to help pilot a fleet of gliders. Additions to the SeeTrack Professional software suite will allow NOC to use a common interface for all the gliders. Operators will be able to improve planning and monitoring procedures.

▸ ***http://bit.ly/1slaCum***

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KVH Industries, USA, has introduced the 1725 inertial measurement unit (IMU) and the 1775 IMU, advanced sensors designed to be integrated into the most demanding stabilisation, pointing and navigation applications. These two products complement KVH's 1750 IMU and create a complete range of choices for 6-degrees-of-freedom (DOF) sensors. All three products utilise the E•Core ThinFiber technology of KVH's DSP-1750 fibre-optic gyro (FOG).

▸ ***http://bit.ly/1slbFuh***

KVH 1775 IMU.

MV *Duke* Chartered for Humpback Whale Seismic Response Research

MV* Duke *in use with Gardline CGG joint venture.

Gardline CGG, Singapore, has been contracted by OGP (International Association of Oil & Gas Producers) to be involved in the last phase of the BRAHSS (Behavioural Response of Australian Humpback Whales to Seismic Surveys) project. Gardline CGG will use MV *Duke* as a source vessel offshore Peregian Beach in Queensland (Australia). BRAHSS is a five-year study that aims to test how humpback whales respond to seismic air guns (2010 – 2014). During the study to date, small numbers of humpback whales migrating along both the east and west Australian coasts have been exposed to air guns.

▸ ***http://bit.ly/1slc8wx***

SevenCs Presents WMS ChartServer Version

Version 4.3 of ChartServer allows more flexible configuration of the chart image and includes support of both Linux and Windows versions, ARCS support, extended chart object filtering, support of all S-52 (ECDIS) chart settings and support of multiple chart formats: S-57/S-63, ARCS, DNC, VMap, ARINC and DTED. It also includes the improved chart loading and installation tool, Chart Handler.

▸ ***http://bit.ly/1slbcrZ***

IMCA Reaches Thousand Membership Milestone

The International Marine Contractors Association (IMCA) now has over a thousand member companies involved in offshore, marine and underwater engineering in more than 60 countries, delivering major offshore construction projects from arctic to equatorial waters. Chris Charman, the association's chief executive, finds this an important milestone as the members employ some 350,000 people and have an annual turnover of around USD150bn.

▸ ***http://bit.ly/1slb5g2***

Southern Africa: Establishing and **Maintaining the Required Capacity** and Competence

A national hydrographer with a longstanding experience – that's how we can describe Captain Abri Kampfer from South Africa. It is a country with interesting characteristics and with a pro-active attitude towards the profession. *Hydro International* interviewed him on current issues like capacity building, the challenges developing countries can experience within the IHO when they want to fully participate and of course the role of hydrographic data for navigation and for use in the wider economy.

What is your view on successful capacity building for the Southern African region?
To maximise success rates, capacity building should be considered holistically with awareness and support being engendered at all levels of government in the state being supported. Awareness at high levels of government should generate support for the in-country officials with regards to a supported mandate for the establishment of a hydrographic capability. Strict adherence to the IHO Capacity Building Strategy to develop hydrographic capability in accordance with the three phases of hydrographic development is required. The provision of support and training should consider the current levels of development and be escalated only to the next phase once the required capacity and competence are established and maintained.

How could developed and developing states function on equal terms within the IHO?
All members of the IHO should share the vision of the IHO, irrespective of their levels of development. Developed countries should however recognise the difficulties that developing countries may experience from a lack of capacity and resources to fully participate in all IHO organs. The limited representation of developing countries in IHO working committees may in most instances be ascribed to this fact. Nothing however prevents developing countries from participating fully through correspondence in the work of the IHO and by sharing in the decision making process by responding timeously to the circular letters of the organisation.

What would be the key factors to success for efficient maintenance of the standards of the IHO?
Standards set should in the first place be achievable by the vast majority of IHO Member States and also supported in principle by the industry it is intended to support. The various working groups of the IHO have been doing a sterling job over the years in maintaining the standards of the IHO, but the success of these working groups is totally dependent on the active participation of Member States and input from industry and the maritime community.

How could IHO increase the membership of developing states?
The IHO Capacity Building Strategy is focused on encouraging developing states to become members of the IHO. The benefits of being a member should also be continuously communicated during high level and technical advisory visits so as to emphasise that SOLAS obligations are best met through membership and active participation in the workings of the IHO. It is possible that the economic circumstances of a prospective Member State could be the major factor in the reluctance to commit to full membership and it should therefore be clearly communicated that the benefits gained through the capacity building programme will outweigh the membership contribution.

Continuous communication of the importance of hydrography should not be relaxed

How can we raise awareness of the importance of hydrography worldwide, be it for safe navigation or for sustainable development?
It is vital that a better understanding of the purpose, role and function of a hydrographic service be brought to national and international attention with every means possible. I believe that the efforts by the Member States of the IHO and the directors of the IHB to continuously communicate the importance of hydrography should not be relaxed. The hydrographic industry can

benefit from this message and shows and exhibitions should incorporate this in their communications strategy. The hydrographic industry also has an important role to play in sensitising their clients of the importance to make hydrographic data, gathered for other purposes, available to charting authorities for improving navigational charts, thereby increasing safety of navigation and assisting in the protection of the environment.

Is hydrography really much more than just producing nautical charts, as was the slogan of this year's World Hydrography Day?

Absolutely, it was a very important message to communicate not only to the public, but also to Hydrographic Offices as they have an important role as national hydrographic data custodians.

The concept of the services provided by Hydrographic Offices being restricted to charting and some allied publications must surely be something out of the past. Hydrography is far more than making and distributing colourfully prepared charts, it is vital in the provision of Maritime Safety Information. Hydrographic Offices are involved in measuring most of the parameters of the oceans and seas, advising and servicing those that utilise these areas in so many other fields related to maritime transport, exploitation of maritime resources and environmental protection.

What is the percentage of waters around SA adequately surveyed against those not surveyed and in need of a survey or re-survey?

All the waters around the coastline of South Africa have been surveyed, some areas (± 40%) still require surveying by modern standards. This is an ongoing task conducted in accordance with a prioritised re-survey schedule.

How important do you think it is to achieve full ENC coverage, if the underlying data is old or incomplete?

I believe that the emphasis both within international shipping and the IMO is for universal coverage by ENCs. If the ENC represents the current available data, matching the compilation scale to the chart scale, it has the same value as the existing paper chart, but value can be added by encoding caution areas that will draw the mariner's attention to the unreliable data and deficiencies of the product. The danger however still exists that the mariner can view the data in a much larger scale before the over scale alarm on the ECDIS will draw his attention to this fact.

Do you see economic benefits for South Africa once the navigable waters have all been adequately surveyed?

All approaches to harbours are surveyed and charted to international standards and the areas still to be re-surveyed are mainly inshore coastal waters. Better data in the nearshore will most definitely help in the accurate determination of coastal setbacks and improving modelling to assist with coastal defences.

Do you have a message for (young) people starting a hydrographic career or wishing to take professional qualifacations in hydrography?

A hydrographic career can be most rewarding in the sense that you are exploring the unknown, always striving to acquire more details on the seafloor. The acquisition of hydrographic information to assist with improving nautical charting is particularly satisfying as you can see the results of your efforts being applied in the updating or creation of new navigational charts and thereby contributing to safe navigation and the protection of the marine environment. ◂

Captain Abri Kampfer

Captain Abri Kampfer joined the South African Navy in 1979 and qualified as a warfare officer, specialising in mine warfare, before completing a CAT A Advanced survey course at RNHMS *Drake* and a post graduate qualification from Plymouth University. He had command of several ships including the SA Navy survey ship SAS *Protea* as his last command. He was appointed Hydrographer of the South African Navy in 2004, having been in an acting capacity since August 2003. Captain Kampfer represents South Africa at various committees of the International Hydrographic Organization (IHO). He is the current chairman of the IHO Regional Hydrographic Commission, Southern Africa and Islands Hydrographic Commission (SAIHC).

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No. 3525

The Effect of Antenna Height Difference on Heading Quality

Error in GNSS Augmented Heading Systems: **Influence of Attitude**

My earlier articles on the alignment of motion reference units (MRU) with the ships reference frame (SRF) did not cover the calibration of GNSS augmented heading systems. Although the alignment can be done in the same way as mentioned in the previous articles, GNSS augmented heading systems need special attention regarding their installation. This article will show that the accuracy of these systems may be seriously affected by the vessel's attitude if the antennas are not installed at the same mutual height above the X/Y plane of the SRF.

The more accurate ROVINS (0.05° x SEC(LAT) which is the accuracy at the equator that deteriorates with latitude, and PHINS (0.02° x SEC(LAT)) have become increasingly popular since the previous articles, and we have been aligning more than a dozen of them, within their specifications.

GNSS augmented heading systems (see Figures 1 and 2) have an accuracy that depends on the mutual distance between its two antennas. An accuracy of more than 0.10° can easily be achieved and even 0.02° or more is possible. Alignment can be done in two ways; either by measuring the perpendicular distances between known on board nodes (e.g. the vessel's bollards) and a known reference (e.g. a quay side), as discussed in 2008; or simply by calculating the misalignment from the relative positions of the antennas within the SRF. The accuracy of the latter method depends on the accuracy of the offset survey. With modern survey techniques it should be no problem to achieve a point accuracy of 0.002 metres at a 40 metres long vessel (1σ, 68%). This corresponds to an angular accuracy of approximately 0.04° at a 4 metres baseline between the antennas.

Assuming a coordinate system with the Z-axis upwards, the misalignment θ follows from the following simple formula where L is the horizontal (i.e. parallel to the X/Y plane of the SRF) baseline length between the two antennas:

$$\tan(\theta) = dX/L. \quad [1]$$

Dual antenna GNSS augmented heading systems are either installed with this baseline parallel to the vessel's centreline (see Figure 1) or perpendicular to it (see Figure 2). The former configuration will provide heading and pitch of the baseline, while the latter configuration will provide heading and roll of the baseline. The resulting roll or pitch will be the true attitude of the SRF if the two antennas have an equal height in the SRF or if the angle between them and the X/Y plane of the SRF is known.

Let us suppose that we have a vessel with two antennas along the centreline, therefore having equal coordinates in the direction perpendicular to the ship. According to equation [1] the misalignment would be zero degrees. Let us also suppose a nonzero mutual antenna height difference dZ, combined with a nonzero roll ρ. The higher antenna will be displaced further from the centreline than the lower (see Figure 3). The induced difference between them along this X-axis dX_i is calculated as:

$$dX_i = \sin(\rho) \cdot dZ. \quad [2]$$

This attitude induced displacement dX_i causes an error in the heading which I call the attitude induced heading error θ_i. The attitude induced heading error can be calculated by combining [1] and [2]:

$$\tan(\theta_i) = (\sin(\rho) \cdot dZ)/L, \quad [3]$$

which can also be written as:

$$\sin(\theta_i)/\cos(\theta_i) = \sin(\rho) \cdot dZ/L. \quad [4]$$

It is assumed that the resulting θ_i will be small, which means that $\cos(\theta_i)$ approaches one. Therefore, [4] can be simplified to:

$$\sin(\theta_i) = \sin(\rho) \cdot dZ/L. \quad [5]$$

If we also assume that ρ is small, and as a consequence sin(ρ) almost equals ρ (expressed in radians), the result is:

$$\theta_i / \rho = dZ/L. \quad [6]$$

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Figure 1: A Kongsberg Seapath (in oval) and a Seabed FROG III GNSS augmented heading system, mounted along the ship's centreline during trials.

Figure 2: An Applanix POS MV GNSS augmented heading system, mounted perpendicular to the ship's centreline.

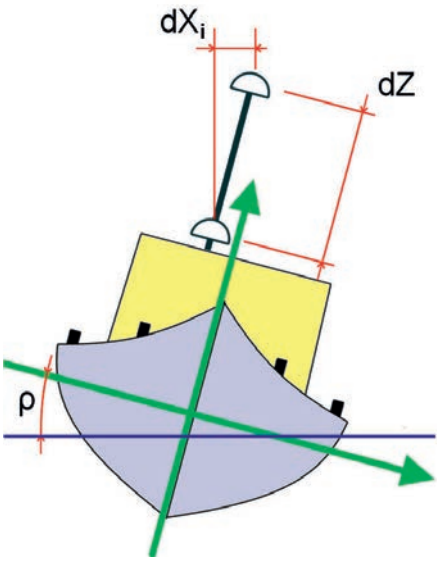

Figure 3: Attitude induced antenna displacement perpendicular to the ship's centreline.

From [6], it becomes clear that the height difference (dZ) should be kept to a minimum, preferably zero. It also becomes clear that the baseline length (L) should be as large as possible, which is also beneficial for the heading accuracy of the system. Even when the momentary pitch or roll misalignment angle can be fed into the system, the system will not be able to distinguish between attitude induced heading error or an actual heading change. The attitude induced heading error with respect to ratio dZ/L is shown in Figure 4.

The maximum acceptable height difference depends on the role heading plays in the on board system. Except for survey vessels, the maximum allowed induced heading $\theta_{i,max}$ is calculated using the propagation law of variances from the positioning accuracy (σ_{Pos}) in combination with the horizontal lever-arm length to the reference position (L_{LA}) and the required accuracy of this reference position (σ_{ref}):

$$\tan \theta_{i,max} = \mathrm{sqrt}(\sigma_{ref}^2 - \sigma_{Pos}^2)/L_{LA}. \quad [7]$$

Equation [7] is of course only valid if the positioning accuracy is better than the required accuracy of the reference position, as it is impossible to increase the accuracy of the positioning system by adding a heading device.

For hydrographic survey vessels the heading requirement does not only depend on the required reference point accuracy, but especially on the installed echo sounder system. Hydrographic vessels should always try to position within their footprint. When using a multibeam echo sounder this does not only account for the head, but the heading accuracy should be within the along-ship bundle width of the multibeam echo sounder to position each sounding within its footprint along the whole swath. Given a typical along-ship signal width of 1° for shallow water multibeam systems, the heading accuracy should thus never be greater than 0.5°, but preferably not exceed half of that (0.25°).

Example for the calculation of the maximum allowed induced heading for regular ships

Let us assume: a requirement for positioning the reference position with an accuracy σ_{ref} of 0.25 metres; a standard deviation σ_{GNSS} of 0.03 metres for LRK-GNSS positions; and a 30 metres lever-arm L_{LA}. With equation [7], this results in a heading accuracy $\theta_{i,max}$ of 0.5°. Using an expected maximum roll ρ_{max} of 5°, the ratio θ_i / ρ of equation [6] becomes 0.1 and therefore dZ should not exceed 10 percent of the baseline length between the antennas. As the 0.5 degrees requirement is about ten times the system accuracy of the GNSS augmented heading systems, the influence of the system accuracy itself can be neglected in the calculations.

Example for the calculation of the maximum allowed induced heading for survey ships

It is not unusual for hydrographic vessels to experience a roll ρ_{max} of 10°. Assuming that a maximum induced heading accuracy $\theta_{i,max}$ of 0.25° would be acceptable at such a roll, the ratio θ_i / ρ of equation [6] becomes 0.025. Consequently, dZ should not exceed 2.5 percent of the baseline length between the antennas when mounted in the direction along the centreline.

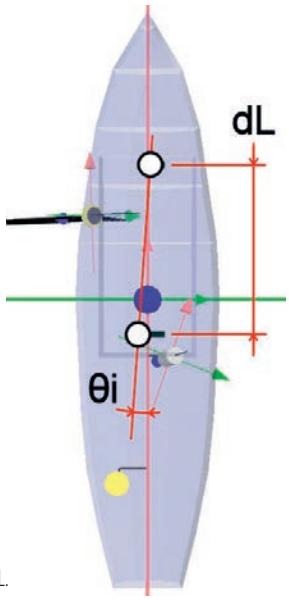

Figure 4: Attitude induced heading error from ratio dZ/L.

Not all vessels allow easy installation of the antennas within the dZ/L ratio of the examples. In contrast to the examples that assume installation along the ship's centreline, mounting the antennas in the perpendicular direction has the advantage that the accuracy is affected by the less extreme pitch values. In addition, getting the antennas mounted at the same height above the X/Y plane of the SRF is easier, as vessels are more symmetrical in that direction.

As the acquisition software has knowledge of both attitude and heading of the SRF, it should be a minor issue to extend the heading driver with an option to correct for the attitude induced heading error. The software would need to know the positions of both antennas. One of those is usually the primary navigation antenna, which obviously has a known position in the SRF.

Conclusion

In order to benefit from the full accuracy of GNSS augmented heading systems, attention should be paid to the height difference between the antennas during installation. For survey ships similar to the example given, it is recommended to keep the height difference between the antennas within 2.5 percent of the baseline length. In addition, it is recommended to extend acquisition software with an option to correct for the attitude induced heading error. Such an extension should require only minor changes to the software.

Further Reading

N. de Hilster, 'The MRU and SRF aligned, Part I: Solving the Yaw Angle', in: *Hydro International*, Vol. 12, Nr. 9 (2008) pp.24-29.
N. de Hilster, 'The MRU and SRF aligned, Part II: Solving the Pitch and Roll Angles', in: *Hydro International*, Vol. 12, Nr. 10 (2008) pp.18-21.

Nicolàs de Hilster

After his education in hydrography, Nicolàs de Hilster was employed by Osiris from 1989 to 1996. He then moved to the Survey Department of Rijkswaterstaat (GAM-Department). In 2000, Nicolàs became the founding owner of Starmountain Survey & Consultancy BV.

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The Past, Present and Future

S-101 – The new IHO Electronic Navigational Chart Product Specification

S-101 is the new product specification for Electronic Navigational Chart (ENC) datasets based on the overarching S-100 framework standard of the International Hydrographic Organization (IHO). The development of S-101 is being coordinated under the IHO's Transfer Standard Maintenance and Applications Development Working Group (TSMAD). In the future, S-101 compliant ENCs will succeed and ultimately replace S-57 compliant ENCs as official chart data for ECDIS.

The development of S-101 reflects the experience of stakeholder feedback in regards to the current limitations of S-57 based ENCs. The ultimate goal is that an S-101 ENC will provide the base chart layer for S-100 integrated products and the underpinning of e-navigation. Its full potential will be realised as other types of products used within the maritime domain, such as aids to navigation, vessel traffic services, oceanography and meteorology, etc., adopt the concept and develop interoperable products and services modelled along the S-100 framework as well.

S-101 – How is it Different from S-57?

S-101 compliant ENCs are not a radical reengineering of the S-57 concept. S-101 retains most of the characteristics that are currently used in S-57 ENCs, but also improves those elements of S-57 that benefit from the flexible framework, which has been established under S-100 and aligned with the current ISO 19100 series of geospatial standards. While S-101 encompasses a variety of new elements, this article will only cover a select few.

Machine Readable Catalogues

The biggest advantage that S-101 has over the existing S-57 ENC product specification is the introduction of dynamic feature and portrayal catalogues. The term dynamic is used to indicate the possibility of adapting them when required. While similar in content to the current S-57 object catalogue and S-52 presentation library, S-101 implements the dynamic constructs prescribed by S-100. Under the current S-57 ENC regime updates of such elements may take up to five years to implement through the development and implementation of ECDIS software updates because the catalogues are embedded in the ECDIS software. In S-101, the relationship between features, attributes and enumerants are defined within a single feature catalogue. The elements of the portrayal catalogues link the feature catalogue elements to their graphical representation. Although, part of the standard, the feature and the portrayal catalogues are built through a registry responsible for defining dataset elements and are machine readable. Under S-100 the content of the registry is continuously adapted, but the S-101 feature and portrayal catalogues will be versioned, enabling the IHO to take advantage of the dynamic register content. In addition to the feature and portrayal catalogues, S-101 will also provide another catalogue containing the official IHO producer codes and – as a new element - a catalogue defining alerts and indications for use in the ECDIS. The advantage of moving to a fully machine readable catalogue system is that the ECDIS will be able to update new elements via a catalogue update which comes together with a regular data delivery. This 'plug and play' mechanism will be much simpler to implement by both manufacturers and end users than the current process which requires prolonged software updates.

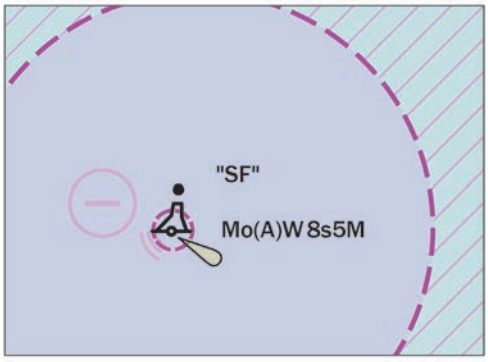
Complex Attributes

S-101 will also make use of a new S-100 feature to enhance the encoding, transfer and portrayal of data called a complex attribute. A complex attribute is an aggregation of other attributes, either simple or complex and is similar to the ISO 19000 attribute of attribute.

Complex attributes are a significant improvement to enhance S-101 applicability. It provides the ability to either replace multiple attributes or break down attributes into new sub-attributes.

For example, the existing S-57 attribute OBJNAM (name of the feature) is remodelled

▲ *Figure 1: Display of buoy name in S-57.*



▲ *Figure 2: Display of buoy name in S-101.*

into a complex attribute. This is done to better control the display of the feature name on the ECDIS. It now includes two sub-attributes called 'displayName' and 'name'. The sub-attribute 'displayName' is defined as a Boolean and when toggled in the data it indicates that this is the name to be displayed on the screen. By having the feature name as a complex attribute, it allows producers to store multiple names of the same feature. So instead of the ECDIS showing 'San Francisco Approach Lighted Whistle Buoy 'SF" (Figure 1) the ECDIS will only display the 'SF' (Figure 2) and the full name of the buoy will be discoverable via the pick report.

Update Feature

One of the biggest problems users have with S-57 data is ascertaining what changes have been made after an update has been applied to the data. In this case, the ECDIS does not have enough information to properly depict or highlight what are commonly important changes. The main problem is that in order to update a simple feature in S-57, it may affect underlying geometry that is also transmitted as part of the update. This results in unrelated information depicted in the highlight update routine that the ECDIS performs. In order to streamline this function and enable users to clearly see what changes have been applied to a dataset via a notice to mariners, including any features that have been deleted, S-101 has introduced the update feature carrying this meta information. The update feature will enable the ENC producer to clearly indicate what has been updated and if necessary the source of that update – such as a notice to mariners. For example, this will be particularly useful for detecting changes that may affect a route chosen during passage planning.

Text Placement

Another new feature that has been introduced in S-101 is the cartographic feature type. This new feature type, and its associated attributes, will enable S-100 based ECDIS to have better control over the way text is positioned on the display. Gaining individual control about the positioning of text will improve the overall look and feel of ENCs in ECDIS. For example, instead of description of

Introduction of dynamic feature and portrayal catalogues

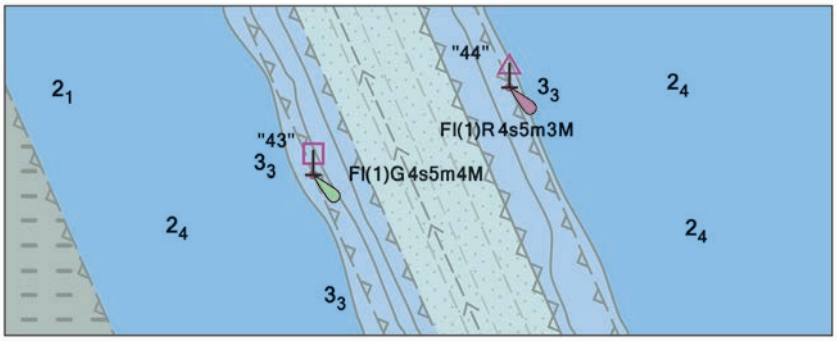
channel buoy lights appearing across a channel area (Figure 3), it will be possible to move them away from the channel area (Figure 4).

Production System Attributes

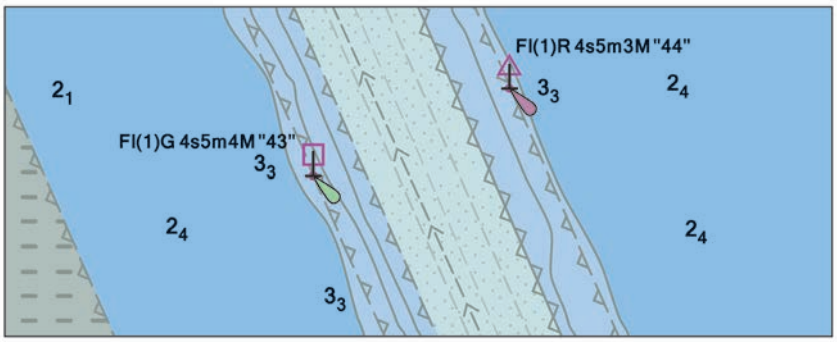
Currently, an S-57 based ECDIS has to spend considerable time during loading to identify the relationships between the geometries of certain features e.g. a wreck and its surrounding depth area. This is done in order for the System ENC (SENC)

Term	Definition
Attribute	Describes the characteristics of features. E.g. The attribute 'colour' would describe the colour of a light.
Enumerant	A descriptive list of values. E.g. The enumerant 'Red' or 'Green' would be options for the attribute 'colour'
Feature	The description of real world entities. E.g. The 'Eiffel Tower' may be classified as a feature type 'tower'.
Feature Catalogue	A catalogue containing definitions and descriptions of feature types, feature attributes occurring in one or more sets of geographic data
Portrayal Catalogue	A catalogue containing the symbols and rules used to portray the features defined in the feature catalogue.
Registry	An entire information system which is a collection of data dictionaries or registers. The register is a database that contains descriptions of many types of information, including definitions of features and attributes.

▲ Table 1 - Common terms used in S-101.



▲ Figure 3: ENC display without using the text placement feature.



▲ Figure 4: ENC display utilising the text placement feature.

▲ Figure 5: S-100 test strategy phases.

to pre-determine the appropriate display criteria so that the system can execute the S-52 Conditional Symbology Procedures (CSP) correctly. In order to reduce the need to call up these complex procedures that need to be calculated by the ECDIS at any change of the presentation, the ENC production systems will pre-calculate the values describing this relationship; store them as an attribute of the feature and export it as part of the S-101 dataset. This will increase the efficiency of creating the SENC, reduce the need for a significant number of CSPs and contribute to a faster and simpler loading process.

Better control over the way text is positioned on the display

S-101 Test Bed

Before the IHO Member States can approve S-101 as a functional standard, it must undergo a rigorous testing process that will require the implementation of test bed projects. It is important to understand that this test bed will need to be S-100 based, capable of testing other product specifications which can be either supplementary to S-101 ENCs or non-related GIS applications. The overarching test bed strategy is depicted in Figure 5 which shows the logical progression from catalogue creation to use within an ECDIS.

The testing process has been divided into nine phases that cover the entire end-to-end process.

Breaking out the testing through phases allows for the iterative development of future ECDIS as a system by gradually expanding requirements and the different types of test scenarios that are needed to validate S-101 as a functional standard.

The outcome of testing will also enable a more detailed impact study, as prescribed by IHO Resolution 2/2007 on principles and procedures for making changes to IHO technical standards and specifications, and will provide a clear picture of the effects on the various stakeholders involved in the eventual introduction of S-101.

Conclusion

Developing S-101 requires the support from both the IHO Member States, ENC production software companies and ECDIS manufacturers. Even though the test bed is in the early phases, the introduction of S-101 and S-100 based ECDIS systems will result in greater interoperability between different navigational products such as high-resolution bathymetry, surface currents and weather overlays. It will introduce greater flexibility in updating mechanisms and improve the display of electronic navigational charts for an improved user experience.

Acknowledgements

Thanks are due to Barrie Greenslade, Mathias Jonas and Gilles Bessero. ◀

Julia Powell

Julia Powell is the Electronic Navigational Chart technical director for NOAA's Office of Coast Survey and represents the United States on various standards committee's in the development of the ENC product specification. She is also the vice chair for the IHOs TSMAD working group and the work item leader for the development of S-101. Ms. Powell has been with NOAA since 1997 and has a Bachelor's degree in Geological Sciences from Cornell University and a Master's Degree in Computer Systems Management from the University of Maryland.

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Dual use Hydrographic Surveys for Seabed Nature and Morphological Research

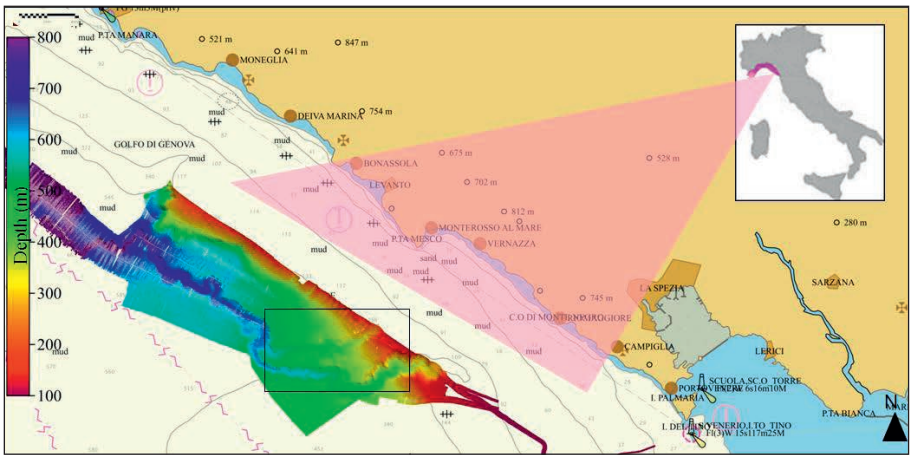
Integrated Mapping of Seabed Features

The Italian Navy surveyed the Levante Canyon system using survey vessel *Ammiraglio Magnaghi* and personnel from the Istituto Idrografico della Marina (IIM), in cooperation with ENEA Marine Environment Research Centre. This system is located in the offshore area of Cinque Terre, eastern Ligurian Sea, NW Mediterranean.

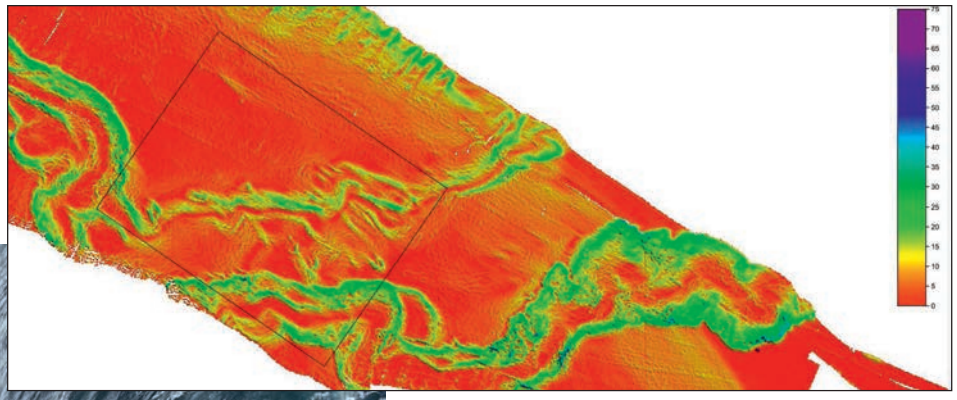
The purpose of the operation in the area depicted in Figure 1 was to collect the data necessary to update nautical documentation on the one hand and to carry out scientific research on the seabed nature and specifically on deep coral banks on the other hand.
Italian Navy ships are equipped with state of the art equipment and designed to be 'dual use' in terms of enhanced logistic autonomy, support and service flexibility. Furthermore, Italian Navy personnel are highly trained and the Navy's expertise can be made available for civilian purposes. The Italian Navy shares its resources with many Italian research institutes and universities, which carry out joint survey activities while performing their institutional tasks, with no additional costs.
Through data integration and the use of seabed-mapping technologies it is possible to obtain a high-resolution (HR) study of seabed morphology and nature, showing ecological features and habitats at different spatial scales. The methods used for this hydrographic research are based upon data integration and multiple focusing approaches to identify areas to be investigated with different resolution systems in order to perform data exploitation and multiple usages of available resources.
This particular approach and the scientific results obtained prove the power of 'dual use' purposes to make HR maps that can be used by different stakeholders with different aims but only one standard.

Mapping Data

The Levante Canyon was investigated in autumn 2013 using the high-resolution multibeam echo sounder (MBES) SeaBeam 1050 and side-scan sonar (SSS) Klein3000. The MBES (50kHz) survey was conducted in a 183 km^2 area covering the main part of the canyon system (from 150m to 800m depth). Through digital processing techniques, seabed morphology maps, based on shaded-relief bathymetries, were obtained. Echo-strength data (reflectance) can be extracted and presented as seabed 'backscatter' maps that display not only information on sediment types, but also seabed morphodynamics and habitat.
MBES data show that the Levante Canyon is a peculiar meandering submarine valley, extending SE-NW (coast direction), strongly structurally controlled, characterised by a main valley with channels and drainage structures that determine fine sediments deposition (low energy hydrodynamic processes). These geometries are typical of a valley with a complex origin, referring to different tectonics and hydrodynamics processes clearly shown by slope maps (Figure 2). In fact, from a combination of shaded-relief bathymetries, slope analysis and backscatter maps, the seabed can be interpreted in terms of both relict and recent processes (erosive-depositional).
Swath systems (such as SSS) are most likely to provide the best HR maps made of pictures, particularly over wide areas, such as the Levante Canyon (Figure 3). They provide information on sediment texture and bedform structure and allow for dynamic processes (e.g. sediment transport) to be deduced.
For broad-scale mapping of aggregate habitat (>1 km^2), SSS and MBES are considered to be the most cost-effective means of identifying different sediment types and dynamic processes. For small-scale habitat classification (<1km^2), high-resolution SSS, associated with ROV underwater cameras, allows for the ground-truthing of the surveyed area.



▲ *Figure 1: Map of the research area showing MBES data. Investigated seafloor depth from 150m to 800m (red min/ blue max). Black square: section studied in detail.*



▲ *Figure 2: Slope (%) map showing the particular meandering shape of the canyon system at different scales (valley, channels).*

▲ *Figure 3: SSS Klein 3000 system during the Levante Canyon survey operation.*

It is clear that the different levels of HR spatial analysis is only limited by the instruments and choice of approach made during the advancement of the survey. However, the system selection will depend on survey objectives and scale of the area to be mapped. For baseline broad-scale mapping of the continental shelf, where geological features, such as sand valley, channels, gullies, sediment waves and reefs are of interest, the quantitative data offered by MBES in conjunction with object detection in the order of tens of metres (at 200m depth) is often the preferred choice. However, for inshore areas and depths <50m, where identification of small (<10m) habitat features may be required, a combination of MBES and SSS ensures that both quantitative bathymetric data (0.3m - 1m resolution) and qualitative, high-resolution habitat relief data (10cm resolution) are obtained.

In conclusion, Morphodynamics can be shown to integrate morphology (bathymetry) and SSS backscatter maps. Slope is the most variable element and through its analysis, at a regional scale, it is possible to display high/medium sedimentation rate in low gradient sectors (bottom channel). Moreover, on a local scale, it shows hard bottom covered by fine deposits with benthonic features/deep corals.

Multiple Focusing

A multiple scale methodology approach was chosen in accordance with instruments and software available on board the Italian Navy ship. MBES data acquired were processed by CARIS HIPS&SIPS software and compared with the IIM database. At first, a seabed map of the area with high detail of the seafloor shapes was obtained, and used for other similar sectors of the canyon catchment area. The canyon is characterised by a gully network with a diverging pattern.

On a metric scale (medium scale), acoustic backscatter analysis enables the accurate description of the drainage canyon system (with variable slope up to 30% in the channel sectors) and its geomorphic variability in relation with seabed nature. HR maps enable the identification of sites of interest for substrate dislocation and benthic features. These were investigated at a larger scale (sub-metric) by SSS Klein 3000, 100-500kHz (Figure 3). SSS operation was planned in accordance with seafloor canyon morphology and optimising recording data operations on board. In fact, SSS lines were recorded in a selected area from 510 to 370m depth (Figure 4), where the seafloor morphology showed variable and interesting features characterised by different size, shape and slope.

Operating with MBES and SSS integrated data, morpho-bathymetric analysis and acoustic characterisation of the sub-bottom made it possible to calibrate a large area by ground-truthing. Figure 5 shows the section, chosen for its morphology, and used for higher resolution analysis with SSS. The presence of round structures (mound) of multi-metric dimensions inside the drainage system must be remarked. The highest values of slope (17%) can be found in the steep canyon heads and flanks. Slope values up to 10% can be seen depicting seabed mounds on the northernmost and central interchannel system. MBES and SSS data show higher acoustic backscatter in the deepest sections of the canyon than in the channels and the changes in the seabed nature on the mounds are highlighted as areas of variable intensity characterised by high level of reflectance typical of substrate. Besides that, SSS images show a flat heterogeneous seabed with signs of trawler fishing (Figure 5).

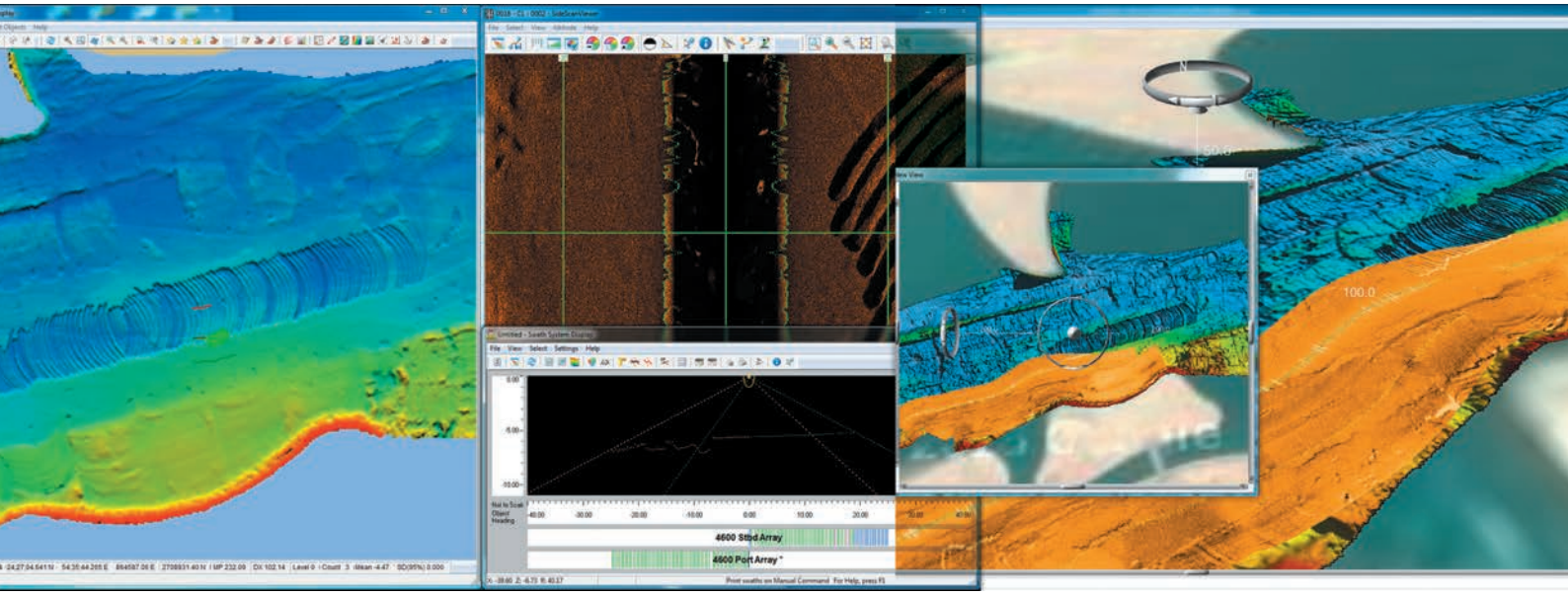
The Italian Navy shares its resources with many Italian research institutes and universities

In conclusion, the direct sampling bottom data collected on the mounds displayed the presence of biological communities, mainly typical of a deep muddy bottom and small cold water coral colonies, possibly identified as 'Madrepora oculata'. The hard bottom, probably made of buried coral banks, is also present.

Concluding Remarks

The sharing of knowledge and instruments is the basis of this integrated work focused on the study of seafloor features with particular

GEOSPATIAL TOOLBOX



Our geospatial toolbox is a powerful enabler for acquiring, processing and sharing maritime geospatial data. We are working with those engaged globally in maritime projects to have seamless systems that meet needs for integrated tools to improve effectiveness in data management and production. The modern maritime geomatic business process starts with data collection and input, through validation and visualisation, to producing and sharing data deliverables. Fundamental to this workflow is the use of common data files and the avoidance of intermediate exchange data files.

Acquisition – use QPS QINSy to collect once and use many times

Modern maritime mapping projects often simultaneously collect data from multiple survey sensors, and then the data from one survey sensor is used a number of times.

Validation – use QPS Fledermaus for true space and time 4d environment

The industry leading interactive true 4D geospatial processing and analysis tool that is used by commercial, academic and government organizations to interact with massive geospatial datasets of numerous data types for ocean mapping and land-based projects.

Sharing – the power of geospatial information systems

GIS is being applied to a wide range of maritime activities, including maritime information systems, nautical and electronic chart systems, vessel monitoring and tracking, port management, port security, facility management, environmental monitoring and management, and coastal zone management.

Seamless workflow - Acquisition - Validation - Sharing

QINSy acquisition data files become Fledermaus processing data files, and Fledermaus exchanges survey results directly with the GIS system.

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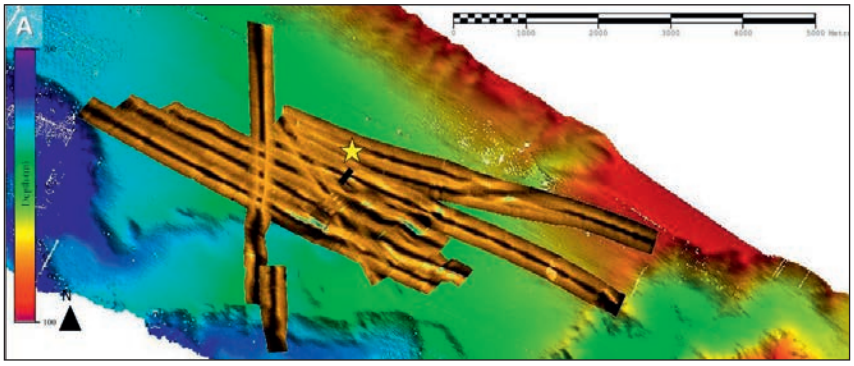

Figure 4: A: SSS images overlapping MBES data.

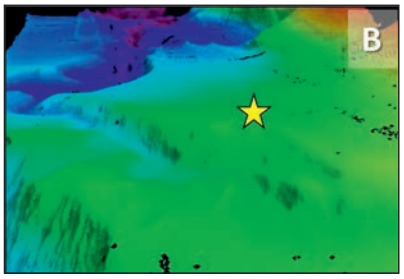

Figure 4: B: 3D MBES, from the westernmost upper channel down to the deepest part of the Levante Canyon, and the star indicates the site of C image;

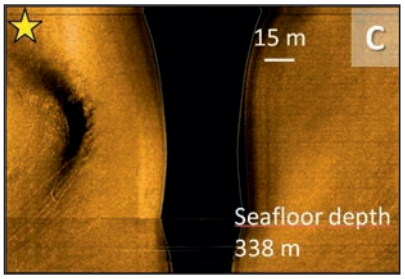

Figure 4: C: SSS acoustic image of the interest seabed referring to a mound structure showing hard and mixed nature bottom (sandy/muddy sediments and small coral colonies) with clear signs of trawler fishing.

reference to morphology of the proximal area of the Levante Canyon system.

Maps revealing the geophysical characteristics of the seabed represent an essential tool for the effective management of the marine environment because they allow for the wide-scale geology and present-day (Holocene) sedimentary processes to be determined and understood. Furthermore, the integration of different maps, resulting from the use of different equipment and data processing methods, enabled the research to focus on the best possible area.

Operating with SeaBeam 1050 and Klein 3000, seabed morphological characterisation, sediment type discrimination and processes dynamic description, on a wide scale (>1km^2) were carried out. Besides that, small-scale habitat classification (<1km^2 up to a centimetre) was achieved thanks to SSS images analysis integrated with direct sampling methods such as grab sampler or underwater camera.

During the real-time survey processing, the establishment of a confidence level to each feature of interest, at the different scales, justified the multiple focusing and HR investigation of the seabed variability and nature using different instruments.

Finally, it is highly recommended that appropriate biological ground-truthing is undertaken where remote-sensing technologies are to be used for habitat-mapping purposes. In fact, the ground truth confirmed the area's ecological interest.

Thanks to Italian Navy resources, the survey provided not only a detailed mapping of the variable morphology of the proximal area of the Levante Canyon at different scales, but it also investigated the seabed nature and the biological communities in the canyon system for the assessment of a potential Site of Community Importance under the European Commission Habitats Directive (92/43/EEC).

Further Reading

Delbono, I., Ivaldi, R., Pratellesi, M., Fanelli, E., Peirano, A., Cocito, S., Dialti, L., Delfanti, R., 2014. Seafloor morphology: nature of the seabed and the cold water corals of the Levante Canyon (eastern Ligurian Sea, NW Mediterranean). *Geophysical Research Abstracts* 16, EGU2014-14732.

Kenny, A. J., Cato, I., Desprez, M. Fader, G., Schuttenhelm, R.T.E., Side J., 2003. An overview of seabed-mapping technologies in the context of marine habitat classification. *ICES Journal of Marine Science* 60, 411–418.

Kostylev, V.E., 2012. Benthic habitat mapping from seabed acoustic surveys: do implicit assumptions hold? In: *Sediments, Morphology and Sedimentary Processes on Continental Shelves*, Li, M.Z., Sherwood, C.R., Hill, P.R. (eds.); Wiley Blackwell, IAS Spec. Pub., 44, pp 405-416.

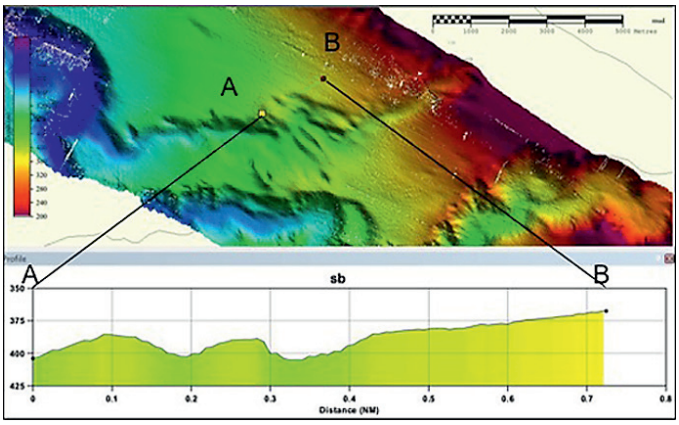

Figure 5: Detail of MBES study area and AB is cross profile of a canyon flank and a mound.

Marta Pratellesi

Marta Pratellesi is an Italian Navy Lieutenant and chief Hydrographer of the oceanographic department on board survey vessel *Ammiraglio Magnaghi*. She attended the Naval Academy from 2003 to 2008 and gained a Bachelor degree in Maritime and Naval Science. She took part in several military operations as telecommunication officer. In 2011, she obtained an MSc degree in Marine Geomatics (University of Genoa and Istituto Idrografico della Marina). In 2014, she obtained FIG/IHO/ICA Category A Level Hydrographic Surveyor certification.

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Roberta Ivaldi earned a PhD in Environmental Science, Sea Science, (Trieste University, 1997) and an MSc degree in Geological Science (Genoa University, 1993). She has been Associate Professor in Marine Geology at the Istituto Idrografico della Marina since 2008. Her research focuses on high-resolution seismic stratigraphy, seabed mapping, physical mechanical properties and microstructures of sediments.

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Missed Opportunities and Triumph

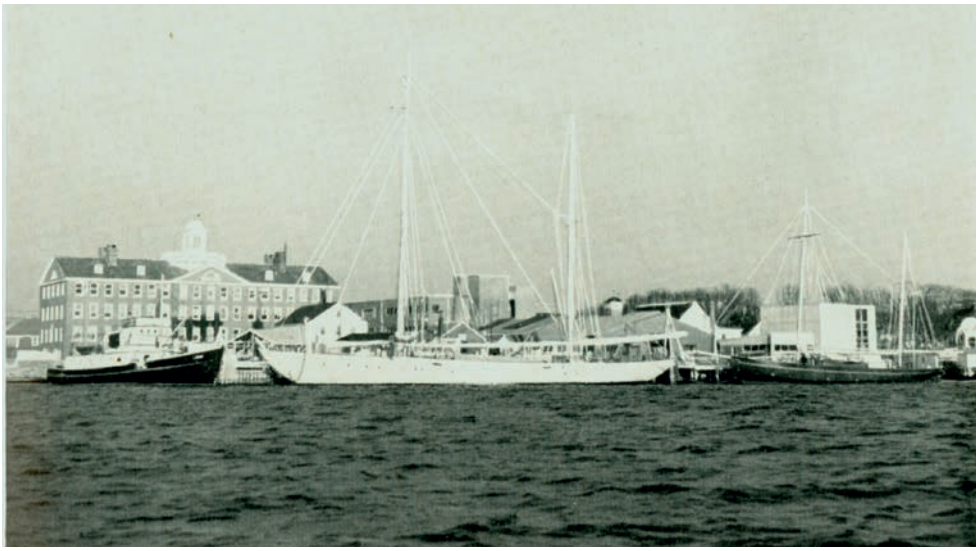
Unravelling **the Ridge and Rift**

Following Maurice Ewing's first cruise to the Mid-Atlantic Ridge, two more were made by the end of the 1940s. The first of these was led by Ewing while the second was led by Bruce Heezen. Although Gunter Dietrich's paper was referred to in the 1949 paper by Ivan Tolstoy and Ewing (see part I in last issue), neither seems to have comprehended its significance as he reported in the November 1949 *National Geographic* magazine: "Crossing the ridge, we drew a detailed profile of its peaks with our fathometer. Flanking the central highlands, we found deep trenches separating the main Ridge from the lower terraces on either side.

These trenches drop down to depths of more than two miles, while the central peaks of the main Ridge are approximately one mile under water. We found similar trenches when we again crossed the Ridge farther south, but do not yet know whether they run its entire length. These trenches may mark the locations of the great faults that undoubtedly extend somewhere through or near the Mid-Atlantic Ridge and which are the sources of many submarine earthquakes that centre there."

This statement does not refer to a central 'trench' but Ewing was definitely on the trail at that time. Part of the problem of these early descriptions of findings is evolving terminology. Ewing's first pronouncement in the 1948 National Geographic article refers to a 'rift' for an east-west feature, then trenches for north-south features on the ridge. Dietrich referred to 'striking depressions' for features that he interpreted as being in the centre of the ridge and today referred to as the rift valley.

Ivan Tolstoy, as sole author, produced the next significant paper regarding the MAR in 1951. It was an expansion of the first paper that he and Ewing had produced in 1949 for the Geological Society of America. Tolstoy could have been famous in the annals of MAR exploration and interpretation based on the map he produced with this paper and its accompanying profiles. However, Tolstoy was fixated on the east-west trough and the parallel trenches and ridges in the vicinity of what is now known as the Atlantis Fracture Zone. Unwittingly, he showed the MAR median valley heading north to east of the Atlantis Massif and heading south at the western end of the active fault zone. His map compares well to modern multibeam maps of the Atlantis Fracture Zone and associated features. However, he did not recognise the median valley on the map or the significance of what he had mapped. He had one more chance at making what in retrospect would have been the discovery and announcement of a median rift valley. He produced an east-west profile of the Atlantic seafloor at latitude 31N. It was his misfortune to produce this profile with a vertical exaggeration of 3.3 to 1. By comparison, Dietrich's profiles were drawn at 100 to 1, and later profiles by Bruce Heezen and Marie Tharp at 40 to 1. Because of the low vertical exaggeration, features appeared subdued and Tolstoy missed the near perfect symmetry of the central highlands and the accompanying deep valley. He even pointed out the deepest portion of the median valley by placing a 2020 depth value over the deepest portion of the central valley (Figure 2). As Tolstoy had major spinal surgery in late 1947, it is unclear if or when he ever went to sea again as chief surveyor/bathymetrist for Lamont. Bruce Heezen seems to have begun his tenure as senior surveyor and bathymetrist for Maurice Ewing in late 1948 and led the Atlantis cruises to the MAR over the next four years and then cruises of the R/V *Vema* after the acquisition of that vessel by Lamont in late 1952. Although their exploration of the Atlantic basin was continuing, Heezen and Ewing concentrated on the concept of turbidity currents and the role of submarine canyons as conduits for these phenomena during this period and Heezen's reputation as a marine geologist was secured.

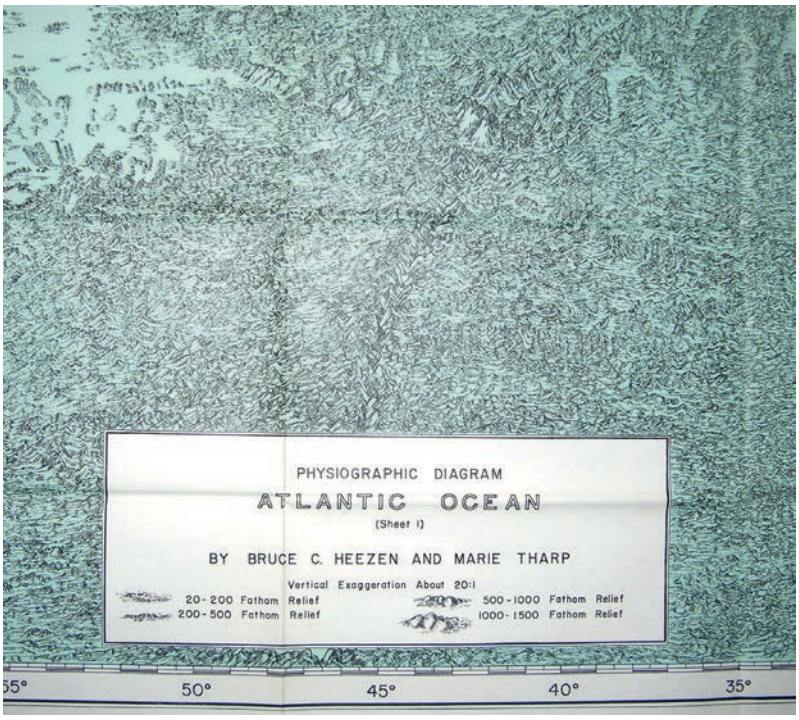


▲ *Figure 1: Survey vessels moored at the Woods Hole Oceanographic Institute, from left to right* Bear, Atlantis *and* Caryn.

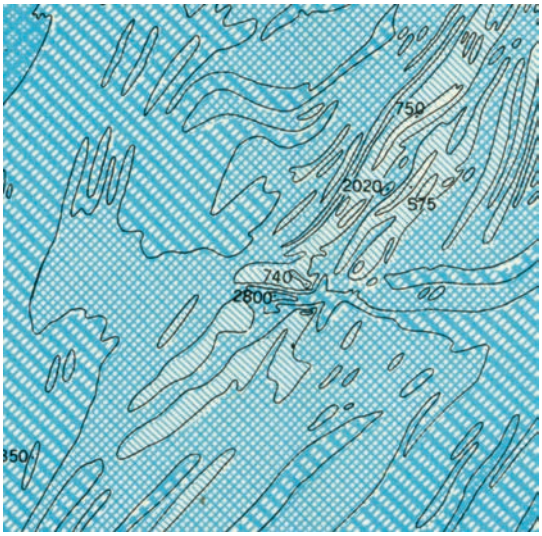
The MAR was not totally forgotten, however, as five papers were written over the next decade that helped change our view of our planet. The first of these was a short 1953 paper by

Heezen, Ewing and Miller that contained both a bathymetric profile and magnetic profile of Heezen's 1948 15N trackline from Dakar to Barbados. This paper had little impact but is notable for containing the first magnetic anomaly profile of the basin of the Atlantic. If the two sides of this profile relative to the ridge axis had been mirrored, the magnetic symmetry from one side of an oceanic ridge to another would have been seen. (It was another 15 years before symmetry was noted as a result of other surveys, a major proof of plate tectonics.) Also in 1953, the British began investigating the MAR under Maurice Hill. The following year, Hill noted the existence of a 'deep central trench' in the MAR extending over 70 nautical miles from 47 45 N to 46 34 N. Then in 1956, Ewing and Heezen, published *Some Problems of Antarctic Submarine Geology.* This paper was in anticipation of the upcoming International Geophysical Year and declared the existence of a worldwide rift in the seafloor that followed the oceanic ridges. This paper gave credit to the British scientists R. B. Seymour Sewell and G. D. Wiseman of the 1937 John Murray *Mabahiss* Expedition to the Carlsberg Ridge of the Indian Ocean, to Maurice Hill for his 1953 work in the North Atlantic, and to Theodor Stocks of the 1925-1927 *Meteor* expedition for producing profiles showing that the MAR and Carlsberg Ridge are characterised by "a median rift zone which follows the crest of the ridge very accurately." Sewell and Wiseman were also the first to point out the similarity between the oceanic ridges and the East African Rift Valley as similar features. Ewing and Heezen also gave credit to Beno Gutenberg and Charles Richter for their "magnificent studies on seismicity" that "can be used to supplement the bathymetric data in a powerful manner."

1957 was an interesting year. Gunter Dietrich published a German-language textbook on oceanography in which he included his 16 50 N profile of the 'striking depression' that showed so prominently in his 1939 publication. No one noticed. On 31 January, Maurice Ewing announced the existence of the worldwide rift in the New York Times: "One day, Marie Tharp, a cartographer at the Observatory, was working on charts of the Atlantic Ocean bottom. She noticed that the deepest rifts in the mid-Atlantic formed the locus of an oceanic earthquake belt. When Miss Tharp noticed the mid-Atlantic-rift-seismic zone, she pointed out her discovery to Dr. Bruce Heezen, a research associate at the Lamont Observatory. Drs. Heezen and Ewing and their associates examined other undersea topographical profile charts and unpublished data in the Lamont files." This was the first of a number of evolving stories as to how Marie Tharp discovered the rift valley.



▲ *Figure 3: Physiographic map by Bruce Heezen and Marie Tharp.*



▲ *Figure 2: Tolstoy's map showing the 2020 depth value.*

This same year Heezen was co-author with an undersea cable engineer of *Oceanographic Information for Engineering Submarine Cable Systems*, a paper published in the Bell System Technical Journal, in which he described the rift valley and its association with seismic activity. He produced a small black and white graphic of the rift valley in the North Atlantic Ocean extending from 60N to 30N. Although this area contains the Charlie Gibbs Fracture Zone at 52N, this large feature is shown as an east-west bend in the axis of the MAR. Fracture zones confounded Heezen, and as will be shown, he and Marie Tharp basically ignored their existence in a large beautiful 'physiographic diagram' that was folded into a pocket in the back cover of the 1957 Bell Telephone Technical Journal (Figure 3). This diagram was the first of the celebrated Heezen-Tharp physiographic diagrams although there was no accompanying explanation. It was actually a 3D map of the North Atlantic Ocean between 50 N and 17 N. The most prominent feature was the MAR and associated rift valley that bisected the map.

The explanation of this map was published by the Geological Society of America in 1959 as Special Paper 65, *The Floors of the Oceans*. This paper was the first to attempt to describe the bathymetry of an oceanic basin. As in the Bell Telephone Technical Journal paper, no credit was given to Marie Tharp as discoverer of the rift valley. The same year Maurice Hill published a paper with nine profiles that unambiguously showed a continuous median valley.

In not one paper published in a scientific journal with Heezen, Tharp, or Ewing as

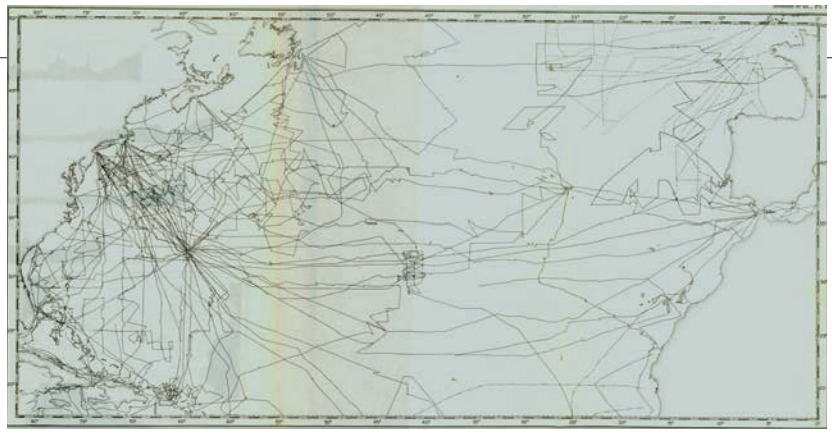
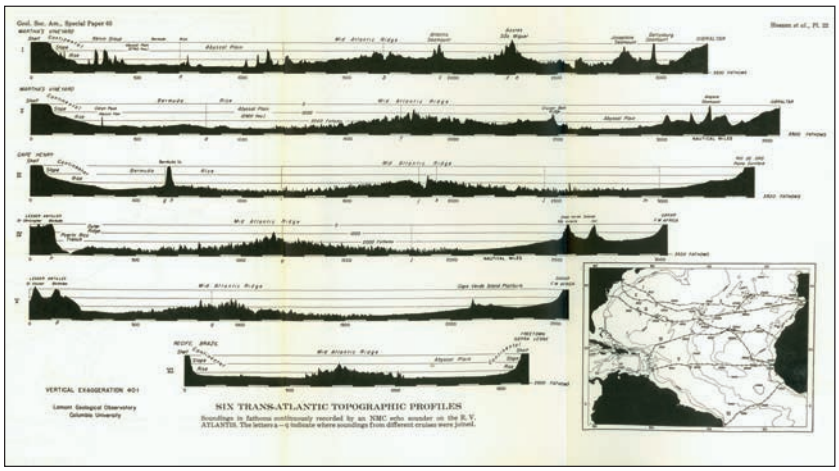


Figure 4: Control chart indicates Lamont Geological Observatory and Woods Hole survey cruises (by the lines). Dashed lines are soundings by British Admirality, lines of a long dash and two short dashes depict soundings by Meteor.

Figure 5: Six trans-Atlantic topographic profiles.



authors through 1959 was there a claim that Marie Tharp and Bruce Heezen were the first to discover the median rift valley of the MAR or that they were the first to note the same. However, in a 1960 Scientific American paper on the Great Global Rift, Heezen gave the second version of the claim that Marie Tharp had discovered the rift valley in 1953 while she "and I were making a detailed physiographic diagram of the floor of the Atlantic, based upon a large number of echo sounding profiles. As the preliminary sketch emerged, Miss Tharp was startled to see that she had drawn a deep canyon down the centre of the Mid-Atlantic Ridge."

A third version of this story was told by Heezen in a biography of Maurice Ewing in 1974: "Marie's job for me was to decide what a structure was – whether a rise in the echo soundings represented a hill or something longer like a ridge – and to map it. In three of the transatlantic profiles she noticed an unmistakable notch in the Mid-Atlantic Ridge, and she decided they were a continuous rift valley and told me. I discounted it as girl talk and didn't believe it for a year…." Heezen implies but doesn't state that this was 1952. This version with slight variations has become the standard version of discovery of the rift valley by Marie Tharp with late 1952 as the date of discovery.

As a footnote to the 1974 story, the following year Bruce Heezen stated in an interview: "Marie did not point out to me the close coincidence between the [earthquake] epicenters and the location of the rift. I had pointed it out to her… from then on she used the data of the epicenters very closely for the rift valley correlation." All of the principals in the discovery of the true nature of the Mid-Atlantic Ridge have now passed on and there is no way to determine the absolute truth of any or all of these stories. However, in a last and final look at the mapping of the MAR, the maps and graphics produced by Heezen and Tharp as well as some of the published material they used will be looked at in the next issue of *Hydro International*. A version of the true story can be found in their maps and graphics as well as the surprising role of Gunter Dietrich in influencing this story of discovery.

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By MacArtney

No. 3549

Monaco, 6-10 October 2014

5th Extraordinary International Hydrographic Conference

A Conference of the International Hydrographic Organization, which is more commonly known as an Assembly in other inter-governmental organisations, meets to review progress and to take decisions on strategic, technical and administrative matters. Under its current Convention, the IHO meets in ordinary Conference every five years and last met in April 2012. In the intervening years, an Extraordinary Conference can be called.

18th International Hydrographic Conference (2012).

The 5th Extraordinary International Hydrographic Conference will take place in Monaco from 6 to 10 October 2014. As Head of State of the host country of the IHO and a constant and generous supporter of the Organization, HSH Prince Albert II of Monaco will open the Conference.

The majority of the 82 Member States of the IHO will be represented at the Conference, normally by a delegation led by the national hydrographer, together with the various accredited international observer organisations representing the wide range of the IHO's stakeholder community. All sessions of the Conference will be supported by continuous interpretation in the two official languages of the IHO - English and French, as well as in Spanish and Russian.

The Extraordinary Conference will consider various proposals submitted by individual Member States, as well as reports and recommendations related to the technical capacity of the IHO Secretariat, the working conditions of the IHO Secretariat staff, and a revised IHO Capacity Building Strategy. Topics and proposals for discussion will include progress reports relating to the IHO work programmes, with a focus on the status and availability of hydrographic surveys and nautical charting worldwide, in particular electronic charting, and the implementation of IHO S-100 - the Universal Hydrographic Data Model and its associated product specifications.

Four special information sessions are included in the conference format. The purpose of the information sessions is to provide IHO stakeholders, user representatives and subject matter experts with an opportunity to brief the IHO Member States' representatives on various topics of relevance and to provide their views and perspectives on current issues.
The information sessions will cover four themes:

- The place of hydrographic data in a geospatial world - covering spatial data infrastructures and the enabling technologies;
- E-navigation - its impact on the IHO and its Member States;
- A technology update - including users' views on ECDIS and ENCs, satellite derived bathymetry and crowdsourced bathymetry;
- Capacity Building - the view and contribution from industry and from recipients.

A hydrographic industry exhibition will be held in conjunction with the Conference. Over 30 companies and organisations from around the world will present their capabilities.

A first time event at the Conference will be an extensive poster display of IHO capacity building activities, supported by alumni from the IHO capacity building programme. Successful graduates from the IHO-Nippon Foundation CAT-B Cartographic Training (CHART) programme for nautical cartographers at the UKHO, graduates from the Masters Programme in hydrographic science at the University of Southern Mississippi sponsored by the Republic of Korea through the IHO, and alumni from the IHO-IOC GEBCO Project-Nippon Foundation ocean mapping programme at the University of New Hampshire will be present to display their progress and achievements since graduating.

Two surveying ships from the Russian Federation and the United Kingdom respectively are expected to be alongside Port Hercule in Monaco during the time of the Conference.

The Conference is not open to the general public.

More information
www.iho.int > International Hydrographic Conference

Computer Aided Development Corporation Ltd (Cadcorp)

Sharing **Spatial Data**

Cadcorp is a British software development company focused on geographic information systems (GIS) and web mapping software. From its headquarters in Stevenage, UK, Cadcorp is growing both its direct and indirect sales into the hydrographic market – particularly with port and harbour authorities.

Cadcorp was originally founded in 1989 to develop a CAD product. Cadcorp sold the product outright in 1994, and started the development of a family of Microsoft Windows-based GIS products. The first release of the Cadcorp Spatial Information System (Cadcorp SIS) was in 1995.

Mike O'Neil, CEO and founder of Cadcorp, recalls the early years. "We were able to take our expertise in building CAD products and apply this to GIS. The underlying technologies are undoubtedly different, but we were able to transfer the attention to detail and the powerful geometric functionality that is mandatory for a CAD product into a family of GIS products."

Current Profile

The Cadcorp website describes the company's mission as being 'to help organisations in the public and private sectors maximise their return on investment in geographic information by making it easier to share and distribute spatial data between people and between systems.' To this end, the company has a track record of promotion, implementation and support for open standards in the GIS industry.

We expect our marine and coastal environments to serve us in many ways

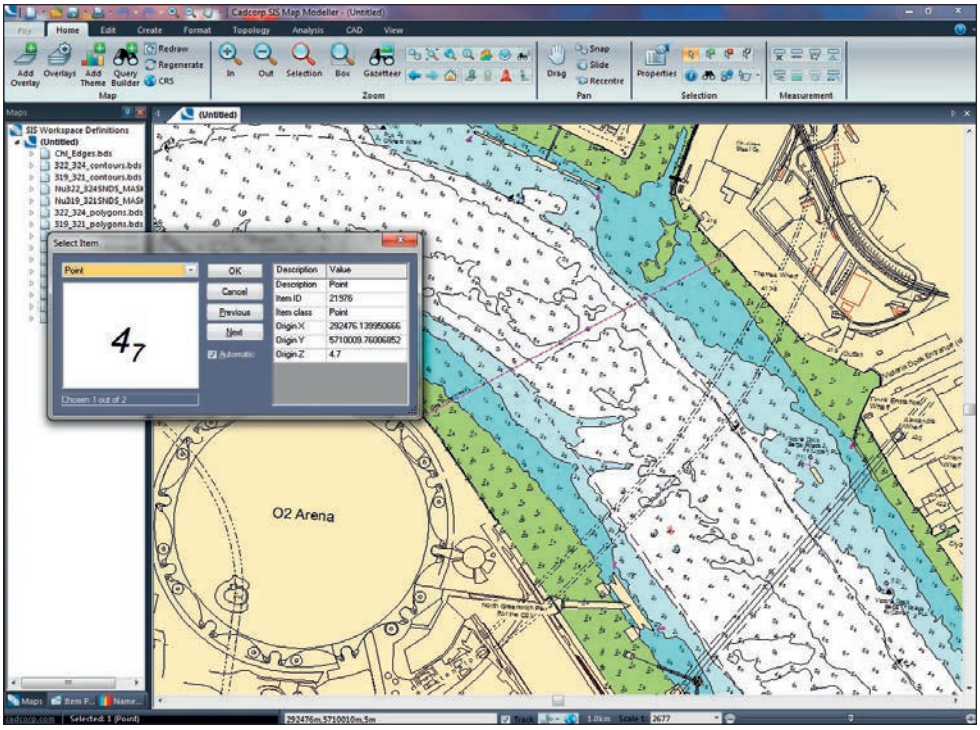
International and Global Scope, Current Situation

Cadcorp targets five markets with its GIS and web mapping products. These are: government, emergency services, land and property, finance, and energy and infrastructure. In the UK, Cadcorp sells via its own direct sales team and through partners. Outside of the UK, sales are handled through Cadcorp's international partner network.

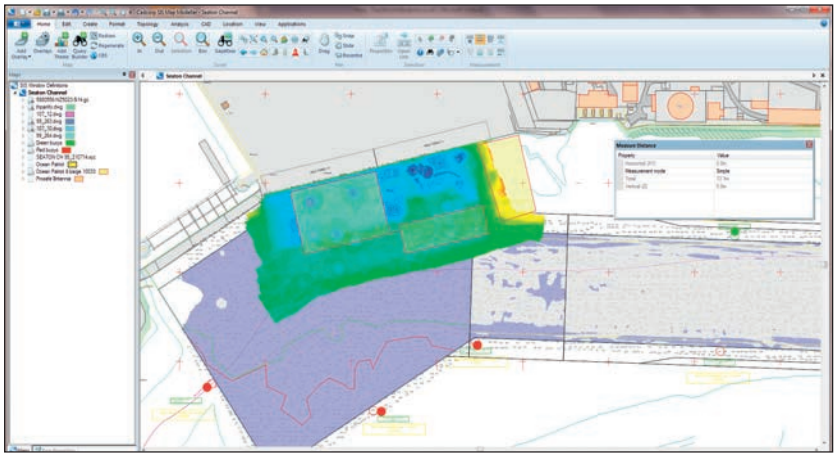
In the UK, Cadcorp customers include local authorities, fire brigades, police services and many commercial organisations. In The Netherlands, over 180 municipalities rely on Cadcorp software for property registration. Through its Tokyo-based partner Informatix Inc., Cadcorp is a now major player in the Japanese market.

Cadcorp's hydro business falls within 'Energy and Infrastructure' which is also home to utilities, engineering, transport, logistics and renewables. "What these diverse industries have in common", notes Mike O'Neil, "is a focus on the design, planning and management of infrastructure. They all need to use CAD and GIS software interchangeably. We try to make sure that our GIS and web mapping software can exchange data easily with CAD systems."

Within the hydrographic sector, Cadcorp is particularly strong in port and harbour management. The Port of London Authority (PLA) acquired its first desktop Cadcorp system in 1995, as a digital mapping product to produce paper-based maps and charts. Cadcorp software is still being used to help PLA meet its legal requirement to keep its maps and charts up to date and to share current information with its customers, but today this is achieved through a combination of desktop and web mapping products.



▲ *Main survey colour chart.*



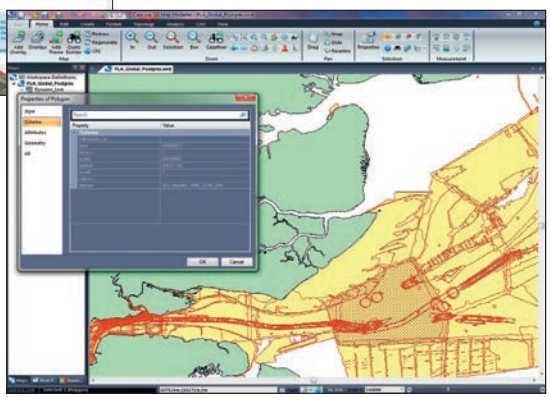
◀ *Cadcorp SIS Map Modeller being used to assess the space and depth of water available for berthing rigs and barges at a facility on the Tees estuary.*

View on the Future

Cadcorp remains a specialist developer of GIS and web mapping software, and has no plans to deviate from its mission to facilitate greater sharing of spatial data. Mike O'Neil notes "We expect our marine and coastal environments to serve us in many ways: as sources of energy, minerals and food; as transportation networks; and as tourist destinations. Even without climate change, the need for cooperation is clear. That's why we see a continued demand for information systems such as Cadcorp SIS: systems which can promote the sharing of data, information and knowledge."

Cadcorp continues to develop and enhance its GIS and web mapping products, and earlier this summer unveiled its latest release – Cadcorp SIS 8.0. The new release includes a new free-to-use desktop GIS product - Map Express, multiple performance improvements and both new and enhanced core functionality.◀

▲ *Oil spill visualisation.*



Cadcorp-CARIS interface. ▶

The Caribbean Netherlands Science Institute at St Eustatius

Research on Varied Caribbean Geophysical Aspects

The Caribbean Netherlands Science Institute at St Eustatius (CNSI) is a research facility that supports basic, strategic, applied, societal and policy relevant research and education in all fields of science. This initiative has been made possible by the Netherlands Ministry of Education, Culture and Science (OCW), the island government of St Eustatius, the Netherlands Organisation for Scientific Research (NWO) and the NIOZ Royal Netherlands Institute for Sea research in close cooperation with the European and Caribbean Netherlands knowledge communities and stakeholders. CNSI welcomes and supports relevant activities of users (public and private) from around the globe. CNSI officially opened on 24 April 2014.

Objective and Mission

CNSI aims to facilitate scientific curiosity in which issues and questions relevant to the sustainability of tropical small island economies are addressed. It fosters the ambition to develop into an authoritative expert and facility centre acknowledged in the wider Caribbean region, positioned at the intersection of scientific research, education, management and governance.

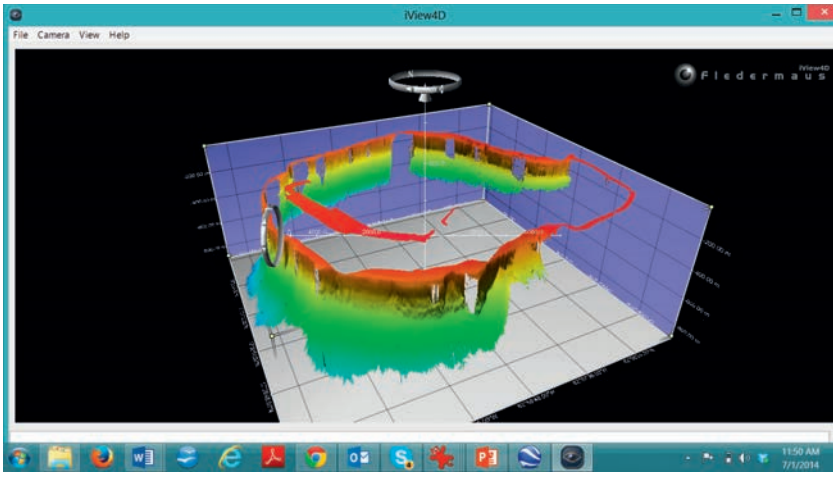
Its mission is to realise a permanent scientific presence in the Caribbean Netherlands (the islands of Bonaire, Saba and St Eustatius) with research facilities, outreach facilities and accommodation for visitors. This mission is based on the vision that the Caribbean and the Netherlands share a mutual responsibility for the sustainable development of the Caribbean Netherlands islands and their marine territories. Working toward this goal requires an understanding of each other's institutional organisations, historical and cultural backgrounds, management and development priorities and natural and societal resources. CNSI is therefore committed to multidisciplinary knowledge development and human and institutional capacity building by fostering (academic and vocational) education and training, and organising courses, workshops and meetings in cooperation with local organisations and international stakeholders. It is clear that the sustainability of these small island economies cannot be regarded in isolation and should be addressed within the context of the greater Caribbean region so as to encourage a sustainable socioeconomic impulse in the region.

▲ *CNSI building.*

Marine and Maritime Issues

The marine environment makes up the largest part of the Caribbean. It is potentially an important asset to the Caribbean communities, e.g. for fisheries, trafficking, deep sea mining, etc. Further exploration of the marine environment may reveal its use potential. There are a couple of research projects underway that will be supported by CNSI so as to disclose some of the unknowns of the Dutch Caribbean marine environment:

- Stability of Caribbean coastal Ecosystems uNder future Extreme Sea level changes (SCENES) (Utrecht University). For many Caribbean islands, the shallow bays and lagoons consist of calcic sediments that are maintained primarily by calcifying algae. To determine the effects of climate change on the coastal ecosystems in the Caribbean, a comprehensive multidisciplinary project has been formulated involving analysis of regional ocean observations and global high-resolution ocean modelling, high-resolution biogeomorphological modelling and field work on sediment dynamics, wave climate, temperature and pH dynamics. CNSI is the host of experiments on how



▲ *St Eustatius multibeam survey by RV* Pelagia.

key species respond to multiple interacting stresses in a multispecies situation and at a diversity of temporal scales.

- Caribbean coral reef ecosystems: interactions of anthropogenic ocean acidification and eutrophication with bioerosion by coral excavating sponges (Royal NIOZ).
- 4D crust-mantle modelling of the eastern Caribbean region: toward coupling deep driving processes to surface evolution (Utrecht University).
- Caribbean cruisers in the Kingdom: ecology and protection of sea turtles (Groningen University).
- Biodiversity Base-line Study (Naturalis Biodiversity Centre, Leiden).

Another plan is to study the potential of beach restoration and coral regrowth making use of an artificial reef structure at St Eustatius. Funding for information about Statia's coastal bathymetry, its morfodynamics and a coastal dynamics model is required. This information could also be used for managing St Eustatius' harbour, underwater archaeology, and the dive sector. 'Blue Economy' is also a development for which CNSI would like to team up with relevant partners.

CNSI has been made possible by NIOZ and has a Steering Group consisting of its main stakeholders: NIOZ, the Faculty of Archaeology of Leiden University, IMARES Wageningen UR, Naturalis Biodiversty Centre, the Royal Netherlands Institute of Southeast Asian and Caribbean Studies (KITLV), NWO and OCW. This was reflected during the opening, as Island Governor Gerald Berkel of St Eustatius opened CNSI on 24 April 2014 together with Jos Rokx of OCW and Edwin van Huis, director of Naturalis. Edwin van Huis then opened the biodiversity photo exposition entitled 'The natural beauty of Sint Eustatius' at CNSI.◀

More information
1. www.cnsi.nl
2. http://bit.ly/NL-CNSI

Australasian Hydrographic Society

New Zealand Region

On 23 June 2014, the NZ Region of the Australasian Hydrographic Society celebrated World Hydrographic Day with a symposium and its annual AGM. The event was generously hosted by Trimble in its newly completed facility in Christchurch. The seminar commenced with a tour of Littleton Port and the Christchurch Earthquake areas. The day included presentations from industry practitioners, the government and the education sector. The topics covered included developments in survey capability, practical utilisation of existing and emerging technology, military survey and Rapid Environmental Assessment, the National Charting programme and more. Perhaps of greatest interest were the targeted presentations provided this year by the students representing the academic sector. Almost all of these presentations reinforced the 2014 World Hydrographic Day theme of 'Hydrography – more than just charts'. Copies of the presentations are available on the NZR Website. It was particularly pleasing to observe the continued growth within the academic sector in NZ of hydrographic and related course offerings, and the increased collaboration between the academic institutions. The NZR has assisted this growth through engagement and direct support to the universities. This has been evidenced most recently by the provision of sponsorship for student attendance at the NZR Seminar. The intent of this initiative was to expose the current NZ hydrographic practitioners with the future workforce and the hydrographic leaders of tomorrow. The sponsorship provided by the AHS, NZR, Trimble and DML meant that over a dozen students were able to attend.

The NZR annual seminar was both enjoyable and a professionally rewarding event. The day seminar was closed in fine fashion with the announcement of an AHS Career Achievement Award in Hydrography to Mr John Mitchell of NIWA.

▲ *The collective audience of NZR members, students and other guests listening to one of the day's presentations*

▲ *Students from Otago and Waikato University pose for a photo at the NZR Seminar in Christchurch.*

Hydrographic Society Benelux

HSB Workshop - AUVs and Other Matters

On 29 August, the HSB organised an afternoon workshop in Delfshaven, Rotterdam. The workshop was planned on this day as an addition to the scheduled series. The theme of autonomous propelled vehicles was expanded somewhat as *Hydro International* announced that its September issue would also focus on AUVs.

The open presentation room on the upper level of the historic shipyard Rotterdams Welvaren has now been used twice. A total of almost 60 HSB members were present.

The workshop was very lively with six very different presentations. First, the search for Malaysian Airways flight MH370 in the Indian Ocean, was presented by Fugro manager Rob Luijnenburg. Advanced equipment will be mobilised to deploying AUVs for reconnaissance and deep-tow acoustic equipment (on a 10km-long tow cable) for high-resolution mapping. If the aircraft is found, its wreckage will be spread out, making it very difficult to spot.

The two other presentations before the break were about AUVs and drones, programmable geomatic sensors below and above the sea surface. The Kongsberg range of six AUV families was shown by Richard Mills from Kongsberg Maritime. He focused on the use of AUVs in shallow water, less than 20m, and the associated pitfalls. HSB board member and nautical lecturer Helga van Noten presented the Master graduation work of Dominique Clybouw on drones. She showed the various classification types and explained the status of Belgian and Dutch legislation when using drones and the liabilities for the user. This invoked a discussion during the break as drones may be obtained very cheaply indeed, e.g. by 3D-printing.

After the break Michiel Munnik and Bart Root of TU Delft invited the audience to revisit the breakthrough of marine gravimetry as a means of improving our knowledge of the shape of the earth by Prof. Dr Ir F. A. Vening Meinesz in the 1930s. He was the first to show in gravimetric results that the earth resembles a somewhat oblate sphere due to mass thrown away from the rotation axis. The research on the work of Vening Meinesz does need additional funding. The HSB is considering a contribution.

Then Rob van Ree showed his private little ROV. Inspired by a TED talk he obtained an OpenROV building kit, costing less than USD1,000. The unit can work up to 100m (also in depth) from the operator. It has now been decided to introduce the building and operation of this small ROV into the course programme of Ocean Technology on Terschelling.

The final presentation was by Frans Nijssen of CARIS BV, who presented the educational surveys and invited undergraduate students from Terschelling for a one week lake survey, whereby various suppliers

freely provide the necessary resources. The survey has now been held twice, with great success, resulting in a professional chart that was presented to local authorities. Particularly worth mentioning is the PDOK website on which the Dutch national authorities have put a wealth of geomatic datasets and spatial information available to the general public.

The presentations will be documented on the website hydrographicsocietybenelux.eu. Two more HSB workshops have been scheduled for 2014, one around Hydro14 (28 - 30 October in Aberdeen), one on 30 September together with CEDA at Van Oord in Rotterdam, and one on a Friday in December together with NIN, location yet to be decided.

Hydrographic Society Russia

On 26 August 2014, Victor G. Rybin died at the age of 83 after a long illness. He was captain of first rank known as hydrographic and marine cartographer and served and worked in the Hydrographic Service of the Soviet Navy and Russia for more than 60 years.

He was born on 21 October 1931 in Omsk; his father, a military hydrographer, later became a member of the Great Patriotic War and helped defend besieged Leningrad.

From 1949 to 1953 Victor studied at the Hydrographic Department of the Higher Naval School of M.V. Frunze and later served in the North Hydrographic Expedition where he performed soundings in the White and Barents Seas and hydrographic work on the drifting ice in the Arctic Ocean, the Black Sea, the Baltic Sea and the Atlantic Ocean.
From 1962 to 1965 V.G. Rybin attended the Naval Academy from which he graduated with a gold medal. He then served at the Research Institute for Hydrography where he developed new tools, techniques and technologies for hydrographic and cartographic work.

Victor G. Rybin was the USSR representative to the IOC of UNESCO (Paris) and other international organisations, in particular, the Regional Data Centre International Monaco.

Captain of first rank V. Rybin was the head of a foreign relations group of the main USSR Department of Navigation and Oceanography of the Ministry of Defence for the period from 1975 to 1986 and after the transfer to the reserves he worked in the Central cartographic production of the Navy until 2000, where he gathered information and analysed cartographic activity (domestic and Russian).

In 1992, the sociable Victor G. initiated the establishment of the Hydrographic Society (HS). He was the executive secretary of the HS from 1992 to 2005. He was the organisation's correspondent for the magazine *Hydro International*. In 2006, Victor G. was elected Emeritus member of the Society but he continued to work actively in the Council of the HS until 2014.

The deceased was a real officer, an intellectual of St. Petersburg, a wonderful man, a good friend, and a good husband, father and grandfather.

His funeral was held on 29 August 2014 at the Smolensk Orthodox cemetery of St. Petersburg. More than 60 people came to pay their last respects.

OCTOBER

Ocean Energy Europe 2014
Paris, France
→ 01-02 October
For more information:
W: www.oceanenergy-europe.eu/index.php/en/

AUV 2014
Oxford, USA
→ 06-09 October
For more information:
W: www.auv2014.org

Extraordinary International Hydrographic Conference (EIHC)
Monaco
→ 06-10 October
For more information:
W: www.iho.int

Kongsberg Maritime HiPAP Survey Engineer Training Course
Aberdeen, UK
→ 09-10 October
For more information:
E: km.training.aberdeen@kongsberg.com
W: www.km.kongsberg.com/training

Sea Tech Week 2014
Brest, France
→ 13-17 October
For more information:
E: seatechweek@brest-metropole-oceane.fr
W: www.seatechweek-brest.org

ACI's 15th Maritime HR & Crew Development
London, UK
→ 22-23 October
For more information:
E: mmulazzi@acieu.net
W: www.wplgroup.com/aci/conferences/eu-mhr15.asp

SEG Annual Meeting
Houston, TX, USA
→ 26-31 October
For more information:
W: www.seg.org/web/annual-meeting-2014/overview

IADC Dredging Seminar
Singapore
→ 27-31 October
For more information:
W: www.iadc-dredging.com

Offshore Energy
Amsterdam, The Netherlands
→ 28-29 October
For more information:
E: oe@offshore-energy.biz
W: www.offshore-energy.biz

Hydro14
Aberdeen, UK
→ 28-30 October
For more information:
W: www.hydrographicsociety.org

NOVEMBER

Trimble Dimensions
Las Vegas, USA
→ 3-5 November
For more information:
E: trimble_dimensions@trimble.com
W: www.trimbledimensions.com

Seawork Asia
Shanghai, China
→ 04-06 November
For more information:
W: www.seaworkasia.com

Teledyne RESON Training
Santa Barbara, USA
→ 08-14 November
For more information:
W: http://bit.ly/1ic9QnS

E-Navigation Revolution
London, UK
→ 11-12 November
For more information:
E: alison@quaynote.com
W: bit.ly/1qqUWSI

2nd International Ocean Research Conference (IORC)
Barcelona, Spain
→ 17-21 November
For more information:
E: secretariatiorcbcn@fnob.org
W: www.iocunesco-oneplanetoneocean.fnob.org/

5th PLOCAN Glider School
Gran Canaria, Spain
→ 17-22 November
For more information:
W: www.gliderschool.eu

Inmartech
Corvallis, Oregon, USA
→ 18-21 November
For more information:
W: www.inmartech2014.com

DECEMBER

2nd Convention Mexican Hydrography
Manzanillo, Colima
→ 08-10 December
For more information:
E: digaohm.hidrografia@semar.gob.mx
W: http://digaohm.semar.gob. mx/ConvencionHidrografia2014/MX/codes/ConvHidro2014.htm

Ocean Tech South China Sea (SCS) Expo & Forum 2014
Guangzhou, China
→ 10-12 December
For more information:
E: daniel.shi@informa.com
W: www.maritimeshows.com/oceantech

JANUARY 2015

HYPACK 2015
San Antonio, TX, USA
→ 05-08 January
For more information:
E: sales@hypack.com
W: www.hypack.com

FEBRUARY

Euromaritime 2015
Paris, France
→ 03-05 February
For more information:
E: sabrina.jonas@euromaritime.fr
W: www.euromaritime-expos.com

The Unmanned Systems Expo (TUSExpo)
The Hague, The Netherlands
→ 04-06 February
For more information:
W: http://tusexpo.com

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

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