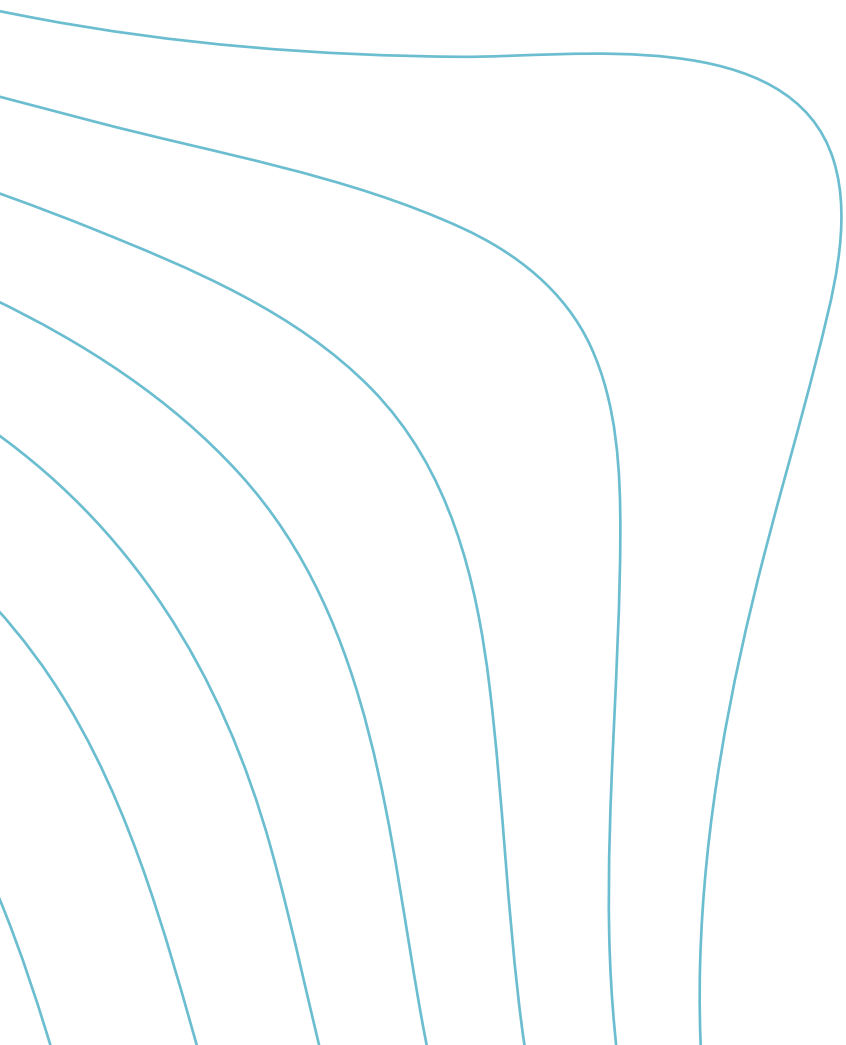
HYDRO 2016
ROSTOCK-WARNEMÜNDE
08.-10. NOVEMBER

Conference Handbook



Welcome to Hydro 2016

by: **Sabine Müller** and **Thomas Dehling** – Organising Committee

The hydrographic world is gathering in Rostock-Warnemünde again, for the second time since 2010. "Sea you..." was our theme six years ago and when we started our plans for the Hydro 2016 it didn't take long until we decided that we should "sea you again" here in this cute and slightly remote place. We asked many who joined us last time and found out that the very nice spot, the surroundings, the close location of all conference events and the very special mood generated by all of the participants deserves a second gathering in this very place at the Baltic Sea.
And you all are here, either again or for the first time and we are more than happy to welcome you.
After more than one year of intensive work, coordination, planning, decision making and revision we hope that all is in shape and in place now for another sequence in the series of Hydro conferences.
We would like to thank all those who supported us, all the partners, colleagues and friends in the hydrographic field. Namely the sponsors, the exhibitors and the speakers are the key for the success.
The exhibition was sold out even earlier than last time with 49 stands. 16 user workshops and quite a few demonstrations of different hydrographic equipment are awaiting you.
But what is a conference without ambitious and interesting presentations? More than 50 papers with trending topics like "space hydrography" have been accepted by the paper committee. So Hydro 2016 participants can expect a high-profile conference programme.
The scene is set. Now it is up to you. We wish you inspiring talks and discussions, enjoyable events and new or renewed friendships within our hydrographic family.

Sponsorship

Main Sponsors

ATLAS ELEKTRONIK
A joint company of ThyssenKrupp and Airbus DS

FUGRO

GERMANROV
OFFSHORE SERVICE

Innomar

7Cs
SevenCs

WÄRTSILÄ

Sponsors

IntellinQ
Spatial Data Management

KONGSBERG

M·B·T
UNDERWATER TECHNOLOGY

QPS
a SAAB group company

SBG SYSTEMS

ROSTOCK BUSINESS
Rostock Business and
Technology Development GmbH

TELEDYNE CARIS
Everywhereyoulook™

Supporters

EdgeTech
The Leader in Underwater Technology

esri

GMT
Gesellschaft für Maritime Technik e.V.

OCEANEERING®

Thank you for sponsoring
Atlas Elektronik, Fugro OSAE, German ROV, Innomar, SevenCs, Wärtsilä ELAC Nautik

IntellinQ, Kongsberg Maritime, MBT, QPS, Rostock Business, SBG Systems, Teledyne CARIS

Thank you for support
EdgeTech, Esri, GMT, Oceaneering

Welcome by the DHyG

by: **Thomas Dehling** and **Holger Klindt** – DHyG Chairmen

A very warm welcome to you here in Rostock-Warnemünde.
Situated directly at the coast of the Baltic Sea, Rostock is the centre of hydrography in Germany. It is the home base of the Hydrographic Office, research institutes, companies and other players in the hydrographic domain. And for this week, Rostock will be the centre of hydrography worldwide. From the 8th to 10th November 2016, our German Hydrographic Society, the DHyG, is proud to host this international event in the beautiful resort of Hohe Düne.
We expect more than 300 participants. 48 exhibitors will provide their latest developments. Presentations in 14 sessions will cover the emerging topics ranging from the "Perspectives of hydrography" to "Space hydrography", covering strategic, practical and technical issues. All this will be accompanied by workshops, boat demos and open ships.

It is a perfect coincidence that on the first day of the conference, the revised convention of the International Hydrographic Organization (IHO) will enter into force. That means that we will have the honour to welcome the then former President of the IHB as the new Secretary General of the IHO on his very first day of taking office.
A very important factor of this event is to attract young people to this wonderful profession, to support and promote young hydrographers and to foster the visibility of our hydrographic branch. Student awards are being presented to extraordinary papers and presentations, and on Wednesday afternoon the exhibition is open to the public without entrance fee.
Whether you are exhibiting your products, presenting a paper or are a regular participant, the Hydro conferences represent an excellent platform to exchange knowledge and experience, to build and improve cooperation and friendship, to recruit new personnel, to show the importance of our hydrographic branch to a wider audience and last but not least to enjoy the hydrographic community.
We'd like to wish you fruitful discussions with colleagues from all over the world and a pleasant stay here in Rostock-Warnemünde.

Sea you again ...

The German Hydrographic Society

The "Deutsche Hydrographische Gesellschaft" (DHyG) is proud to host the Hydro 2016. This is a good opportunity to give a short overview of the society.
The DHyG was founded in 1984 and is an association of individuals, companies, agencies and institutes involved in the broad spectrum of hydrography. The members are mainly from Germany, but there are several members from Austria and other neighbouring countries and quite a few corporate members from abroad.
The society's main goals are:

- To promote next generation hydrographers and students;
- To foster the practical and scientific hydrography;
- To inform the public and politicians about the importance and fields of our profession;
- To cooperate internationally.

Once a year a national conference is being organised, called "Hydrographentag". It provides a forum of professional exchange of first-hand information and is accompanied by an exhibition and a social programme. In 2012 and 2014 these conferences have been organised in cooperation with the Hydrographic Society Benelux. One meeting in Papenburg and one on the Dutch island Terschelling. Another Hydrographentag took place in Vienna, organised together with our Austrian members.

The DHyG publication *"Hydrographische Nachrichten" (HN)* is the only hydrographic magazine in German. Ten years ago, the *HN* has had a complete redesign and become very successful. This success is mainly related to the editor-in-chief Lars Schiller and the high-quality of the articles. As hydrography is largely international and the *HN* have become well-known beyond the limits of German-speaking countries, you will find the second completely English edition of the *HN* at the Hydro 2016.

The DHyG issues a seal of quality as a "Recognised Hydrographer" according to a strict scheme to professionals working in the field of hydrography.

Benefits of a membership in the DHyG are a.o.:

- Printed version of the *Hydrographische Nachrichten* free of charge;
- Students pay no membership fee;
- Reduced prices for conferences;
- Contact to and exchange with other professionals;
- Recognised Hydrographer;
- DHyG Student Excellence Award.


ROSTOCKER
2162

Rostock – Hanseatic and historical city on the Baltic Sea

Rostock is the largest city in north-eastern Germany as well as of the federal state of Mecklenburg-West Pomerania. It's on the Warnow river; the district of Warnemünde 12 kilometres (7 miles) north of the city centre is directly on the Baltic Sea coast. The city territory of Rostock stretches for about 20 km (12 miles) along the Warnow to the Baltic Sea. The largest built-up area of Rostock is on the western side of the river. The eastern part of its territory is dominated by industrial estates and the forested Rostock Heath.

Behind the historic walls of the city, a world of impressive brick buildings, gabled houses and rocking sailboats stretches along. At a picturesque square you'll find the oldest University of northern Europe, founded in 1419 and built in Italian Renaissance style. In the courtyard of the Holy Cross Convent which was erected in 1270 by Queen Margarete of Denmark, you'll find a cultural museum today. Other sights are the Fountain of Joy, dedicated to the city's rebirth after World War II, and the gate Kröpeliner Tor. Built in 1270, it's one of the only surviving gates that helped fortify the city during the Middle Ages.

The street Kröpeliner Straße which is lined with well-preserved buildings featuring gabled roofs and timbered façades leads you towards the historic Town Hall, seat of the town council for almost 800 years with its 18th century Baroque front structure, and St. Mary's church built around 1398, the most famous of Rostock's seven medieval churches. The stunning stained-glass window, which features the Day of Judgment, measures 85 feet tall and is one of the largest single stained glass windows in Europe. Another awe-inspiring sight is the church's astronomical clock. Built in 1472, it sits behind the church's high altar and is the only one of its kind still in working condition and with its original clockworks. On the hour the apostles cross before Jesus for a blessing, but Judas, the last in line, is refused. The clock's middle portion features the daily time, a zodiac, moon phases and the month. At the bottom is a calendar that's dated until 2017.

A little further north lies the picturesque seaside resort of Warnemünde, one of the most popular sites for spa on the Baltic coast with a lighthouse, captain's houses, fishing boats, cruise liners and a wide fine sandy beach. The Baltic beach resort was purchased as a small fishing village in 1323 by the rich merchants of Rostock to safeguard their access to the sea.

The heath Rostocker Heide, the largest enclosed coastal forest in Germany, offers next to the diversity of flora and fauna also well-developed horse riding, biking and hiking trails. Discover the many faces of the vibrant Baltic metropolis and fall in love with its Hanseatic charm!

Conference venue: Yachthafenresidenz Hohe Düne

On a headland at the Neuer Strom – directly at the white beach and with a view of the cruise-line terminal opposite – the Yachthafenresidenz Hohe Düne is located in Rostock-Warnemünde. The excellent hotel complex offers 368 lovingly furnished maritime rooms and suites. The unique, heavenly wellness area of the Hohe Düne SPA gives a sensual experience of the world's bath cultures. The gastronomic concept of the Yachthafenresidenz fulfils every wish: At Hohe Düne the guests can choose from 12 restaurants and bars – from the Shark Bar to the gourmet restaurant Der Butt, from the Kamin Bar to the Brasserie. With the children's boat Sylvia, an impressive cog in the middle of the hotel complex, the baby playroom Käpt'n Knuddel and the youth lounge Sea Lounge the Yachthafenresidenz the Hohe Düne offers ideal conditions for an unforgettable family holiday with nothing to be desired. Located at the promenade, the Hohe Düne marina – Germany's first five-star marina – awaits demanding skippers from near and far with its 920 berths.


Lighthouse
Beach
Congress centre
Yachthafen Residenz Hohe Düne
Footway
Rostock-Warnemünde
Train Station
Ferry

Conference programme at a glance

Tuesday, 8 November 2016

09:00		**Opening ceremony**
09:45	K	**Keynotes** // 17–19
11:10	1A	**Perspectives of hydrography** // 21–24
13:30	2A	**Student session** // 25–29
15:50	3A	**Emerging topics in multibeam echo sounding and surveying** // 31–35
	3B	**Software & data management** // 37–41

Wednesday, 9 November 2016

09:00	4A	**In situ and remote hydrography** // 43–46
	4B	**Improving nautical information** // 47–50
10:45	5A	**Space hydrography** // 51–55
	5B	**Nautical charting** // 57–60
13:30	6A	**Energiewende – Challenges in the wind offshore business** // 61–65
15:50	7A	**LiDAR case studies for hydrographic assessments** // 67–72

Thursday, 10 November 2016

09:00 8A **State-of-the-art GNSS techniques** // 73–76

8B **Education** // 77–80

10:45 9A **Hydrography in extreme environments** // 81–85

13:30 10A **Nautical depth and new survey vessels** // 87–91

15:15 **Closing ceremony**

List of authors and presenters

Opening Ceremony

Keynotes

K1	*Peter Ehlers*	Ocean governance and hydrography
K2	*John Hughes Clarke*	Future perspectives on multibeam backscatter and seabed classification

Ocean governance and hydrography

by: **Peter Ehlers**[1]
Keywords: ocean governance | blue growth | law of the sea

The seas are gaining in importance as part of a healthy economy. They satisfy elemental needs, e.g. for food, natural resources and energy supply. As transport routes, they are a fundamental basis for the worldwide exchange of goods. However, the increasing use of the seas is associated with environmental threats which cannot be ignored. "Blue growth" can only be accepted if the principles of sustainable development are applied. That requires balancing the economic and sociopolitical needs and the capacities of the natural systems to meet the needs and aspirations of the present generation without compromising the ability of future generations to meet their own needs. A sustainable and comprehensive ocean governance system is urgently needed. For improving ocean governance international cooperation has to be enhanced including a system for financing the conservation and sustainable use of the seas. The law of the sea has to be further developed in particular with regard to marine biological diversity, the designation of marine protected areas, fisheries activities on the high seas and the introduction of large scale marine spatial planning. Capacity building has to be intensified focussing on ocean policy and management. Sufficient knowledge about the oceans and the seas is an indispensable perquisite for ocean governance. In this context hydrographic survey and services play a fundamental role going far beyond the traditional needs of maritime shipping, but covering geospatial data for all marine purposes.

1: Federal Maritime and Hydrographic Agency, Hamburg, Germany (President ret.)

Future perspectives on multibeam backscatter and seabed classification

by: **John Hughes Clarke**[1]
Keywords: multibeam backscatter | radiometric calibration | geometric calibration | angular response | multi-spectral

Multibeam backscatter has long been recognised to be a valuable complementary data set that can be derived from multibeam bathymetric surveying. Its use, however, has never reached the same widespread acceptance as the bathymetry. Part of this issue is due to an imperfect understanding about what the measurement actually represents, and part is a failing in the fidelity of that measurement.

It is now quite routine to use backscatter to delineate the broad regional distribution of sediments of strongly contrasting physical character (e.g.: rock vs mud). To be more valuable however there needs to be the ability to confidently (and reproducibly) discern sediments of less contrasting character (such and muddy-sands vs sandy-muds). Such finer discrimination places much higher demands on calibration, particular the removal of radiometric and geometric effects.

Even if this were achievable, there remain inherent ambiguities in inverting seabed backscatter. This is because, over a narrow range of grazing angles, quite different seabed physical properties can result in similar mean backscatter strength. Two promising approaches are using the full angular response (a much wider range of grazing angles) and multiple scattering frequencies (multi-spectral).

Both of these approaches, however, place even higher demands on those same radiometric and geometric effects. For angular response, the geometric issues dealing with data close to normal incidence and at the lowest grazing angles are the main problem. For multi-spectral, particularly for the case of multi-sector systems, the radiometric problems are compounded with each added frequency.

In the absence of absolute calibration, empirical approaches to addressing these issues have been developed in the field using surface mounted systems. All of these issues would be easier to resolve if the imaging platform were able to significantly change its altitude and orientation over a given seabed. For that AUVs are uniquely suited. Examples of these issues and potential new methods to better address them will be presented.

1: Center for Coastal and Ocean Mapping, University of New Hampshire, USA

Session 1A

Perspectives of hydrography

General future perspectives of the IHO

by: **Robert Ward**[1]
Keywords: IHO | S-100 | crowd-sourced bathymetry | capacity building | standards of competence

Robert Ward, Secretary-General of the International Hydrographic Organization, will provide an overview of current and future priorities of the IHO.
He will describe the ongoing work and impact of the IHO Universal Data Model – S-100, which will eventually replace S-57 as the key hydrographic and maritime geospatial data transfer standard that is also underpinning the International Maritime Organization's e-navigation concept.
He will describe the work being undertaken to implement an IHO global crowd-sourced bathymetry programme aimed at gathering hydrographic information for those parts of the world's seas, oceans and coastal areas that are currently unsurveyed or inadequately surveyed.
He will comment on the development of spatial data infrastructures at the regional and the global level – and the consequent need for national hydrographic offices to transition from their traditional nautical chart-based focus to organisations that have a marine spatial data infrastructure focus that provides access to the underlying national hydrographic data set.
He will describe the IHO Capacity Building programme, the ongoing work in revising the international standards of competence for hydrographic surveyors, and the opportunity for industry to participate and provide feedback to all aspects of the work of the IHO.

1: International Hydrographic Organization, Monaco

The provision of hydrographic services as core element of e-navigation – Status and perspective

by: Gilles Bessero[1], **Mathias Jonas**[2], Julia Powell[3]
Keywords: e-navigation | S-100 | S-101 | ENC

The further improvement of the universal hydrographic data model S-100 forms the basis of the current technical standardisation activities of the International Hydrographic Organisation. S-100 specifies, for hydrographic and related information, the methods and tools for data management, processing, analysing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. Those features form the basis for all aspects of information handling envisioned under the e-navigation concept of the IMO. The submission reports on the latest development of the S-100 framework, the scope of derived data products and describes the purpose and contents of the interoperability specification. Special attention is put on the flag ship project S-101 Next Generation Electronic Navigational Chart (ENC). The related synopsis comes with a time line for the regular provision and use of such data sets. The transfer of the S-100 concept to other scientific domains is demonstrated for meteorological data (sea ice).

1: International Hydrographic Organization, Monaco
2: Federal Maritime and Hydrographic Agency, Rostock, Germany
3: NOAA Office of Coast Survey, Silver Spring, USA

Intelligent exploitation of the Blue Economy – A hydrographic perspective

by: **Don Ventura**[1]
Keywords: Blue Economy | data layers | hydrographic data set

How does one intelligently exploit the Blue Economy to benefit one's nation, one's company, one's agency, or oneself? From a hydrographic perspective, economic benefits derived through maritime trade are only really benefits when they arrive on land: at market. The success of vessel trade relies upon safe navigation and sustainable, resilient shore-side infrastructure. Not for the first time is it therefore emphasised that the land-sea interface is a critical component of any successful interaction between the Blue Economy and the terrestrial market which it serves. Land and sea data supporting the maritime activity upon which a Blue Economy is built have however, up until very recently, always been dealt with as separate entities, by separate agencies and industries, on distinct geodetic reference frames.

This paper will emphasise the importance of a holistic capture of marine and terrestrial terrain and the important additional data layers necessary to support successful, enduring maritime trade. A multi-faceted approach to data collection can be conducted to create a homogenous data set which can be exploited by a greater number of stakeholders than can the mere sum of the component marine and terrestrial parts. These stakeholders include not only the traditional end data users but an increasing number of marginal stakeholder entities and other data managers.

1: Fugro Pelagos Incorporated, USA

Session 2A

Student session

2A1	*Jean-Guy Nistad et al.*	Backscatter adjustment for multi-sector multi-swath multibeam echo-sounders
2A2	*Mark Gray et al.*	RapidCast: Analysis of spatio-temporal variability in high resolution speed of sound measurements
2A3	*Arne Lohrberg et al.*	Spatial and temporal analysis of gas seep activity in Eckernförde Bay and assessment of its linkage to pockmark morphology and sub-bottom strata using marine acoustic methods
2A4	*Gerard Naankeu Wati*	Error budget analysis for hydrographic survey systems – Implementation on an inspection campaign of pipelines by an AUV

Backscatter adjustment for multi-sector multi-swath multibeam echo sounders

by: **Jean-Guy Nistad**[1], Jean-Marie Augustin[2], Xavier Lurton[2], Patrick Lajeunesse[3]
Keywords: multibeam echo sounders | backscatter | transmission patterns

Many survey organisations whose primary focus is bathymetry simultaneously collect the co-registered backscatter from multibeam echo sounders, more often than not in an opportunistic manner. While technological innovation and good survey practice have rendered bathymetric data collection more efficient and measurements both precise and accurate, so much cannot be said about backscatter data. Indeed, the sensitivity of the backscatter measurement cycle coupled with limited good survey guidelines leads to real-time backscatter measurements of poor quality requiring intensive post-processing efforts. While accurate geometric and environment compensations cannot be known until time of survey, an accurate system-dependent a priori compensation is possible by properly accounting for the transmit antenna sector pattern(s). Especially with multi-sector multibeam echo sounders however, the transmit sector patterns can strongly modulate the backscatter response. This unwanted effect, inherent to the sensor characteristics, requires an appropriate compensation. A method to minimise this modulating effect has been developed at IFREMER (Brest, France). The method consists in conducting a field calibration survey, modelling or parameterising the transmission sector patterns and injecting the results into the multibeam echo sounder to produce real-time backscatter measurements devoid of system-dependent artefacts. This method was applied successfully on Kongsberg EM302 and EM710 multibeam echo sounders. Results demonstrate a clear improvement in the precision of the backscatter measurements following application of the calibration even when the real-time uncorrected backscatter measurements are of very poor quality. However, the analysis also highlights the difficulty in obtaining consistently accurate results when no prior knowledge of the field calibration survey seabed substrate exists. Such prior knowledge obtained from an auxiliary calibrated echo sounder offers considerable improvement potential.

1: Federal Maritime and Hydrographic Agency, Rostock, Germany
2: IFREMER Centre Bretagne, Plouzané, France
3: Université Laval Département de Géographie, Québec, Canada

RapidCast: Analysis of spatio-temporal variability in high resolution speed of sound measurements

by: **Mark Gray**[1], Timothy Scott[1], Iain Slade[2], Jim Gardiner[3]
Keywords: multibeam | SoS – speed of sound | RapidCast | SwiftSVP

Acoustic waves are the primary medium utilised by hydrographers for multibeam bathymetric surveys (MBES). Variation of speed of sound (SoS) through water causes these waves to bend and refract, which if not properly accounted for, can lead to misrepresentation of depth and features.
Traditional, static measurements of SoS are costly due to time "offline". The Teledyne Oceanscience RapidCast system with Valeport SwiftSVP reduces these losses and enables temporal and spatial quantification of SoS variance, with the potential to increase statistical confidence levels in swathe data with commercial applicability.
An MBES was undertaken in an 12 km^2 area in Plymouth Sound with large SoS variances. Simultaneously, the RapidCast system collected sound velocity profiles (SVPs) at 100 m intervals. Survey of the site was repeated 6 times over half a tidal cycle. The resulting data has enabled graphical representation displaying SoS change spatially and temporally and the inclusion of high density SVPs into MBES data. This data provides the potential to display and quantify spatial and temporal SoS changes in a new, comprehensive manner. Geo-referenced 3D models of SoS variability will be created and analysed as a function of temporal change throughout the tidal cycle. We will test the hypothesis that when compared to reduced frequency SVP incorporation into MBES data, high density SVPs will increase the percentage of cells satisfying the 95 % confidence level in total vertical uncertainty to achieve special order classification.
The RapidCast system allows the surveyor to minimise losses incurred with offline SoS measurements. Findings from statistical analysis of the MBES survey may highlight potential advantages to commercial activities. The high density of data the system can collect means detailed representation of temporal and spatial SoS variance has become possible.

1: School of marine science and engineering, University of Plymouth, UK
2: Fugro academy training centre, Plymouth, UK
3: Valeport Ltd, Totnes, UK

Spatial and temporal analysis of gas seep activity in Eckernförde Bay and assessment of its linkage to pockmark morphology and sub-bottom strata using marine acoustic methods

by: **Arne Lohrberg**[1], Jens Schneider von Deimling[1]
Keywords: Eckernförde Bay | pockmark morphology | shallow gas | gas ebullition | in situ monitoring | hydroacoustic detection

Highly elevated methane concentrations in Eckernförde Bay bottom waters during campaign AL447 raised attention. Earlier studies focused on pockmarks and groundwater seepage to be the main factor controlling methane concentration in the water column. This thesis presents high-resolution bathymetry data for three pockmark clusters, high-frequency sub-bottom profiles for methane-rich sediments, a spatial activity distribution grid of gas seepage and a time series of in situ monitored gas seepage events. It aims to (1) analyse pockmark morphology, (2) estimate the spatial distribution of shallow gas accumulations, (3) examine the spatial and temporal activity of gas seepage, (4) find possible trigger mechanism and (5) estimate a gaseous methane flux to the water column of Eckernförde Bay.
High-resolution bathymetry data indicate the formation of micro-scale structures on the pockmark floor of 20 to 50 cm depth and less than 5 m in diameter. Comparison with bathymetric data acquired eight years earlier suggests a stability of the pockmark rims over decades.
Shallow sub-bottom data suggest the presence of methane accumulations in the sediments at water depths exceeding approximately 20 m surrounding the biggest pockmark close to shoal Mittelgrund. Surface sediment methane concentrations appear to be higher at pockmark rims and the pockmark floor and lower in the central part of the bay.
Single beam data show gas seepage to occur in wide areas of the bay, especially in the southwestern extent of the survey area. Gaseous methane flux estimations using gas bubble ebullition rates derived from in situ monitoring and radius estimations derived from single-beam echo sounding suggest a significant contribution to methane concentrations in the water column.

1: University of Kiel, Marine Geophysics and Hydroacoustics department, Germany

Error budget analysis for hydrographic survey systems – Implementation on an inspection campaign of pipelines by an AUV

by: **Gerard Naankeu Wati**[1]
Keywords: error budget | surface and underwater survey systems | uncertainty propagation law

To install the subsea infrastructures (pipelines, subsea wells, etc.) necessary for the development of hydrocarbon resources, TOTAL regularly contracts several hydrographic survey companies. These companies mainly use two types of systems: surface and underwater survey systems. The error budget estimation allows to identify all the parameters which affect the acquired data quality and to check if the measurement uncertainty of the sounding position meets minimum standards proposed by the International Hydrographic Organization (IHO). This work gives an in-depth analysis on the error budget estimation of surface and underwater survey systems describing briefly the state-of-the-art of these systems and proposing an estimation method of error budget of these systems. This work also contributes improving bathymetric sounding position equations and demonstrating the yaw misalignment influence between the inertial sensors (IMU, etc).

1: ENSTA Bretagne – Graduate and Post-graduate Engineering, School and Research Institute, Brest, France

Session 3A

Emerging topics in multibeam echo sounding and surveying

Transitioning research to operations: The case of wobble analysis

by: **Jonathan Beaudoin**[1], John Hughes Clarke[2], Maurice Doucet[3]
Keywords: multibeam | echo sounder | processing | analysis | troubleshooting

Errors in mapping system configuration and integration can lead to dynamic data artefacts that vary with platform motion, resulting in so-called "wobbles" in bathymetric data. Recovering from these types of problems is sometimes possible in post-processing, however it is generally desirable to address these types of issues prior to acquisition. These typically require experienced or even expert personnel to diagnose, however, it is not feasible to have your best personnel on all mobilisations for all projects as this can lead to very high staffing costs. Even with experienced and expert personnel, there is a general lack of good troubleshooting software to streamline and facilitate diagnostic efforts. Methodologies to diagnose these types of problems have been developed at the University of New Brunswick's Ocean Mapping Group (UNB/OMG) in 2003 and have since been used successfully in a research environment. Though there has been continued interest from the marine geomatics community to have such tools at their disposal, there has been no effort to port the research tools to commercially available software until recently. A few isolated efforts have been made to transition the research tools to a production environment with very limited success.

In this paper, we discuss the implementation of the UNB tools in QPS Qimera. In particular, we explore the process of transitioning a research grade tool that was designed by and for expert users to a tool that is usable by non-expert personnel. Real examples from problematic data sets are examined, to demonstrate how the tool is used.

1: QPS Canada Ltd, Fredericton, NB, Canada
2: Center for Coastal and Ocean Mapping, University of New Hampshire, USA
3: QPS USA, Portsmouth, NH, USA

Sediment classification from multibeam backscatter images using simple histogram analysis

by: **Rozaimi Che Hasan**[1/2], Mohd Razali Mahmud[3], Shahrin Amizul Shamsudin[1]
Keywords: sediment analysis | seabed classification | backscatter images | multibeam | histogram analysis

The use of multibeam echo sounder (MBES) has provided an advantage to study how acoustic data can be used for sediment classification. In particular, the availability of backscatter intensity offers alternative method to study seafloor hardness and softness, as compared to side-scan sonar imagery. In many seabed mapping processes, many classification techniques can be used to produce sediment maps from backscatter images, ranges from a simple clustering to the tops machine learning approaches. In this study, the authors attempt to investigate how a simple data arrangement method can be applied for backscatter images from MBES using the histogram generated from the backscatter intensities. The idea is to test whether this simple data arrangement process can produce similar classes as compared to a sediment classification map. To achieve this, acoustic data from WASSP MBES (i.e. model WMB-3250) was used for this purpose, which was acquired at a small area in Pulau Agas, north-west of Peninsular Malaysia. First, the bathymetry was processed using Qinsy and Fledermaus software, and for backscatter author's Matlab code was used to extract the intensity values from the original raw data and rescaled them to 8-bit architecture (0-255). Secondly, 'Reclassify' function in ArcGIS was used to reclassify the pixel intensities based on the shape of the histogram. A few data classify techniques in ArcMap were tested to produce classification maps such as using manual approach, equal interval, quantile method, natural breaks, geometrical interval and standard deviation. Classification maps derived from these methods were then validated with ground truth samples collected using underwater videos and grabs to assess their accuracies.

1: UTM Razak School of Engineering and Advanced Technology, Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia
2 Center for Coastal and Ocean Engineering (formerly known as COEI), Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia
3 Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia, Skudai Johor, Malaysia

Maximising business value from offshore survey data in the oil and gas industry

by: **Auke van der Werf**[1], Øyvind Ruden[1], Philip Riddell[1], Mark Jones[1], Rhian Parkin[1]
Keywords: geomatics | multibeam echo sounding | surveying | Seabed Survey Data Model – SSDM | International Association for Oil & Gas Producers | geoinformation

The oil and gas industry is facing a challenging business climate, therefore we need to be competitive yet innovative and show value year on year. This paper, and subsequent presentation, will give an insight into the type of surveys acquired, how competitive scoping is performed, new technology is applied and how (hydrographic) survey data is managed internally.
Efforts are being made to identify ways to further reduce costs for seabed survey projects: Workscopes are reduced, competitive rates are achieved by re-tendering or mini tendering contracts, combining surveys where possible by continuously engaging with assets and projects and working in collaboration with other operators for seabed surveys where feasible.

Surveys can be acquired more competitively by applying affordable new technology; as a result, survey requirements have been updated to account for high-resolution multibeam echo sounders and side-scan sonar and survey methodologies have been implemented to fit the area of interest. Additional deliverables such as multibeam backscatter are being used to help to make correct business decisions.
Survey deliverables are shared through the Seabed Survey Data Model (SSDM). The SSDM reduces the dependency on hard copy mapping and CAD deliverables and leverages the use of GIS and web-based mapping and as result, the acquired hydrographic data sets can be integrated with corporate data holdings.

1: Shell, Assen, The Netherlands

Multibeam water column imaging for charting least depth value

by: **Marco Filippone**[1/2]
Keywords: WCD – water column data | least depth measurements | quality check

Commercial maritime world expectation, mainly focus in trading between continents, is largely increasing during the past few years. This important developments could significantly alter the pattern of shipping in the near future in term of vessel building, logistic infrastructure and new seaways. The vessel size is increasing in order to maintain the market share, channel and straits are dynamically changing with the higher demand of passage.
In this new scenario, the bathymetric data is inadequate or non-existent, with large areas either un-surveyed or surveyed with obsolete methods of measurement, were taken nearly a century ago.
It is therefore imperative that those governments and ports that are keen to herald the arrival of newer, larger vessels provide accurate bathymetric data to modern standards, where necessary, to ensure safe and navigable waterways.
The water column imaging is only part of large bathymetric data set can be collected with modern equipment and for different use (seeps detection, archeological feature analysis, wreak least depth definition).
WCD collected with high-resolution multibeam echo sounder and processed with the new state-of-the-art software, now available on the market (no more external tool for WCD identification) using internal algorithm, can significantly enrich the data set knowledge and assist during the quality control check.
Wreck position and depth value (Z) listed on electronic/paper nautical charts must be provided within the best possible accuracy. Several number of methods can be used for identify the wreck least depth (side-scan sonar systems with backscatter interpretation, diving (not always possible) rudimentary methods (with higher risk of fail and bigger uncertainty) and of course WCD analysis). A combination of above methods is the suggested way to follow but the new software's available with WCD analysis tools are now supporting the cartographer for quality check better than other technique. Older data set, where WCD was recorded together with SSS or diving control/validation, can be reprocessed in order to increase the least depth accuracy. In this exercise, an older data set of several wreck, will be reprocessed and analysed in order to confirm that WCD method is the most accurate, safe and time-consuming method.

1: Fugro OSAE GmbH, Bremen, Germany
2: Genoa University, Italy

Tailor-made surveys for customers needs

Meritaito is one of the Northern Europe's largest marine survey companies. We provides hydrographical, geophysical and geotechnical survey services in offshore, near shore, inshore and inland water areas.

Our certified services meet the highest international quality standards (IHO S-44) and the most demanding customer needs and charting authorities expectations.

Meritaito has a team of highly skilled professionals in hydrographic surveying, marine geology, engineering and data processing. Hydrographic surveyours are internationally certified.

Further information:
Sales Director Kari Pohjola, Tel. +358 40 571 3193

Come and visit
our stand 64
at Hydro 2016
Exhibition!

SeaHow®
by MeriTaito

Serving the world of Hydrography & Oceanography

Tide Gauges

Telemetry

Optical Sensors

Wave Recorders

CTD & Multiparameter

Current Meters

Ocean Engineering

Echo Sounders & Bathymetry

Sound Velocity

VALEPORT
in our element

Tel: +44 (0) 1803 869292
Fax: +44 (0) 1803 869293
sales@valeport.co.uk

Valeport Ltd I St Peter's Quay I Totnes
Devon I TQ9 5EW I United Kingdom

www.valeport.co.uk

ISO 9001 ISO 14001

Session 3B

Software & data management

Using CARIS to automate bathymetric data management at Rijkswaterstaat

by: **Charles de Jongh**[1]
Keywords: CARIS bathymetric data management | workflow automation | Rijkswaterstaat

Rijkswaterstaat (RWS), the executive body of the Ministry of Infrastructure and Environment in the Netherlands, is responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands. This includes the main waterway network and water systems. Because the Netherlands has one of the most advanced and busy waterway networks in the world, the best possible management is essential, not only for the Netherlands' economy, but also for neighbouring Germany and Belgium. As such RWS maintains a large amount of bathymetric survey data, both of Dutch waterways and the North Sea.
For the implementation of a new national storage system for hydrographic survey data at RWS, CARIS Bathy DataBASE was chosen. Since then legacy data sets and metadata have been converted from the old database to CARIS Bathy DataBASE, recently followed by the creation of a new and efficient automated bathymetric data management workflow.
This presentation will focus on this workflow as it is an example of state-of-the-art techniques, combining both CARIS COTS software and customised scripting. When new bathymetric data sets are uploaded to an RWS portal, they will be automatically modelled and placed in an import database. An RWS operator will check the bathymetric model, after which it is moved to the bathymetric source database that contains all validated bathymetric data sets (currently around 60,000 data sets). To have the best available representation of the seafloor available per region (e.g. a waterway), multiple source bathymetric data sets are automatically combined on a regular basis, making sure the combined model contains the most recent survey data. The resulting combined data sets are moved to a separate combine database and are accessible using OGC compliant web services for multiple stakeholders, both internally at RWS as well as externally. The combined bathymetric models are the basis for dredging, for assessing the state of maintenance of the waterways, for flood management and scientific research, as well as for the creation of electronic navigation charts.

1: Teledyne CARIS EMEA, 's-Hertogenbosch, The Netherlands

Semi-automatic generation of depth curves and sounding selection

by: **Morten Revsbæk**[1], Ian Berg Sonne[2], Jakob Truelsen[1], Sigvard Stampe Villadsen[2]
Keywords: depth curves | sounding selection

In this talk we present a new workflow and software suite for semi-automatic generation of cartographically acceptable depth curves and sounding selection from detailed marine survey data. The software and workflow has been developed throughout the last two years in a close collaboration between cartographic experts at the Danish Geodata Agency and algorithm experts at SCALGO, a Danish algorithm-technology company. We will present the concept behind the software, and show how this results in a new technology-supported workflow, that has the potential to significantly improve the efficiency of cartographers when creating nautical charts. We will do this based on the first experiences from applying the new techniques in the production of nautical charts of the waters around Greenland and Denmark.

The background for the development project is that both the detail, speed and efficiency, with which marine survey data is collected, has increased due to advances in sensor technology, moving from single-beam to multibeam. The technology for processing these massive amounts of detailed survey data into cartographically acceptable depth curves and soundings, has not seen the same increase in efficiency. The process of generating depth curves and selecting soundings from survey data is still largely a manual and cost intensive process.

The goal of the project has been to both reduce the amount of manual work required when generating cartographically acceptable depth curves and soundings from detailed marine survey data, but also to maintain accuracy and important details by producing a set of curves and soundings that are mathematically constrained in how much they can vary from the detailed survey.

The Danish Geodata Agency is responsible for creating and maintaining nautical charts for the Danish territorial waters, the waters around the Faroe Islands and the waters around Greenland. In recent years the ship traffic around Greenland has increased significantly, and therefore the demand for efficient production of high-quality nautical charts for these waters have grown. However, the manual process of generating depth curves and selecting soundings for this large region result in high costs and long processing times. The first trials of the developed workflow and software indicate a potential for significant reduction in cost and time.

1: SCALGO, Aarhus, Denmark
2: Danish Geodata Agency, København, Denmark

Managing hydrographic data for multiple usage

by: **Mark Terlien**[1]
Keywords: maritime spatial data management | GeolinQ | point clouds | WMS | WFS | REST

Managing hydrographic data varying from point clouds to object data like buoys, contours and wrecks is getting more challenging, because of increasing volume of acquired data and multiple usage. The traditional use for hydrographic data for navigational purposes rapidly extending over the years to new fast growing usages like offshore wind farms, dredging and environmental issues. A new innovative approach of hydrographic data management is crucial to cope with these challenges.
The presentation starts with an assessment of the functionality needed for data management to cope the challenges. Data management solutions are needed that offer a combination of fast and efficient storage, visualisation and web distribution and flexibility with respect to point, raster and feature attributes, metadata and styling. Users need to be able to browse data sets based on metadata and location, visualise point cloud data according to their own needs and publish point cloud data sets based on customer requirements.

Second part of the presentation shows how this new approach is implemented in GeolinQ. The data management approach based on the concept of flexible data modelling will be explained. Examples will demonstrate how the approach improves data quality by structuring and validation, allows fast data retrieval, customised visualisation and multiple options to share or export hydrographic data. Experiences will be shared defeating the challenges managing hydrographic data for multiple usages.

1: IntellinQ, Rotterdam, The Netherlands

Marine cadastre as an application of MSDI

by: **Derrick R. Peyton**[1], John Conyon[1], David Dodd[1]
Keywords: SDI | MSDI | marine cadastre | hydrography

A Marine Spatial Data Infrastructure (MSDI) is a framework consisting of marine geographic data, associated metadata, and the information technology infrastructure to enable the discovery and use of this data by the wider community. A well-known application of MSDI is the hydrographic chart as it consist of a representation of hydrographic data, as this data is immediately available and easily organised through hydrographic offices in standardised formats. Another application of MSDI is the marine cadastre.
A marine cadastre is a system of registries that allows for the systematic recording of all recognised legal rights, restrictions and responsibilities in the offshore area. On land, cadastral systems are an essential component in the land management structure and a pillar of economic development. They ensure the security of public and private interests and create a positive environment for investment. As a modified extension of the land cadastre, the marine cadastre is at the centre of the dynamics between usages and the ocean space. It requires accurate, up-to-date and complete information.
This paper presents some background information on MSDI and marine cadastre and discusses an idealised concept of how a multipurpose MSDI could operate.

1: IIC Technologies Inc., North Vancouver, BC, Canada

Session 4A

In situ and remote hydrography

Comparison and characteristics of oceanographic in situ measurements and simulations above submerged sand waves in a tidal inlet

by: **Ingo Hennings**[1], Dagmar Herbers[1]
Keywords: Acoustic Doppler Current Profiler | suspended sediment concentration | asymmetric compound sand wave | dynamic buoyancy density | action density

Ocean colour and its transparency are related to turbidity caused by substances in water like organic and inorganic material. One of the essential climate variables (ECV) is ocean colour. However, this implies the correct interpretation of observed water quality parameters. Acoustic Doppler Current Profiler (ADCP) data of the three-dimensional current-field, echo intensity, modulation of suspended sediment concentration (SSC), and related water levels and wind velocities have been analysed as a function of water depth above submerged asymmetric compound sand waves during a tidal cycle in the Lister Tief of the German Bight in the North Sea. Signatures of vertical current component, echo intensities and calculated SSC modulations in the water column depend strongly on wind and current velocity. Bursts of vertical current component and echo intensity are triggered by sand waves itself as well as by superimposed megaripples due to current wave interaction at high current ≥ 1.0 m s^{-1} and wind speeds ≥ 10.0 m s^{-1}, preferably of opposite directions, measured at high spatial resolution. The magnitude of currents and SSC modulations during ebb and flood tidal current phases are only weakly time dependent, whereas the local magnitudes of these parameters are variable in space above the sand waves. Intense ejections caused by tidal current velocity transport higher SSC near the bottom boundary layer at the sand waves superimposed by megaripples towards the free water surface. Such typical upwelling mechanism above sand waves creates distinct SSC signatures of remote sensing data visible in air- and space-borne optical imagery. Hydrodynamic parameters such as dynamic buoyancy density, total energy density and action density due to semi-diurnal M_2 tide motion which are associated with sand waves are investigated and analysed. Results and characteristics of simulated hydrodynamic parameters in coastal waters above sand waves are presented. It is shown that ADCP measurements are to be consistent with simulations based on the applied theory.

1: GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany

Tidal correction and height referencing for bathymetric survey data

by: **Martin Verlaan**[1/2], Maialen Irazoqui Apecechea[1], Sandra Gaytan Aguilar[1], Firmijn Zijl[1], Cornelis Slobbe[2]
Keywords: tidal correction | height referencing | sea level modelling | vertical datum | numerical model

Measurements of the bathymetry, either from a ship or from space, usually provide the local total water-depth, i.e. relative to a water surface that changes both in space and time. For further use of the data corrections are needed for the movement of the water surface with tides and wind induced effects on the sea level. In addition, the vertical datum needs a conversion to a vertical reference surface that is useful for the users of the data. Here, we will show how a global model of the sea level variations due to tides and meteorological forcing can contribute to these tasks.

We developed a numerical model (GTSM v1.0) that computes fluctuations of the sea level and currents globally on a variable resolution that increases to roughly 5 km at the coast. The model incorporates the gravitational tidal forcing by the moon and sun as well as the forcing from atmospheric winds and pressure. It is now running 4 times a day to provide near real-time results and forecasts for the next few days. In addition, the model can compute historical values for the past few decades using a meteorological reanalysis. The accuracy of the model is typically around 10 cm near the coasts depending of course on the local conditions. Work is ongoing to further improve the accuracy.

The same numerical model can be used to compute the difference between Lowest Astronomical Tide (LAT) and the mean sea-level (MSL). For a regional application, we have also shown that this approach can be used to compute the difference between MSL and the geoid. We are currently testing if a similar approach can be applied on a global scale.

The final aim of this work is to provide a global service for tidal reduction and vertical reference conversion in the near future.

1: Deltares, Delft, The Netherlands
2: TU Delft, The Netherlands

Quantifying turbulence in tidal channels

by: **Fabian Wolk**[1]
Keywords: turbulence | microstructure | tidal channel | tidal energy

This paper discusses methods and instrumentation solutions for the reliable measurement of flow turbulence in tidal channels, which are the preferred locations for tidal energy generation. While the natural geographic constrictions of tidal channels accelerate the flow, thereby increasing the energy density available for extraction, topographical features and curvatures of the channels create intense turbulence in the flow. Numerical models and scale model tests in laboratories attempt to emulate turbulence and predict its impact on the energy converters. However, direct measurements in situ are required to assess and understand the full impact of the turbulence effects and to account for local effects of the sites.

Unfortunately, turbulence is extremely difficult to measure in the harsh conditions that are typical of tidal channels. The most advantageous measurement techniques involve a mix of non-acoustic and acoustic sensors. These can be mounted on the seabed or deployed on anchored floating platforms, which provide measurements in the middle of the water column, at the hub height of tidal turbines. Combining non-acoustic and acoustic sensing technologies makes it possible to characterise the entire turbulent velocity spectrum pertinent to tidal energy generation. The Nemo system is a floating platform that carries a combination of sensing technologies to measure turbulence. Nemo has been developed in Canada out of a collaboration between industry and academia. The system has been tested in tidal channels in Canada and the UK.

Two research and develop projects InSTREAM and TiME are described, which establish methodologies and instrumentation to fully characterise the turbulent flow in and around tidal energy sites.

1: Rockland Scientific Inc., Victoria, BC, Canada

Session 4B

Improving nautical information

Enabling hydrographic offices to support new markets with S-57 data sets

by: **Tom De Puyt**[1], Rafael Ponce[1]
Keywords: S-57 data set | marine spatial data infrastructure | web services

Hydrographic offices have been producing high-quality S-57 data sets for navigational use for decades. Hydrographic offices are becoming more relevant in the 21st Century and their data ever more useful for a broader audience in addition to the traditional mariner. The time for a new distribution model to support non-navigational use of S-57 data sets has arrived. With advances in GIS technologies those same data sets can now be used to open up and support new economic opportunities within the so-called blue economy, support of shore-based e-navigation systems and to provide an authoritative foundation to national marine spatial data infrastructure. Hydrographic data is a critical asset for any activity at sea and in coastal areas, and S-57 data sets, rich in high-quality content can be used in many different ways.

By enabling the use of S-57 data sets within standard web services such as REST and OGC WMS, and other non-navigation systems, hydrographic agencies empower many other organisations to make informative decisions using this data in combination with other sources in a GIS platform. Some steps towards that end had been made by progressive hydrographic offices; an example of this is already available at: https://gis.charttools.noaa.gov/MACHC/MACHC%20ENCOnline/

1: Esri, Redlands, CA, USA

Finalising Baltic Sea surveys for the needs of shipping

by: **Benjamin Hell**[1]
Keywords: FAMOS | Baltic Sea | sea traffic management | under keel clearance

Reliably surveyed shipping routes at sea are a major pillar of the marine transport infrastructure and an indispensable precondition for the safety of ship navigation and transports at sea. Still, in the Baltic Sea the water depth of extensive areas used by commercial shipping traffic has not yet been mapped to modern standards, providing a full picture and precise information of the sea floor. The FAMOS project is mainly focusing at hydrographic surveying of the Baltic Sea according to the BSHC-HELCOM Revised Baltic Sea Harmonised Hydrographic Re-Survey Scheme. A collaboration between seven Baltic Sea countries, the project encompasses 15 organisations, including six national hydrographic offices.

Accurate and complete digital information infrastructure with adequate coverage is a requirement for the revolution that marine navigation is facing: Sea Traffic Management is no longer a concept but will be deployed in the near future. The European Galileo and similar positioning systems will allow for navigation with better accuracy than ever. The next generation of ECDIS will make it easy to use full-coverage detailed depth data for e.g. route planning, based on factors such as the actual Under Keel Clearance (UKC) of the vessel, its squat and optimised water depth along the route. Together these developments will significantly improve the environmental impact and economy of the shipping industry. But they all rely upon better base data. Besides hydrographic surveys and investments into the infrastructure needed for these, the FAMOS project encompasses activities that focus directly on the benefits for the end users of this digital maritime infrastructure: The project will lay foundations for highly accurate vessel navigation optimised with regard to UKC and vessel routes. It will also improve the production chain from survey to navigational chart, in order to provide the navigators with the most relevant, complete and up-to-date information as possible.

1: Swedish Maritime Administration, Norrköping, Sweden

Recent developments for an improved chart datum in the Baltic Sea

by: **Gunter Liebsch**[1], Joachim Schwabe[1], Wilfried Ellmer[2], Jonas Ågren[3], Jyrki Mononen[4]
Keywords: Baltic Sea | chart datum | geoid model | European Height Reference System (EVRS) | Baltic Sea Chart Datum (BSCD)

So far, nautical charts of the Baltic Sea are referenced to a large number of local, tide-gauge based vertical datums. Bathymetric data do not fulfil the requirements of a seamless data set due to the lag of a definition and realisation of an unique height reference frame for the whole Baltic Sea area. Therefore, the Chart Datum Working Group (CDWG) of the Baltic Hydrographic Commission proposed to thoroughly revise the charts based on a common and unified Baltic Sea Chart Datum (BSCD).The new chart datum shall be directly linked to the European Height Reference System (EVRS), which particularly facilitates applications in the coastal areas.
In the future, bathymetric surveys and improved navigation at sea shall be based on refined GNSS techniques also for the vertical component. For this purpose a precise model of the height reference surface – called chart datum in hydrography or geoid in geodesy – is needed. However, the available national and regional models are currently not precise and consistent enough. A unified and precise geoid model requires both unified modelling based on consistent standards as well as shipborne campaigns to collect precise marine gravity data. Therefore, establishing a geoid model which is suitable to realise the BSCD is one major pillar of "FAMOS Activity 2". In that context, "Activity 2" of the FAMOS project, which is co-financed in the frame of the Connecting Europe Facility (CEF) transport program of the European Commission, is concerned with the realisation of a modernised vertical datum in the Baltic Sea. Goals of "FAMOS Activity 2" are the collection of new gravity data over the Baltic Sea, the stimulation of a mutual data exchange, the validation of existing data and the computation of a geoid model with an accuracy of at least 5 cm by 2020.
The presentation describes the background and current developments for the realisation of the Baltic Sea Chart Datum 2000 (BSCD2000) in the frame of "FAMOS Activity 2". Special emphasis is put on the activities in the southern Baltic Sea.

1: Federal Agency for Cartography and Geodesy (BKG), Leipzig, Germany
2: Federal Maritime and Hydrographic Agency, Hamburg, Germany
3: Swedish Mapping, Cadastral and Land Registration Authority, Gävle, Sweden
4: Finnish Transport Agency, Helsinki, Finland

Session 5A

Space hydrography

The BASE-platform project: Deriving the bathymetry from combined satellite data

by: **Stefan Wiehle**[1], Bernat Martinez[2], Knut Hartmann[3], Martin Verlaan[4], Tim Thornton[5], Simon Lewis[6], Dick Schaap[7]
Keywords: remote sensing | earth observation | oceanography | bathymetry | data fusion

The project "BAthymetry SErvice platform" (BASE-platform) addresses the lack of available up-to-date, high-resolution bathymetry data in many areas of the world. With the increasing number of earth observation satellites, e.g. by the ongoing deployment of ESAs Sentinel fleet, remote sensing data of the oceans is widely available. BASE-platform's ambition is to use this data for creating bathymetric maps and supply them to end users.

Three sources of satellite information are combined in BASE-platform: optical, SAR and altimetry data. From optical satellite images, the water depth can be obtained by analysing the spectral changes of the seafloor. This method works in optically shallow waters only, where the seafloor contributes a detectable part of the measured signal. Farther from the coast, SAR bathymetry is used which detects changes of wave lengths in the ocean, indicating changes of the underlying bathymetry due to the shoaling effect. Information about deeper areas is then acquired from altimetry data. Altimetry satellites use radar signals to determine the height of the ocean surface below them. Changes in the bathymetry cause gravimetric distortions which influence the height of the sea surface; this allows a reproduction of underlying bathymetric features.

Additional input is gathered from crowd sourced data, providing depth information from a large number of ships and small craft along their regular tracks. These in situ measurements are also used for the calibration of EO data. With tidal modelling, all data are corrected for the tides during their respective acquisition time. By combining all these sources, a merged bathymetry product can then be created.

A major point of BASE-platform is the distribution to the user by a bathymetry data portal, where data will be available off-the-shelf as well as on demand. Adequate metadata will be provided along with the bathymetry so usability by the end user is ensured.

1: German Aerospace Center (DLR), Maritime Safety and Security Lab Bremen, Germany
2: isardSAT, Barcelona, Catalunya, Spain
3: EOMAP GmbH & Co. KG, Seefeld, Germany
4: Deltares, Delft, The Netherlands
5: Smartcom Software, Stockbridge, United Kingdom
6: Find Mapping Ltd, London, United Kingdom
7: MARIS BV, Voorburg, The Netherlands

Satellite based bathymetry and seafloor mapping for the shallow-water zone: Recent advances and applications

by: **Knut Hartmann**[1], Thomas Heege[1], Magnus Wettle[1], Julian Wenzel[1]
Keywords: satellite derived bathymetry | seafloor mapping | seafloor classification

Satellite Derived Bathymetry (SDB) and seafloor habitat mappings from multispectral satellite or airborne imagery play an increasing role to fill information gaps for the shallow-water and near-shore zones. In the last years, both, a significant progress in algorithm and process developments, and the utilisation of satellite mapping services in commercial applications has been done. Satellite Derived Bathymetry and seafloor mapping has proofed to support various data demands, such as rapid bathymetric data provision to aid navigation in uncharted waters, high-resolution mapping for charting or large-scale mapping for environmental and coastal zone management. The acceptance as mature technology and beneficial 'mapping tool' for the shallow-water zones significantly increased with a clear understanding of both, capabilities and limitations, and thus established quality assurance processes, service readiness and common standards. This presentation will focus on recent advances on the reduction and quantification of uncertainties. Real-world application examples will address the implementation of Satellite Derived Bathymetry and seafloor mapping for coastal planning, charting, reconnaissance mapping and seafloor classification.

1: EOMAP GmbH & Co. KG, Seefeld, Germany

Global bathymetry from satellite altimeter sensor

by: **Pau Gallés**[1], Maite Muñoz[1], Bernat Martínez[1], Eduard Makhoul[1], María José Escorihuela[1], Mònica Roca[1]
Keywords: bathymetry | satellite altimeter | gravity anomaly | geoid

Satellite altimetry derived bathymetry offers global coverage especially in deep waters where other techniques have strong limitations. The principle for estimating bathymetry from satellite altimetry is that topography impacts the earth gravitational field. The sea-mountains add an extra pull of the earth's gravitational field drawing more water around them and swelling of the sea surface to the outside.
The ocean surface can be modelled from satellite altimeter sensors which can be used to derive the geoid by filtering temporary effects on the surface such as tides and wind. Laplace equation helps to define a relationship between the gravity anomalies and the east and north vertical deflection gradients from the filtered surface. The formal gravitational potential definition can be easily related by Fourier transforms with submarine topography undulations therefore the calculation procedure for the global bathymetry from satellite altimeter is completed.
The satellite altimeter method is great for a range of bathymetric wavelengths between (~20 to ~200 km) which is suitable for mid-scale maps. However, undulations out of range are less reliable due to the upward continuation and isostatic compensation physical restrictions. The first phenomena can be explained by Newton's law of universal gravitation, where the gravity is attenuated by the square distance from the source meaning the small protuberances are not detected on water surface. On the other hand large submarine hills with high volumes are reaching the strength of the earth's outer layers. Hence irregularities are buoyant in the mantle leading to compensated gravity anomalies caused by the lack of high-density weight from the mantle replaced by lower-density material from crust. Thus bathymetry from different sources must be integrated in the final model to meet the wavelength range requirements depending on the map scale and the resolution for a specific user case.

1: ISARDSAT S.L., Barcelona, Spain

Sea state from high-resolution satellite-borne synthetic aperture radar imagery

by: **Andrey L. Pleskachevsky**[1], Stefan Wiehle[1], Sven Jacobsen[1], Claus Gebhardt[1], Björn Tings[1], Egbert Schwarz[2], Dietmar Krause[2], Thomas Bruns[3], Jens Kiese[3]
Keywords: remote sensing | oceanography | coastal processes | sea state | NRT | forecast

The Sea Sate Processor (SSP) was developed for fully automatic processing of high-resolution Synthetic Aperture Radar (SAR) data from TerraSAR-X (TS-X) satellites and implemented into the processing chain for Near Real Time (NRT) services in the DLR Ground Station "Neustrelitz". The NRT chain was organised and tested to provide the processed data to the German Weather Service (DWD) in order to validate the new coastal forecast model CWAM (Coastal WAve Model) in the German Bight of the North Sea with 900 m horizontal resolution. The NRT test-runs, wherein the processed TS-X data were transferred to DWD and then incorporated into forecast products reach the best performance about 10 min for delivery of processed TS-X data to DWD server after scene acquisition.
To do this, a new empirical algorithm XWAVE_C (C = coastal) for estimation of significant wave height from X-band satellite-borne SAR data has been designed for coastal applications. The algorithm is based on the spectral analysis of subscenes and the empirical model function yields an estimation of integrated sea state parameters directly from SAR image spectra without transformation into wave spectra. To provide the raster coverage analysis, the SSP intends three steps of recognising and removing the influence of non-sea-state-produced signals in the Wadden Sea areas such as ships, buoys, dry sandbars as well as nonlinear SAR image distortions produced by e.g. short and breaking waves.
For the validation, more than 150 TS-X StripMap scene sequences with a coverage of ~30 km × 300 km across the German Bight since 2013 were analysed and compared with in situ Buoy measurements from 6 different locations. On this basis, the SSP autonomous processing of TS-X Stripmap images has been confirmed to have a high accuracy with an error RMSE = 25 cm for the total significant wave height.

1: German Aerospace Center (DLR), Maritime Safety and Security Lab Bremen, Germany
2: German Aerospace Center (DLR), German Remote Sensing Data Center, Neustrelitz, Germany
3: German Meteorological Service (DWD), Hamburg, Germany

Session 5B

Nautical charting

Integration of bathymetric data management and chart production using dKart tools

by: **Justin Hornby**[1], John K. Klippen[1]
Keywords: dKart Office suite | data management

With the surge of modern bathymetric data acquisition technologies during the last few decades it has become a challenging task for national hydrographic offices to store, validate and prepare an ever growing volume of bathymetric information to be used in final products.
This paper highlights dKart Office suite solution of this problem with emphasis in dKart Bathy Manager, a software solution that Jeppesen has recently added to his dKart Office suite. It introduces the concept of seamless continuous bathymetric surface, making it possible to verify, combine and deconflict individual survey models in a flexible manner into more complex continuous models which are then processed into bathymetric products.
dKart Bathy Manager is a database-driven solution allowing for the storage and management of bathymetric data; it supports the bathymetric workflow from import of survey data to the generation and maintenance of continuous bathymetric models.
The paper also describes how Bathy Manager can be used as stand-alone solution, but is also dynamically integrated with other dKart Office suite tools for the compilation and validation of National ENCs and Paper Charts products.

1: C-Map, Norway

ENC and ECDIS

by: Peter Dugge[1], **Niels Horneburg**[1]
Keywords: ENC | ECDIS | bathymetry | zooming in

Electronic Navigational Charts (ENC) and Electronic Chart Display and Information Systems (ECDIS) are typically created at different places:

- ENCs by various Hydrographic Offices,
- ECDIS by various industrial ECDIS manufacturers.

When in use, ENCs and ECDIS form a closely interconnected "community" with its members strongly dependent on each other when creating results which aim to support the navigator as efficiently as possible.

Recognising the complexity of the standardisation task a great deal of success has been achieved in creating a worldwide community of producers and users of ECDIS and ENCs providing a global coverage for the international maritime community.

However – not surprisingly – gaps exist between worlds of ENCs and ECDIS with regard to the standards and methods applied when producing and using ENCs and ECDIS.

The presentation discusses some effects not foreseen by some stakeholders when using ENC with ECDIS, namely when handling

- information on detailed bathymetry in small to medium scale charts,
- unsurveyed patches within charted areas,
- vanishing chart details when zooming in on ECDIS.

Some of these discrepancies between the worlds of ENCs and ECDIS have the potential to mislead the navigator.

It is hoped that the presentation contributes to the harmonisation efforts of the maritime community to lessen the gaps between the worlds of ENC and ECDIS. Further it would be appreciated if the presentation would contribute to the usability of ENCs not only with ECDIS but in other environments such as tactical displays, too.

1: ATLAS ELEKTRONIK GmbH, Bremen, Germany

Charts on demand: A potential new revenue stream for hydrographic agencies

by: **Kevin J. Ingram**[1]
Keywords: fit-for-purpose nautical charts | not-for-navigation charts | automation

The production of official, suitable-for-navigation paper charts has been an expensive process, requiring expert nautical cartographers who spend weeks or months finishing a chart. Recent innovations in GIS technology now allow many aspects of this process to be automated, reducing the amount of manual finishing required. Meanwhile, hydrographic agencies are being forced to make do with smaller budgets each year. This trend is compounded when the agency is expected to take on additional missions, essentially forcing them to do more with less. An example of this is the requirement to produce additional types of products, such as not-for-navigation charts that are suited for other purposes, in addition to their traditional navigation products. Fortunately, the same technological innovations that have streamlined the production of official paper charts can be used in a system to produce these new product types. In fact, the technology has now reached the point where an agency can implement a fully-automated system for producing fit-for-purpose nautical charts. Such a system will enable an agency to reach new market segments and generate revenues from products designed specifically for those new users.

1: Esri, Redlands, CA, USA

Session 6A

Energiewende – Challenges in the wind offshore business

Use of a GNSS RTK system in a North Sea offshore wind farm

by: **Marc Itgen**[1], Jürgen Rüffer[2]
Keywords: GNSS RTK system | offshore wind farm

Since a couple of years ALLSAT GmbH from Hannover operates a GNSS RTK system for precise positioning and navigation for the installation and operation of offshore wind farm infrastructure in the North Sea. The assigning consortium of Vattenfall Europe Windkraft GmbH and Stadtwerke München currently owns and operates the wind farms of DanTysk and Sandbank ca. 90 km west of the island of Sylt.

The presentation describes the requirements of the owners for such a system as well as the realisation of a redundant RTK system outside of existing GNSS services (e.g. SAPOS, AXIO-NET). In particular the characteristics of such installation and operation as well as numerous utilisations of the system and the cooperation of the owners and various service providers will be focused.

1: Vattenfall Europe Windkraft GmbH, Berlin, Germany
2: ALLSAT GmbH, Hannover, Germany

The challenge of choosing the right method for surveying power cables

by: **Oliver Anders**[1], Manfred Stender[1]
Keywords: cable tracking | depth of burial | HVAC/HVDC | survey power cables

The rising number of wind parks, and thus the demand for new survey tasks, results in continuous development for companies working in the renewable energy sector. Building a wind park requires laying inter-array and export cables. Those cables are buried or covered to protect them, bringing environmental changes to a minimum. A common depth of burial ranges from 1.5 m to 3 m. The challenge of surveying those buried power cables is choosing the right method.

The method involves choosing between a broad field of sensors, techniques, vehicles and software. All claiming to fulfil the task but often lacking in details. The standard equipment used by the industry to survey alternating or direct current or out of service cables, consists of magnetometers, gradiometers, active pulsing, passive detection and acoustic systems.

Different systems are shown that are capable of detecting different types of cables. The challenging part of choosing the right method will be discussed, presenting surveys conducted by Fugro OSAE GmbH demonstrating variable survey conditions on different cable systems and the impact on results. Asymmetric EM fields, radiated by a multi-core cables system may need additional care during the processing and interpretation of data, as common survey systems assume a radial symmetric field as a signal source. The reasons and solutions will give the audience up-to-date information that comprehensive metadata information is needed beforehand to conduct and deliver reliable results. Furthermore, a new approach by determining the depth of burial is shown using seabed difference calculations that result in inverse depth of burial information. The new inversed depth of burial approach is faster and can reduce costs if planned in advance.

1: Fugro OSAE GmbH, Bremen, Germany

Burial depth determination of cables using acoustics – Requirements, issues and strategies

by: **Jens Wunderlich**[1], Jan Arvid Ingulfsen[2], Sabine Müller[1]
Keywords: detection of buried objects | acoustic cable tracking | depth of burial surveys

In the oil/gas business surveys to obtain the depth-of-burial (DOB) of pipelines and cables are done on a regular basis. DOB surveys shall determine the exact position and burial depth of the pipeline or cable directly after dredging and later in regular intervals during it's entire lifetime. With expanding offshore wind farming in the wake of the "Energiewende", site explorations, route and cable DOB surveys become increasingly important in this offshore sector, too. Various geophysical methods like magnetic, electromagnetic and acoustic sensors are used to detect and track buried cables. This paper will consider acoustic technologies only.
For best detection probability of buried cables to date often lines crossing the expected cable route are surveyed. Although this is a good method to detect the cable and get its position, survey companies require more efficient technologies, accounting for both, operational and processing costs. Thus they are looking for easy to operate technologies that follow the cable along its actual route, work at different water depths, weather and seabed conditions and give immediate and reliable results to produce deliverables with high accuracy of XYZ cable positions. Following the cable requires a sufficient survey corridor and real-time cable tracking to avoid the cable falling out of this corridor. Different cable properties like diameter, shape and material, the survey-vehicle's speed and environmental conditions like noise level, weather and type of seabed have to be taken into account.
This paper summarizes user requirements for DOB surveys, identifies limitations of currently used acoustic technologies and discusses different approaches to overcome these issues. Application of the methods shown is not limited to cable DOB surveys, they may also be used for pipeline surveys or other activities during construction and maintenance of offshore structures, e.g. to detect boulders, UXO or other debris during site and route surveys.

1: Innomar Technologie GmbH, Rostock, Germany
2: Swire Seabed AS, Norway

Offshore unexploded ordnance recovery and disposal

by: **Jan Kölbel**[1], David Rose[1]
Keywords: UXO | unexploded ordnance | investigation | recovery | disposal | offshore | underwater positioning

Millions of tons of unexploded ordnance (UXO) and discarded explosive remnants from war can be found in European waters and beyond. Many of them are next to the shoreline, dispensing toxics to the environment. Dumping of ammunition, military practice and warfare are the main source for this large amount posing a risk for the offshore industry besides the undeniable impact this also causes to the environment. With increasing utilisation of offshore areas, the activities in offshore UXO clearance have increased. Due to the governmental commitment and planning of increased usage of offshore wind energy in Germany, research has been conducted to solve the technical question of unexploded ordnance recovery and disposal.

Within the last five years, the market for offshore UXO detection and removal has multiplied as well as experience increased, research has also lead to better analytical results during the UXO survey campaign which has helped achieve fewer false alarms. Better techniques and the development of specialist equipment for the removal results in smaller time frames in which the clearance can be done as well as lower risk for equipment and personnel. Research is also being conducted on how to handle ammunition safely which is classified as not save to transport without the normal demolition procedure.

1: Boskalis Hirdes EOD Services, Hamburg, Germany

Session 7A

LiDAR case studies for hydrographic assessments

High-resolution, topobathymetric LiDAR coastal zone characterisation in Denmark

by: Frank Steinbacher[1], Ramona Baran[1], Mikkel S. Andersen[2], Zyad Al-Hamdani[3], Laurids R. Larsen[4], Martin Pfennigbauer[5], Verner B. Ernsten[2], **Markus Aufleger**[6]
Keywords: topobathymetry | LiDAR | coastal zone

Coastal and tidal environments are valuable ecosystems, which, however, are under pressure in many areas around the world due to globalisation and/or climate change. Detailed mapping of these environments is required in order to manage the coastal zone in a sustainable way. However, historically these transition zones between land and water are difficult or even impossible to map and investigate in high spatial resolution due to the challenging environmental conditions. The new generation of airborne topobathymetric light detection and ranging (LiDAR) potentially enables full-coverage and high-resolution mapping of these land-water transition zones. We have carried out topobathymetric LiDAR surveys in the Knudedyb tidal inlet system in the Danish Wadden Sea and the Rødsand lagoon connected to Fehmarnbelt. The overall aims are to: (i) derive characteristic properties of the morphology, surface sediment, the vegetation and the water column in land-water transition zones like rivers, lakes, wetlands, estuaries and coasts; (ii) improve the understanding of the dynamics of these properties in shallow water ecosystems, which are under pressure due to changing environmental conditions driven by climate change; and (iii) develop tools for quantifying geological resources, habitat distributions and system-indicators in land-water transition zones, developed in and for a GIS in order to optimise application by end-users. Here, we present the preliminary results of these two surveys which were carried out at two locations with different environmental settings. We demonstrate the potential of using airborne topobathymetric LiDAR for seamless mapping of land-water transition zones in challenging coastal environments, e.g. in an environment with high water column turbidity and continuously varying water levels due to tides as well as in an environment characterised by a very heterogeneous surface sediment composition.

1: Airborne HydroMapping GmbH, Innsbruck, Austria
2: Department of Geosciences and Natural Resource Management, University of Copenhagen, Denmark
3: Geological Survey of Denmark and Greenland (GEUS), Copenhagen, Denmark
4: NIRAS, Allerød, Denmark
5: RIEGL Laser Measurement Systems GmbH, Horn, Austria
6: Department of Hydraulic Engineering, University of Innsbruck, Innsbruck, Austria

Analysis and modelling of the effect of wave patterns on refraction in airborne LiDAR bathymetry

by: **Patrick Westfeld**[1], Katja Richter[1], Hans-Gerd Maas[1], Robert Weiß[2]
Keywords: airborne LiDAR bathymetry | refraction | wave pattern | water surface modelling | accuracy analysis

Airborne LiDAR bathymetry (ALB) is a technique to derive the underwater topography by airborne laser scanning, provided shallow water areas and sufficient water transparency. It is recently gaining much attention both due to new sensor developments allowing for a much higher spatial resolution in scanning riverbeds and due to EU regulations requiring hydrographic measurements in water bodies at regular time intervals.
Geometric modelling in ALB data processing is more complex than in conventional laser scanning. Refraction effects of the laser pulse passing the air/water and water/air interfaces have to be taken into consideration. The simplest method is assuming a horizontal and planar water surface at which the laser beam is refracted on the basis of Snell's Law. Even small deviations from the planarity, already caused by moderate swell, can lead to significant measurements errors. Strictly speaking, the local wave-induced water surface inclination needs to be known for every single laser beam. Otherwise wave movements lead to a geometric displacement of the point hit at the bottom of the water body. This effect can take on significant dimensions in the meter range, depending on water depth and wave heights.

This contribution investigates the effect of wave patterns on refraction and subsequently on coordinate accuracy in ALB. For that purpose, typical wave patterns were simulated and their impact on the 3D coordinates at the bottom of the water body were analysed. It has been shown that, depending on water depth and wave heights, the effect on lateral bottom point displacement can take on significant dimensions in the range of several decimetres, in some cases even several meters. Furthermore, local depth errors in decimetre range have to be taken into consideration. The simplified assumption of averaging wave effects often made in many (large footprint) ALB applications is not fulfilled. The effect scales up for modern LiDAR bathymetry systems, which came with much smaller footprints and cannot be neglected in most situations.
There are basically two methods for reducing these coordinate errors: A strict procedure would require modelling the instantaneous water surface in order to perform a strict differential ray tracing for each laser pulse. This will often not be possible due to insufficient information for instantaneous water surface modelling. As an alternative, correction terms may be applied for typical wave patterns, which may be derived from the simulations shown in the paper.

1: TU Dresden, Institute of Photogrammetry and Remote Sensing, Germany
2: German Federal Institute of Hydrology, Koblenz, Germany

Use of laser bathymetry at the German Baltic Sea coast

by: **Wilfried Ellmer**[1]
Keywords: ALB | laser bathymetry | Baltic Sea

In order to study the recent technological development in laser bathymetry, and to investigate its usability for hydrographic surveying in the Baltic Sea, the BSH (Bundesamt für Seeschifffahrt und Hydrographie) executed a three-year scientific project. The German Coastal Waters are quite shallow. The idea arose to use airborne laser bathymetry (ALB) for hydrographic surveying of near-shore areas of the German Baltic Sea. Since these waters are relatively turbid, it became necessary to investigate to what extent modern ALB systems can be of practical use in an area large enough for hydrographic purposes especially in the Baltic Sea. The basic question to be answered by the project was: Which areas can be measured by this method, and how expensive will this be in relation to traditional methods?
From 2012 to 2014, four test surveys have been accomplished in an area north of Wismar. During these surveys, many relevant questions have been solved. In the accompanying scientific studies, turbidity measurements were evaluated in order to expand the findings from the test area to the whole German Baltic Sea coast. Thus, it could be estimated which areas were candidates for future bathymetric airborne laser scanning projects.
The main conclusion is that bathymetric airborne laser scanning will not replace traditional hydrographic surveys as such, but will be an important supplement in shallow areas with minor importance for mariners. ALB has its advantages in these areas to derive a full coverage survey with fewer costs compared to hydroacoustic methods in shallow near shore waters. Disadvantages like poor object detection and seasonal dependencies have to be taken into account. Special attention has been paid to a sophisticated data processing. For a cost-effective use of ALB in the areas in question, a collaboration of different agencies and users is essential.

1: Federal Maritime and Hydrographic Agency, Germany

Coastal protection:
New techniques in capturing and modelling of morphological data

by: **Lutz Christiansen**[1]
Keywords: coastal protection | LiDAR bathymetry | morphological data model | Coons patches

Schleswig-Holstein, the most northern state of Germany, is placed between the Baltic Sea at the east side and the North Sea at the west side of the state. Due to the fact that the Schleswig-Holstein parts of these water bodies are mainly shallow water areas, the conditions for surveying the coastal areas from the coastal protection structures down to the seafloor are difficult on both seas.
Since 2014 the techniques of LiDAR bathymetry have been used for capturing morphological data. The green light of the bathymetric LiDAR is able to penetrate into the water. The reachable depths depend on the turbidity of the waterbody. Therefore, the power of the systems is described as a factor of Secchi-depths. The local turbidity value multiplied with this factor allows estimating the reachable depth. In Schleswig-Holstein round 2,000 km² have already been surveyed with these techniques. Bathymetric LiDAR provides the results that are expected in depths as well as in accuracy.

Using these techniques data gaps only occur locally in tideways or low-lying areas, which are needed to be filled by hydrographic surveys. But compared with the bathymetric LiDAR, these surveys have a substantially lower density of points. Hence, it is difficult to merge these data to a morphological model. As a consequence it is necessary to densify the hydrographic data to create a homogeneous model. The mathematical method of Gordon-Coons-patches is suitable for this purpose. The gaps inside the area of hydrographic survey are filled with data points in desired density. The bathymetric information is then calculated using bilinear interpolation.
As result a data set which has a similar point density as the bathymetric LiDAR is created. After the preparation a homogeneous morphological model can be generated by triangulation, based on bathymetric LiDAR on the one hand and hydrographic surveys on the other hand.

1: Schleswig-Holstein Agency for Coastal Defense, National Park and Marine Conservation (LKN), Husum, Germany

Object detection by ALB

by: Mark Sinclair[1], Dariusz Lejtman[1], **Hugh Parker**[1]
Keywords: ALB | object detection

Object detection by Airborne LiDAR Bathymetry (ALB) requires a number of criteria to be satisfied: the data must be dense enough to illuminate a particular feature, the laser power, water clarity, depth of water, object reflectivity and receiver sensitivity must be adequate to detect the feature, processing software needs to be able to select the feature and processes including quality control systems need to be in place to retain the feature and discriminate seabed features from noise.
Object detection is specified for IHO Order 1a and Special Order Hydrographic surveys and object detection is often included in scopes of work for hydrographic surveys. However, ALB object detection requirements are often not clearly specified, or requirements from acoustic surveys are incorrectly used.

This paper examines the empirical results of ALB object detection trials, in particular the results of detecting 1 m and 2 m cubes. It reviews the requirements for ALB object detection and proposes an appropriate scope of work for object detection by ALB.

1: Fugro LADS Corporation, Kidman Park, South Australia

Session 8A

State-of-the-art GNSS techniques

8A1	*Hans Visser et al.*	Fugro Marinestar G4+ GNSS PPP-RTK improvements for offshore applications
8A2	*Faisal Alsaaq et al.*	Filtering methods to extract the tide height from Global Navigation Satellite Systems (GNSS) signals for hydrographic applications
8A3	*Thomas Artz et al.*	Improved positioning of surveying vessels on inland waterways with HydrOs

Fugro Marinestar G4+ GNSS PPP-RTK improvements for offshore applications

by: **Hans Visser**[1], Dariusz Lapucha[2], Javier Tegedor[3], Ole Ørpen[3], Yahya Memarzadeh[1]
Keywords: GPS |Glonass | Beidou | Galileo | PPP-RTK | Marinestar

Marinestar offers satellite-based GNSS correction services over the world. An overview of the minimum and maximum number of usable satellites in August 2016 is given: GPS (6-13 satellites), Glonass (4-10 satellites), Beidou (0-13 satellites) and Galileo (0-5 satellites).
Since 2006 Marinestar provides precise orbit and clock corrections for GPS. Glonass was added in 2009 and Beidou in 2014. Galileo will be added when "Early Services" is declared. Improvements in the height accuracy from 20 cm in 2011 to 10 cm in 2016 is shown. Here the G4+ service using all four GNSS constellations with fixed GPS ambiguities is introduced.
A description is given of the PPP-RTK algorithm. GPS satellite hardware delays (UPDs) are measured using an independent network of 110 reference stations. Using another network of 46 reference stations orbit and clock errors are estimated. Improvements are realised by applying the UPDs to GPS and adding Glonass, Beidou and Galileo to the solution. A study on the age of corrections shows that the age can be extended to 10 minutes.
Investigating the minimum elevation mask shows that reducing the mask improves availability and accuracy during ionospheric scintillation and local blockage. For the hydrographic surveyor error sources of G4+ as radio interference, rain, local multipath and antenna type are discussed.
It is shown that G4+ gives standard deviations of 2-3 cm in east and north and 4-5 cm in height. Fixing the ambiguities improves the standard deviations between 10 % and 20 %.

1: Fugro Intersite BV, Leidschendam, The Netherlands
2: Fugro Chance Inc., Lafayette, USA
3: Fugro Satellite Positioning AS, Oslo, Norway

Filtering methods to extract the tide height from Global Navigation Satellite Systems (GNSS) signals for hydrographic applications

by: **Faisal Alsaaq**[1/2], Ahmed El-Mowafy[1], Michael Kuhn[1], Paul Kennedy[3]
Keywords: GNSS height observation | sea level height | tide signal | filtering methods

Hydrographic surveys have traditionally relied on the availability of tide information for the reduction of sounding observations to a common datum where the datum derived from a certain phase of the tide. In most cases, tide information is obtained from tide gauge observations and/or tide predictions over space and time using local, regional or global tide models. While the latter often provides a rather crude approximation, the former relies on tide gauge stations that are spatially restricted and often have sparse and limited distribution. A more recent method that is increasingly being used is Global Navigation Satellite System (GNSS) positioning which can be utilised to monitor height variations of a vessel or buoy, thus providing information on sea level variations during the time of a hydrographic survey. In this study, a different type of filtering methods to extract the tide signal from GNSS height observation has been applied and compared. The GNSS heights were estimated by using data collected by a Fugro Starpack GNSS receiver installed on a floating pontoon at Hillarys Boat Harbor, Western Australia. The receiver recorded continuously both (GPS and Glonass) signals for 30 days. Sea level heights determined by a traditional tide gauge at Hillarys were used as a reference to evaluate the effectiveness of using GNSS height in extracting the tide signal. A high degree of agreements of the tide information obtained by GNSS and the tide gauge was found in the time domain, with correlation coefficients of up to 0.98. Different low pass filters (Moving averaging, Savitzky-Golay, Gaussian, Zero-Phase and 1-D digital filters) were implemented to eliminate high-frequency components due to waves and the dynamic draft. Amplitudes and phases of the four major of tidal harmonic constituents (M2, S2, K2, and O1) were determined by spectral analysis and compared to model predictions. The standard deviation of the residuals between the GNSS heights and tide gauge signals was less than 5 cm. This level of positioning is proportional with International Hydrographic Organization (IHO) Special Order of hydrographic surveys.

1: Department of Spatial Sciences, Curtin University, Australia
2: Hydrographic Surveying, Faculty of Maritime Studies, King Abdulaziz University, Saudi Arabia
3: Fugro Survey Pty. Ltd., Australia

Improved positioning of surveying vessels on inland waterways with HydrOs

by: **Thomas Artz**[1], Annette Scheider[2], Marc Breitenfeld[1], Thomas Brüggemann[1], Volker Schwieger[2], Harry Wirth[3]
Keywords: positioning | extended Kalman filter | GNSS | hydrographic multi-sensor system | outlier testing

Surveying vessels on German federal waterways are equipped with Global Navigation Satellite System (GNSS) receivers or GNSS-INS (Inertial Navigation Systems) coupled systems respectively to determine their position. By receiving and processing a correction signal which is provided by a network of continuously operating reference stations (CORS), they determine a precise GNSS real time kinematic (GNSS-RTK) solution. Thereby, the data being captured by multibeam echo-sounders can be georeferenced, and a map of the channel bottom can be produced.
One crucial point of the entire workflow is the quality of the vessel positions, i.e., the GNSS-RTK solution, which is highly influenced by the surrounding topography. For instance, bridges, buildings, vegetation or narrow valleys can cause multipath effects, refraction or even a complete loss of signal reception (shadowing). In many cases, it is also not possible to receive the correction signals. Then, no RTK solution can be determined. To mitigate such gaps in the GNSS-RTK trajectory, the Integrated Hydrographic Positioning System (HydrOs) was developed, which consists of hardware components on the vessel as well as of software being able to record and analyse dedicated measurements.
The hardware component represents an adjustable multi-sensor system, which includes one or multiple redundant GNSS receivers and an Inertial Measurement Unit (IMU). In addition, a compass, and a Doppler Velocity Log (DVL) are installed. Furthermore, information about the turning rates and the direction of the rudder propellers, as well as a model of water gauge can be connected to the system. For processing the measurements of the sensors and the model data, a software component has been implemented by using an Extended Kalman Filter and complementary outlier tests.
The investigations presented in this paper lead to an actual installation of a HydrOs prototype on vessel. The position could then be derived with a maximal deviation of less than 1 dm for the height component and less than 2 dm for the horizontal component, although GNSS measurement gaps of up to 60 s occurred.

1: German Federal Institute of Hydrology, Koblenz, Germany
2: Institute of Engineering Geodesy, University of Stuttgart, Germany
3: Jade University of Applied Sciences, Oldenburg, Germany

Session 8B

Education

8B1	*Johan Stam*	Changing market requirements for competence and certification for the hydrographic surveyor
8B2	*John McDonald*	Changing careers with distance eLearning – from Royal Marine to Hydrographer
8B3	*Nicolas Seube*	The new Standards of Competence for hydrographers and nautical cartographers

Changing market requirements for competence and certification for the hydrographic surveyor

by: **Johan Stam**[1]
Keywords: Category B course | e-learning | Skilltrade

The maritime industry is becoming more aware of certification and competence related standards, the benefits of completing a recognised training programme are greatly increasing. The demand is confirmed by market indications in subcontracting as well as in tenders.
Requirements published by the FIG-IHO-ICA International Board on Standards of Competence dictate that the Category B program is under continuous revision. Also IMCA and ICES provide more detailed guidelines. Therefore, clients and individuals are now searching for more training support to confirm their knowledge, next to their experience.
Skilltrade offers a relatively short Hydrographic Survey Category B programme, of 30 weeks. The course starts with our 3 e-learning modules: Bathymetry, Geodesy, and Global Navigation Satellite Systems (GNSS). Evidence supports that e-learning has proven to be an effective and flexible way to expand the student's knowledge prior to their in-classroom experience.
Skilltrade is committed to supporting students throughout their e-learning activities via e-mail and group video calls. In addition, progress is monitored through interactive questions, tasks, and assessments. And while the e-learning modules were initially designed to be part of the Category B course, we believe that all individuals associated with hydrography can benefit by enrolling and completing them regardless.
After successfully completing the e-learning modules, the student can participate in a 12-weeks training on location in Ijmuiden, which runs twice a year.
Once students arrive in Ijmuiden they can expect the Hydrographic Survey Category B course to be fully intertwined with field trips, workshops, and guest lecturers by individuals associated with the Hydrographic Industry and Governmental Hydrographic Departments.
After completion of the 13-week theoretical course in IJmuiden the student needs to gain at least 4 weeks experience in a fully supervised Field Training Project (FTP) in a qualified survey organisation.
In addition to the aforementioned, Skilltrade publishes the 3 volume Handbook of Offshore Surveying, and the GPS Handbook for Professional GPS Users.

1: Skilltrade, Voorschoten, The Netherlands

Changing careers with distance e-learning – from Royal Marine to hydrographer

by: **John McDonald**[1]
Keywords: Marine Learning Alliance (MLA) | education | e-learning | Plymouth University | IMarEST

Technological developments and innovation within the hydrographic industry today mean that students wishing to enter the profession are expected to have completed an industry recognised academic degree level programme, ensuring they graduate with appropriate levels of education, training and practical survey expertise to achieve the fundamental competence of conducting and operating hydrographic surveys in the field. Traditional routes into the industry would typically require a student to attend a full-time programme which requires a commitment of up to 3 years for an undergraduate and 12 months for a postgraduate programme. Whereas this may be a realistic possibility for a graduate or school leaver, this is quite often an unrealistic approach for a working professional with financial commitments seeking a career change.

As a Royal Marines Commando of 17 years I am very close to making the transition into a second career in hydrography. This profession caught my attention through involvement with the UK task group carrying out maritime operations in support of Operation GRITROCK in West Africa as part of the global effort to contain the Ebola crisis. The survey and reconnaissance aspects of Operation GRITROCK involved finding safe passage through the uncharted rivers of Sierra Leone, an aspect of the operation that was both interesting and rewarding and something that has inspired a future career on completion of military service.

Following research into the civilian hydrographic profession it became clear that to become a hydrographic surveyor would require many years of full-time study. Fortunately through association with the Royal Navy, it became apparent that a distance learning option was available with Marine Learning Alliance (MLA), working in partnership with Plymouth University and the IMarEST.

This paper will describe my own experiences of hydrography as a Royal Marines commando and how myself and fellow military personnel can use their experience coupled with the opportunities that enrolling on e-learning hydrography courses brings in carving out a second career in the hydrographic profession.

1: 4 Assault Squadron Royal Marines, Plymouth, UK

The new Standards of Competence for hydrographers and nautical cartographers

by: **Nicolas Seube**[1]
Keywords: Standards of Competences | Category A | Category B | S-5A | S-5B | IBSC

The accepted international minimum competency standards for hydrographic surveyors and nautical cartographers have served the profession well, but since 2012, they have been under review against changed expectations from the hydrographic community. The International Board for Standards of Competences of Hydrographers and Nautical Cartographers (IBSC) worked on the new Standards development plan, as adopted by the IHO. The outcomes of this work is a separation of the S-5 Standard in two different standards for Category B and Category A corresponding to two levels of competences and associated hydrographic practice. These two standards were developed in terms of content and intended learning outcome.
This conference will present the new S-5B and S-5A, adopted by the IHO in 2015 and 2016, and which are in force since January 2016 (S-5B) and September 2016 (S-5A).

1: CIDCO – Interdisciplinary Centre for the Development of Ocean Mapping, Rimouski, Québec, Canada

Session 9A

Hydrography in extreme environments

9A1	*Melanie Barth*	Case study: The search for Malaysian Airlines flight 370
9A2	*Natália Hurtós et al.*	Forward looking sonar mosaicing: A new approach for underwater inspection in low visibility conditions
9A3	*Max Abildgaard*	Simulation based design & development of autonomous underwater vehicle IMGAM
9A4	*Wilhelm Weinrebe et al.*	Multibeam mapping of remote fjords in Southeast-Greenland – A survey on a vintage vessel

Case study:
The search for Malaysian Airlines flight 370

by: **Melanie Barth**[1]
Keywords: aircraft search | ultra-deep survey | deep-tow system | Indian Ocean

Even today, hydrographic surveys can reach the boundaries of what is technically possible and project sizes as presented in this case study will push our ingenuity. The size-challenge can be defined by the extent of the project area, the water depth, the number of vessels/equipment involved, the data volume or all of the above.

On 8 March 2014 the Malaysian airplane MH370 scheduled on a flight from Kuala Lumpur to Bejing with 239 people on-board went missing. This tragedy started a marine search and rescue mission, which turned later into the largest aircraft accident investigation in history. This case study presents a summary of the underwater search of this investigation.

The mainly uncharted search area in the southern Indian Ocean of 120,000 square kilometres reaches water depths of up to 6,000 metres. The operation was planned in three phases: a deepwater multibeam survey to map the seafloor and enable a detailed search, the detailed survey to find the aircraft, and at last a recovery survey. Fugro was involved with four vessels in phase 1 and 2 of the project.

Main challenges for the operation were:

- Size of the investigation area,
- Remote location of the search zone and its fairly unknown morphology,
- Water depths of up to 6,000 metres,
- Weather conditions in the Indian Ocean with recorded heave up to 17 metres,
- Data volume (reaching Petabytes) to be processed and a requirement to enable quick access to data for processing centres in various locations,
- Technology requirements, including deep sea rated AUVs and deep-tow systems.

1: Fugro NV, Leidschendam, The Netherlands

Forward looking sonar mosaicing: A new approach for underwater inspection in low-visibility conditions

by: **Natàlia Hurtós**[1], Pere Ridao[1]
Keywords: forward-looking sonar | mosaicing | mapping

Vehicle operations in underwater environments are frequently compromised by poor visibility conditions. The perception range of optical devices is heavily constrained in turbid waters, thus often complicating navigation and mapping tasks in environments such as harbours, bays, or rivers. A new generation of high-frequency forward-looking sonars that provide acoustic imagery at near-video frame rates have recently emerged as a promising alternative for working under these challenging conditions.
We have proposed an end-to-end mosaicing framework tailored to the characteristics of forward-looking sonar imagery in order to build consistent overviews of underwater areas regardless of water visibility. Our solution targets versatility: it enables the generation of acoustic mosaics that involve roto-translational motions and comprise different vehicle tracklines; it is suitable for a wide range of scenarios, from feature-rich areas to environments with scarcity of features; it can be applicable on data collected with minimally instrumented vehicles; and it allows both offline and real-time operation. Moreover, the resulting mosaics provide a significant improvement of the signal-to-noise ratio and resolution with respect to the individual sonar images.
The presented system stands up as a valuable tool for short-range high-resolution acoustic mapping (up to centimetre level, depending on the employed sonar) but also opens new avenues for more challenging applications. The capability of being localised within a real-time generated acoustic map of the seafloor holds great potential for providing visual support to ROV pilots under low-visibility conditions (to ensure coverage of the area and immediate location of targets of interest), or in general to any AUV or ROV application that can benefit of context awareness regardless of the visibility conditions.
The proposed framework has been validated with several experiments in the context of relevant field applications such as harbour monitoring or mapping of underwater archaeological sites.

1: Girona Underwater Vision and Robotics, Girona, Spain

Simulation based design & development of autonomous underwater vehicle IMGAM

by: **Max Abildgaard**[1]
Keywords: IMGAM | AUV system design | simulation model

IMGAM is an autonomous underwater vehicle designed for autonomous gas flare detection, localisation, and sampling. It employs sensor reactive behaviour throughout the various autonomous phases of a mission. Such behaviour has an inherent risk of "wrong" decisions with potential catastrophic consequences. Therefore, care must be taken to ensure a thorough understanding of how the vehicle reacts to external stimuli and to itself. For highly complex systems, such understanding can best be achieved by broadly measuring or estimating performance of all known subsystems and by combining this knowledge into an overall simulation model. This model can then be used for development and testing of control algorithms and autonomy behaviour. In IMGAM, Matlab/Simulink® has been used as tool for such a model, which now features both virtual reality visualisation and real-time manual user interfaces for testing overall pilot-in-the-loop behaviour during hybrid AUV/ROV-mode operation.

Using highly detailed models has an inherent risk that sub-model inaccuracies distort overall model performance. This is best mitigated by identification and validation against measured real vehicle performance. Unfortunately, optimisation of models with high level of detail is often too complex for trial-and-error methods. Development work in IMGAM therefore employs system identification procedures and software that were originally developed for identification of highly complex systems in aviation. By maintaining and developing a model in parallel with system design, it has been possible to perform extensive tests of vehicle, controller, and autonomy performance. This has allowed ATLAS ELEKTRONIK GmbH to identify risks and necessary system improvements long before the first metal was cut. Furthermore, automatic code generation of controller and autonomy algorithms has facilitated easy and trouble free integration into ATLAS MARIDAN's highly proven AUV-core system that forms the vehicle's back-bone.

The paper will discuss the subjects mentioned above in greater detail. It will also discuss test results and lessons learned during trials (planned for late summer 2016).

1: ATLAS ELEKTRONIK GmbH, Bremen, Germany

Multibeam mapping of remote fjords in Southeast-Greenland – A survey on a vintage vessel

by: **Wilhelm Weinrebe**[1], Kristian K. Kjeldsen[2]
Keywords: multibeam mapping | South-East Greenland | vintage survey vessel | Timmiarmiut-Fjord | Skjoldungen-Fjord-System

The fjords of Southeast-Greenland are among the most remote areas of the northern Hemisphere. Access to this area is hampered by a broad belt of sea ice floating along the East-Greenland coast from north to south. Consequently, the majority of those fjords have never been surveyed until now. During an expedition by the Center of GeoGenetics of the University of Copenhagen in summer of 2014 we were able to map the Skjoldungen Fjord system with multibeam bathymetry. The topsail schooner "ACTIV", built 1951 as a cargo ship to supply remote settlements in Greenland was chosen for the expedition. Though a vintage vessel, the "ACTIV" was well suited to cross the belt of sea ice and to cruise the ice covered fjords. A portable ELAC-Seabeam 1050 multibeam system was temporarily installed on the vessel. The two transducer of the system were mounted at the lower end of a 6 m long pole attached outboard at port side. Though the installation was quite demanding without any winches or cranes, the construction was sufficiently stable and easy to manage throughout the entire cruise.

The area which was mapped had never been surveyed before using a multibeam system, furthermore, for great parts of the region no sounding information were available at all. The conditions for multibeam surveys in this area and particularly on this cruise were difficult, and of course this has actually affected the quality of the data. Anyhow, the results of the multibeam surveys clearly demonstrate that it is actually possible using a ship such as the "ACTIV" and a temporary installation to achieve bathymetric maps of satisfactory quality even under difficult conditions in remote areas.

1: GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany (retired)
2: Centre for GeoGenetics, Natural History Museum, University of Copenhagen, Denmark

40+

YEARS OF HYDROGRAPHIC EXPERIENCE

Fugro's hydrographic and geophysical surveys inform energy, construction and mining projects around the world.

Our high resolution, large area multibeam surveys - facilitated by Fugro's precise positioning services - deliver IHO compliance, whilst our desktop studies and detailed surveys of cable routes, pipelay and subsea infrastructure, enhance the safety and efficiency of your project.

Fugro OSAE GmbH
+49 4212 239150
info@fosae.de
www.fugro.com
www.fosae.de

Session 10A

Nautical depth and new survey vessels

10A1	*Norbert Greiser*	Safe navigation in fluid mud – Surveying criteria to assess nautical depth
10A2	*Pieter J. de Boer et al.*	Provide end users with the most accurate nautical depth measurement by using the combination of echo sounders and density measurement equipment
10A3	*Mathias Schlösser et al.*	In situ measuring of nautical bottom in respect to dredge works in the Port of Santos
10A4	*Jieun Koh et al.*	The first launching and naming ceremony of 5,000 ton class R/V ISABU

Safe navigation in fluid mud – Surveying criteria to assess nautical depth

by: **Norbert Greiser**[1]
Keywords: fluid mud | nautical depth | nautical bottom | sediment density

The concept of nautical depth means to let vessels sail through fluid mud that obeys accepted criteria for a safe manoeuvring regardless higher density and viscosity values compared to water. Whereas density will be unaffected by a ship's movement, the viscosity of fluid mud does not stay at the same level when exposed to shear stress or pressure so that even (fluid) mud layers represented by density interfaces of ≥ 1.20 g/cm³ may become navigable by shear thinning.
The presence of fluid mud may cause complex sediment density and viscosity stratifications getting unclear transition interfaces to the consolidated nautical bottom and by fathometer surveys alone it is difficult to decide which frequency will give the best estimation of the nautical depth.

Rheological investigations on fluid mud samples from a broad range of European harbours and the U.S. Atchafalaya, Calcasieu, and Gulfport navigation channels have shown that in general fluid mud will become navigable if it is exposed to shear stress.
Field tests in Husum (Germany) and other European dredging locations have proven that conditioning of fluid mud to safe density and viscosity levels can be successfully done also in situ and accompanied by a surveying strategy to generate reliable nautical depth navigation charts.

1: Consultants Sell-Greiser GmbH & Co. KG, Emden, Germany

Provide end users with the most accurate nautical depth measurement by using the combination of echo sounders and density measurement equipment

by: **Pieter J. de Boer**[1], Coen J. Werner[1]
Keywords: nautical depth | fluid mud | acoustic density mapping | yield stress | cable and pipeline detection

Harbours and their access channels need to be dredged to the nautical depth to ensure safe vessel passage. When fluid mud is present, a critical density value is determined to establish this depth, which is area specific. Another consideration for establishing the level of safe vessel passage is yield stress. The yield stress indicates the level in the fluid where solidification of the mud occurs. Traditional survey techniques are not capable of detecting multiple density levels or yield stress. To optimise dredging operations and continuous harbour management one could benefit of using an ultra-high resolution sub-bottom profiler in combination with in situ density and yield stress measurements. The geophysical software package SILAS will link both type of measurements and can in real-time determine density levels which spatially cover the entire harbour or access channel, therefore excluding interpolation in the process. The SILAS software enables all users to manage the nautical depth, while batch processing and data cross-referencing acquired using different sources can improve the overall data quality as well as provide the user with a more detailed understanding of sub-bottom features, such as cables and pipelines. Recent studies show that the SILAS system can detect various types of sub-bottom objects not only limited to cables and pipelines, but also individual boulders. These objects can be detected with a success rate of 75 % and over on objects and cables with a diameter of 25 cm or higher.

1: Stema Systems, Geldermalsen, The Netherlands

In situ measuring of nautical bottom in respect to dredge works in the Port of Santos

by: **Mathias Schlösser**[1], Uwe Boekhoff[2], José Bartolomeu Ferreira Fontes[1], Andreas Klockner[3]
Keywords: Port of Santos | fluid mud | nautical bottom | admodus®USP

The Port of Santos, as the major Brazilian and Latin American port, has the need to be periodically dredged in order to keep the port's operating depth. Santos specific geographic location, access to the Atlantic ocean from the south and the northern region of the port along with Serra Mar mountain chain, estuaries and mangroves, which result in sedimentary migration into the Port of Santos.
An integrated multi-sensor survey was carried out using the admodus®USP pro density probe, a dual-frequency (high-low frequency) single-beam echo sounder and a side-scan sonar, besides ordinary sediment samples were taken, to categorise the bottom and the areas and to compare and analyse the achievements. The admodus®USP pro is an in situ measuring probe for online monitoring of the nautical bottom that provides depth-dependent density profiles. The precise density measurements were combined with the dual-frequency echo sounder results to get an accurate understanding of the bottom. The side-scan images provided a full coverage of the area to register morphological characteristics and helped to identify features on the bottom.

This study aims to present an analysis of fluid mud layers, sediment characterisation and dredge material volume for the Port of Santos as well as to demonstrate how Port Authorities and dredge companies can use this knowledge for planning and dredge works. Consequently, we want to link to the fact: what is navigable depth. In Brazil, navigability and homologated depths in ports and river ways are predominated by high-frequency echo sounder measurements. That has a direct influence for the port activity and vessel transport capacity in reference to the vessel's draft, likewise a financial significance for the port and affiliated economy.
The conclusion of the study shall optimise dredge works and implement new dredge techniques to reduce dredging maintenance costs in the Port of Santos, and finally to give an assistance to decide whether there is a necessity of dredging – and also when where to dredge only, providing a good knowledge of the bottom and sediment attributes.

1: GEO TAG Engenharia Ltda., Brazil
2: NPorts Emden, Germany
3: admodus.MARITIME DEVICES, Schiffweiler, Germany

Introduction of the 5,000 ton new scientific research vessel ISABU of KIOST

by: **Jieun Koh**[1], Yosup Park[1], Yong-kuk Lee[1]
Keywords: ISABU | research vessel

The research vessel (R/V) ISABU is the new oceanographic research vessel of Korea Institute of Ocean Science and Technology (KIOST). ISABU is named after the ancestral general of Korean old dynasty, Silla. It is one of the most up-to-date research vessels for comprehensive ocean investigation and the largest research vessel in Korea. The main purpose of this ship building is to retain the international competitiveness by getting more professional research infrastructure. In order to do so, the whole length was designed as 99.8 m and the gross tonnage was about 5,900 ton. In particular, the dynamic positioning system is employed for maintaining precise positioning, it was designed to consider high safety standards, noise and vibration control efficiency, and effective application of research equipment as priorities. The ship's maximum speed is 15 knots.

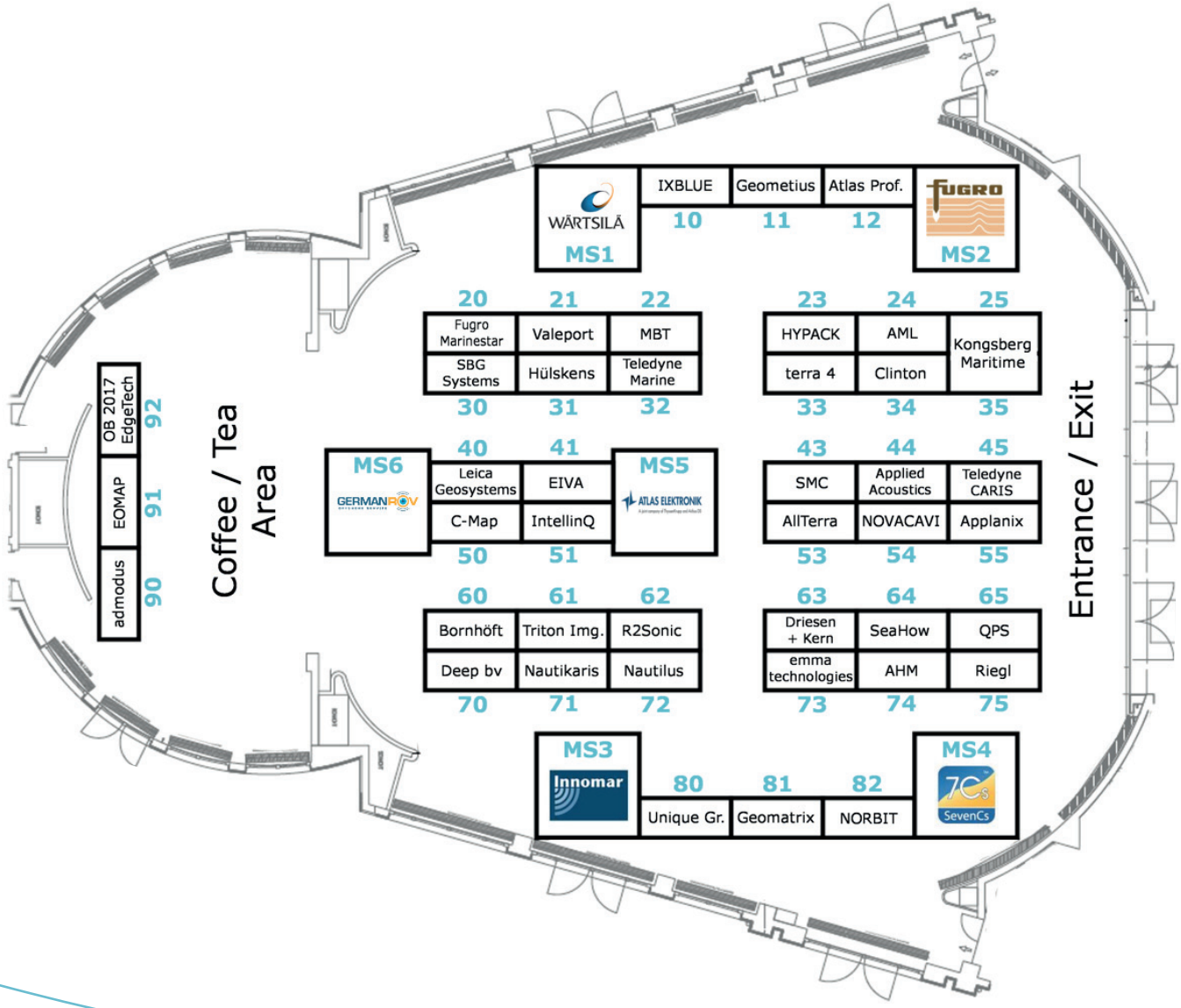
ISABU was constructed for three years and delivered to KIOST in June 2016, and currently the sea trial is performed for 10 days in July at East Sea of Korea and the deep sea trial is expected to be carried out in August.

ISABU was built with six science labs, spaces for support and maintenance of equipment and storage spaces. Total 135 navigational and scientific instruments for carrying out multidisciplinary researches including acoustics, hydrography, meteorology, physics, chemistry, biology, geology, geophysics are installed. The instruments are precision navigation systems, seafloor mapping sonar, USBL, SBP, CUFES, Giant Piston Coring system, and satellite communications and so on. The ship has a-frame, six winches, four cranes, either. The ship will carry out the mission with 22 crew members and 38 scientific researchers for as long as 55 days.

By means of this large scale research vessel, we are expecting the nation's position in the field of R/V power would be enhanced, and this new research vessel would play a leading role in the near future.

1: KIOST, Korea Institute of Ocean Science and Technology, Ansan, Republic of Korea

Exhibition


WÄRTSILÄ
MS1
IXBLUE
Geometius
Atlas Prof.
10
11
12
FUGRO
MS2
20
21
22
Fugro Marinestar
Valeport
MBT
SBG Systems
Hülskens
Teledyne Marine
30
31
32
23
24
25
HYPACK
AML
Kongsberg Maritime
terra 4
Clinton
33
34
35
OB 2017 EdgeTech
EOMAP
admodus
92
91
90
Coffee / Tea Area
40
41
MS6
GERMANROV
Leica Geosystems
EIVA
C-Map
IntellinQ
MS5
ATLAS ELEKTRONIK
50
51
43
44
45
SMC
Applied Acoustics
Teledyne CARIS
AllTerra
NOVACAVI
Applanix
53
54
55
60
61
62
Bornhöft
Triton Img.
R2Sonic
Deep bv
Nautikaris
Nautilus
70
71
72
63
64
65
Driesen + Kern
SeaHow
QPS
emma technologies
AHM
Riegl
73
74
75
Entrance / Exit
MS3
Innomar
80
81
82
Unique Gr.
Geomatrix
NORBIT
MS4
SevenCs

AHM – AirborneHydroMapping GmbH

Repetitive surveying of inshore waters and coastal zones is becoming more and more essential to evaluate water-level dynamics, structure and zone variations of rivers and riparian areas, river degradation, water flow or reservoir sedimentation, and coastal processes. This can only be achieved in an effective way by employing topo-bathymetric airborne laser scanning (hydromapping). A joint development by Riegl LMS and the University of Innsbruck resulted in a new scanner technology for the acquisition of high-resolution topo-bathymetric data dedicated for surveying inland waters and shallow coastal zones. AirborneHydroMapping GmbH, the academic spin-off (founded 2010) of this development, is the leading company in topo-bathymetric geo-mass-data capturing and handling. This was also made possible by a new generation of software development (HydroVISH) specially dedicated to the joint needs of topo-bathymetric data sets and mass data handling not limited any more to former LiDAR data size restrictions.

www.ahm.co.at // Stand 74

AllTerra Deutschland GmbH

The Trimble competence centre for accurate and reliable solutions for Positioning, Mobile Mapping, Surveying, 3D data collection, design and build of permanent Monitoring installation, UAS, and customized Positioning-solution development. AllTerra Germany is one of the largest Trimble distribution partner worldwide. With its own software development, support engineers at 6 sites, and several service centres in Germany, we are close to the customer. Our portfolio includes Trimble GNSS receivers, robotic total station, UAS (fixed wing and copter), Mobile Mapping systems for vehicles and vessels, geodetic and geotechnical monitoring hardware and software, and surveying and hydrographic software.
We are committed to provide high-quality solutions and services to our customers. This includes renting of hard- and software. Standard equipment such as GNSS receivers and total stations are provided within 24 hours anywhere in Germany if necessary.
AllTerra Germany – the partner at your side.

www.allterra-dno.de // Stand 53

AML Oceanographic

AML Oceanographic, headquartered in British Columbia, Canada, is a leading manufacturer of SVPs, CTDs, and other instrumentation for hydrographic surveying, environmental monitoring, and more. AML pioneered the design of field-swappable Xchange™ sensors, which minimise downtime and maximise the utility of each X•Series instrument. More recent innovations include Base•X_2, which brings Wi-Fi and GPS to profiling, enabling automatic data transfer and processing. With new CT•Xchange, Base•X_2 converts from SVP to CTD with the swap of a single sensor head, and Minos•X is the smallest combined CTD/SVP on the market. UV•Xchange and Cabled UV, the industry's only proven UV biofouling control products, ensure multiparameter sondes and other devices maintain performance throughout long term in situ deployments. Our tagline – Xchange your old ideas – brings to life our commitment to generate fresh, innovative ideas for the oceanographic community.

www.amloceanographic.com // Stand 24

AML
OCEANOGRAPHIC
Xchange your old ideas

Applanix Corporation

Applanix is a world leader in products and solutions for hydrographic survey and marine applications. Our technology and customer support gives you the advantage: lower costs of deployment, faster times to completion, and improved quality of data.
The Applanix POS MV blends GNSS data with angular rate and acceleration data from an IMU and heading from GNSS Azimuth Measurement System (GAMS) to produce a robust and accurate full six degrees of freedom Position and Orientation solution.

POS MV comes in 4 models:

- POS MV SurfMaster / SurfMaster One
- POS MV WaveMaster II
- POS MV OceanMaster
- POS MV Elite

All POS MV models are designed for use with multibeam sonar systems, enabling adherence to IHO (International Hydrographic Survey) standards on sonar swath widths of greater than ± 75 degrees under all dynamic conditions.
Go to http://www.applanix.com/#filter-slice.marine to learn more about POS MV and related products.
www.applanix.com // Stand 55

Applied Acoustic Engineering Ltd

Applied Acoustics is a major manufacturer of subsea acoustic navigation and positioning equipment. The product range includes the innovative USBL tracking system Easytrak and a wide variety of positioning & release beacons. Easytrak provides range and bearing information to a variety of subsea moving targets such as divers, ROVs, AUVs and tow-fish. Rack mounted, portable and military systems are available. The latest system, the Nexus 2 USBL, includes 16-target tracking and geographical map overlays.

Applied Acoustics also manufactures a market leading range of sub-bottom profiling products based on a component system configuration. Both the seismic energy source units, the CSP range (50-12000 J), and the seismic energy sound source products, Boomers and Sparkers, are in worldwide use. New products include a triple-plate boomer and a deep-tow sparker, the DTS-500, that operates from a standard coaxial cable up to 500 m depth.
www.appliedacoustics.com // Stand 44

Atlas Elektronik GmbH

ATLAS ELEKTRONIK – a Sound Decision
ATLAS ELEKTRONIK stands for maritime security, reliability and efficiency. For decades now, ATLAS is a leading systems supplier for naval electronics, particularly in the field of sonar technology.
ATLAS ELEKTRONIK helps nations worldwide to make the seas safer and can look back on a company history spanning more than 100 years – a success story that is based on technological excellence, the spirit of research and individual focus on customers.

Today, derived from many years of experience, a well-designed product portfolio provides unmanned solutions to support and secure offshore operating industries.
www.atlas-elektronik.com // Stand MS5

Atlas Professionals

Atlas Professionals is an international recruitment company for the Energy, Marine & Renewables industries. Over the last 30 years, Atlas Professionals has become a major player in specialist offshore recruitment with a mission to turn complex personnel challenges into transparent and secure solutions.
If quality and reliability are key for your business, then Atlas is the partner you need for qualified personnel in specialist areas such as Offshore Survey & Construction, ROV, Diving & Inspection, Seismic & Electromagnetic, Marine Environmental and Offshore Management & QC. We pride ourselves in representing the largest and most highly skilled pool of survey professionals – ranging from personnel for shipyard (Dimensional Control) surveys through to deepwater construction specialists.
www.atlasprofessionals.com // Stand 12

Bornhöft Meerestechnik

Precision in Marine Technology
As specialists in marine technology, we supply everything you need to measure, explore, survey, view, sample, and communicate under water.
Good results must often be obtained under harshest conditions, and that can make any project an adventure in itself. Excellent equipment is a deciding factor. With our experience of almost forty years now, we are assisting our customers in finding the products best suited for their application and delivering precise data.
We cooperate with leading high-tech companies from the USA, Canada and several European countries, and we constantly survey the market for product innovations. For our partners we are the representatives for Germany, Austria and Switzerland, and we also work in the BENELUX countries for some. Our customers rely on us for technical service at all times. Prompt and thorough after-sales service is understood as part of our role as constant partners of marine science.
www.bornhoeft.de // Stand 60

Clinton Marine Survey

Clinton was established in 1989 with the goal of offering all types of geodetic measurement and measurement-related reporting both on land and at sea. It was founded by Johan Nyström, who remains the CEO of Clinton Mätkonsult AB. During 2014 a separate subsidiary, Clinton Marine Survey AB, was established to further continue our growth and investment in the areas of geophysical and hydrographic mapping. Growing from 6 people in 2014 to about 35 in 2016.
The company is based in Sweden and owns a number of vessels specifically designed for working in extreme shallow to medium water depths. We operate specialist shallow-water survey systems capable of achieving and in many cases exceeding the International Hydrographic Organization (IHO) Special Publication S-44 Special Order standard.
www.clinton.se/marine // Stand 34

C-MAP Norway AS

C-MAP is your longterm partner for managing and distributing navigation data. We are known the world over as the leading provider of marine navigation data.
C-MAP works with Hydrographic Offices to supply mariners with current, near real-time information. Our dKart office solutions are used by more than 70 % of the world's Hydrographic Offices.
www.c-map.com // Stand 50

Deep B.V.

Hydrographic & Geophysics
DEEP B.V. (DEEP) is a survey company based in Amsterdam, The Netherlands, specialising in hydrography, geophysics and oceanography. Deep's areas of operation include offshore areas, coastal zones, seaports and inshore waterways. Projects are carried out worldwide.
Deep's main goal is to safely supply its clients with high-quality data that provides reliable insights into the subsea world. Deep's core values and those of its professional staff include quality of data, charts and reports, excellent client relations and a flexible and cost-effective approach to projects.
You will find DEEP working for transmission system operators, renewable energy operators, the dredging industry, engineering consultancy firms, offshore construction contractors, salvage companies and government organisations.
DEEP has applied expertise serving global firms in the following markets:
- Infrastructure
- Renewable Energy
- Salvage
- Oil & Gas
- Public Sector

www.deepbv.nl // Stand 70

Driesen+Kern GmbH

Driesen+Kern GmbH offers a variety of sensors, transducers and dataloggers to measure environmental parameters. Founded in 1977 in Bad Bramstedt, Germany, the company has deployed many environmental test stations around the globe. The company is ISO9001-2000 certified and offers development, production and sales as well as calibration and repair.

Products
- Datalogger and transducers for water level and waterquality parameter (pH,O2, Conductivity, temperature)
- Miniaturised datalogger for Air Quality (CO2,CO, humidity, temperature, etc.)
- Instruments to measure aerosol- and dust concentration
- Flexible datalogger with numerous inputs

www.driesen-kern.de // Stand 63

EIVA a/s

EIVA is an engineering company with more than 35 years' experience in the offshore and shallow water construction and survey industry.
EIVA provides software, equipment, integrated system solutions, rental services, 24/7 support and training to a wide range of segments, covering virtually any offshore and shallow water operation task.
www.eiva.com // Stand 41

emma technologies GmbH

emma technologies is a leading manufacturer, supplier and system integrator of environmental monitoring and measuring applications for multidisciplinary marine tasks.

emma technologies manufactures:
- Electric Winches and Accessories
- Underwater Cameras & Lights up to 12,000 m
- Water sampling system – KIPS
- Epibenthic video sledges
- Unmanned Surface Vehicles (USV/ASV) for various survey tasks
- COMASS (Containerised Marine Service System)
- Multipurpose Survey Boats
- OFOS (Ocean Floor Observation System)

emma technologies distributes:
- Scour sensors for wind farm applications and coastal engineering
- AUV solutions for shallow water applications
- Adaptive Vibrocorer Systems
- NORBIT – High-resolution and compact multibeam echo sounder
- GETAC – Ruggedised Laptop and Tablet solutions
- Seismic Systems for shallow and deep water
- OFOP Software for ocean floor observations
- KLEIN Marine Sonars and Systems

Our experts assist in defining the ideal component for every part of the integrated system to its final installation, setting-to-work, operation and training. Simply ask emma – we'll see to the rest.
www.emma-technologies.com // Stand 73

EOMAP GmbH & Co. KG

EOMAP is the leading global service provider of satellite-derived aquatic information in maritime and inland waters for the commercial offshore industry as well as a multitude of government agencies. Pioneering the field of satellite-derived bathymetry and high-resolution water quality monitoring, EOMAP services rely on standardised physical models which are independent of scale, sensor type and geographic location. Additional key services include seafloor, coastal environment and infrastructure mapping.

EOMAP's technology can be applied at local through to intercontinental scales, with the option of providing continuous and long-term environmental information by harnessing multiple satellite resources.
EOMAP was founded in 2006 as a spin-off of the German Aerospace Center (DLR) and is headquartered in Castle Seefeld, just outside of Munich.
www.eomap.com // Stand 91

Fugro OSAE GmbH

Fugro is a multi-national survey and consultancy group operating at sea, on land and by air in the fields of geodetic, geotechnical and geophysical business, using professional, highly specialised staff supported by advanced technologies and systems. Worldwide, Fugro employs approximately 12,000 people in over 50 countries.

Fugro's mission is to be the world's leading services provider for the collection and interpretation of data and the provision of advice related to the earth's surface, the sea bed and the soil and rocks beneath. Fugro supports clients in their search for natural resources and the development, production and transportation of those resources.
FUGRO OSAE GmbH, a German based FUGRO entity, is specialised in all types of hydrographic surveys. The team of 92 employees has an extensive range of practical experience in survey work throughout the world.

www.fugro.com // Stand MS2

Geomatrix Earth Science Ltd

Rental and sales supplier of Oceanographic, Hydrographic and Geophysical instrumentation providing factory approved maintenance to our principals, we have expertise both in Land and Marine applications.
We are pleased to represent Geometrics range of Magnetometers and High Resolution seismic tools. Falmouth Scientifics Current Meters, Bubble Gun and Chirp Sub-Bottom Profilers. Geonics marine EM system and Iris Instruments Marine Resistivity system.
We will be introducing and displaying data from our recently developed and field proven QAS4 multi sensor TVG frame offering a combined Magnetics Transverse gradiometer with Side-Scan sonar and other sensors all running over a single coax.

www.geomatrix.co.uk // Stand 81

Geometius BV

Since its foundation in 1994, Geometius has evolved into a leading trade company and service provider in the field of GNSS positioning, navigation, data acquisition and data communication. Geometius offers a total solution to customers in the Hydrographic and Marine Construction market as well as the Survey, GIS & Mapping market. Geometius has created a unique position in the Dutch market place by offering comprehensive solutions from three locations across the Netherlands. Geometius has an extended rental service and as Authorised Trimble Service Centre performs maintenance and repairs, even under warranty, providing quick and professional support. To support customers directly in the field, a highly qualified Helpdesk is available. In its training centre Geometius provides practical trainings on a regular base.
Geometius is primarily a distributor of Trimble. Our dealerships include CEE HydroSystems, Teledyne Oceanscience, Ping DSP, Echologger, Sequoia Scientific, NKE Instrumentation, Campbell Scientific and RBR.

www.geometius.nl // Stand 11

GERMAN ROV OFFSHORE Service GmbH & Co. KG

GERMAN ROV is the first commercial Offshore-ROV contractor in Germany, which has been established by a consortium of experienced offshore service suppliers and which will globally operate and develop both, Inspection and Work Class ROVs. GERMAN ROV is an independent subsea service provider for all kind of ROV works, especially within the renewable energy sector. Our team is composed of varied experts within the maritime industry, with more than 30 years of experience. Beside the creation of an in-house training academy for ROV pilots in Rostock, we are focusing on the following services:

- Assistance for diving works
- Visual inspection and tracking
- Measurement and sampling
- Installation operations and construction works
- UXO survey and removal
- Decommissioning and salvage support

www.germanrov.com // Stand MS6

Hülskens Wasserbau GmbH

Hydrography and surveying
Fast, precise and reliable

For more than 25 years, Hülskens Wasserbau has been specialising in hydrographic surveying. For this we use multibeam echo sounders which ensure extremely rapid and high-resolution surveying of the ground.
As the requirements and areas of use vary considerably, the Hülskens sounding boat fleet offers the right boat to suit all size and fittings specifications.
State-of-the-art technology and professionals who also know how to use this – the perfectly coordinated hard- and software together with our expert and experienced employees ensure that each sounding assignment is carried out fast, carefully, precisely and reliably.
Hülskens sounding boats ensure the exact positioning of floating equipment and oversee a wide range of cable and hydraulic excavators with the latest underwater sighting technology.
Furthermore, we also support our customers in land surveying including current status surveys, staking out work and levelling.

www.huelskens-wasserbau.de // Stand 31

HYPACK

HYPACK – A Xylem brand is a world leader in software development for the hydrographic and dredging industry since 1984. HYPACK® is one of the most widely used hydrographic software packages in the world, with more than 10,000 users in over 100 countries.
HYPACK provides all of the tools necessary to complete your hydrographic, side-scan and magnetometer survey requirements. It provides tools to design your survey, collect your data, apply corrections to soundings, remove outliers, plot field sheets, export data to CAD, compute volume quantities, generate contours, create side-scan mosaics and create/modify electronic charts.
Whether you are collecting hydrographic survey data, environmental data, or just positioning your vessel in an engineering project, HYPACK® provides the tools needed to complete your job. HYSWEEP® is our powerful multibeam module that provides for the calibration, data collection and data processing of multibeam sonar and laser scanner data. DREDGEPACK® is our real-time dredge management system, designed to work with cutter suction, hopper, clamshell and excavator operations.

www.hypack.com // Stand 23

INNOMAR Technologie GmbH

For about 20 years INNOMAR develops and manufactures efficient underwater acoustic systems and associated software.
The "INNOMAR SES-2000" series of parametric sub-bottom profilers with about 300 sold units is perfectly suited for exploring the sub-seafloor at high resolution in water depths between less than one metre and full ocean depth. Applications include visualising sediment structures for dredging and geological surveys as well as mapping buried pipelines/cables or prospective offshore building sites. User-friendly data acquisition and control software as well as post-processing software are provided. Transducers are available for hull- and pole-mounting.
There are two models incorporating a narrow-beam parametric SBP and a dual-frequency side-scan sonar for simultaneous operation.
New developments include a multi-transducer SBP providing high data density suitable for 3D visualisation, a towed SBP and a survey catamaran (USV) for remote operation in protected or extremely shallow areas.
INNOMAR's quality management is certified by DIN EN ISO 9001.
www.innomar.com // Stand MS3

IntellinQ

IntellinQ presents and demonstrates GeolinQ.
Understanding the actual situation. Taking decisions based on reliable and all available data. Sharing data. Basic requirements for anyone working with hydrographic data.
Managing hydrographic data is challenging because of data volumes and multiple usages. The use of hydrographic data for navigational purposes is extended to new usages like offshore wind farms and environmental issues, asking for a new innovative data management approach.
GeolinQ offers this innovative approach. GeolinQ is a web-based solution to import, store, manage and share spatial data efficiently. The complete value chain is covered from import to visualisation and distribution.
Point clouds and raster data sets collected with LiDAR and multibeam sonar as well as feature data sets such as buoys, pipelines and depth contours are supported. Data sets from different sources are linked and combined into new information products that are available for visualisation, download and as web services.
www.intellinq.com // Stand 51

iXblue

iXblue is a leading global provider of innovative solutions and services for navigation, positioning, and imaging. Civil and defence customers rely on its systems, operations, and services for the challenges they face at sea, on land, in the air or in space.
iXblue is recognised throughout the industry for our pioneering work on the development of ultimate performance fiber-optic gyroscopes (FOG). Based on its 30 years of expertise, iXblue achieves 15–20 % growth every year, with 80 % of its business taking place in more than 30 countries around the world.
The Group can count on full value-chain expertise: all of its systems are produced internally, from design to manufacturing. Its success is especially informed by its French know-how, from its engineering offices to its production workshops. iXblue's focus on innovation has enabled the company to maintain a major position in its markets over the past three decades.
www.ixblue.com // Stand 10

Kongsberg Maritime GmbH

Kongsberg Maritime Subsea is an established technology provider for the oil & gas exploration, scientific research and maritime engineering sectors with an extensive portfolio of cutting-edge hydroacoustic survey equipment. This ranges from sonar, single- and multibeam echo sounders, positioning technology and sophisticated underwater vehicles to data analysis tools and subsea cameras, sensors and instruments. In addition to developing vital technology for the subsea industry, Kongsberg Maritime Subsea also works closely with leading research institutes and organisations to create advances in the fields of hydrography and underwater positioning for scientific and commercial applications. The company is also committed to leveraging its subsea expertise to develop new solutions for environmental monitoring; supporting the oil & gas industry to minimise the impact of operations in environmentally sensitive locations.
All Kongsberg Maritime Subsea deliveries are tailored to exact customer requirements and benefit from high-quality design and manufacturing. Kongsberg Maritime Subsea solutions cover all aspects of technology on the seabed, in the water, and on a wide variety of vessels involved in hydrographic and seismic survey, offshore support applications and maritime construction.

Maximizing performance by providing the FULL PICTURE.

www.kongsberg.com // Stand 25 + 35

KONGSBERG

Leica Geosystems GmbH Vertrieb

Leica Geosystems – when it has to be right
Revolutionising the world of measurement and survey for nearly 200 years, Leica Geosystems creates complete solutions for professionals across the planet. Known for premium products and innovative solution development, professionals in a diverse mix of industries, such as surveying and engineering, safety and security, building and construction, and power and plant, trust Leica Geosystems to capture, analyse and present smart geospatial data. With the highest-quality instruments, sophisticated software, and trusted services, Leica Geosystems delivers value every day to those shaping the future of our world.
Leica Geosystems is part of Hexagon (Nasdaq Stockholm: HEXA B; hexagon.com), a leading global provider of information technologies that drive quality and productivity improvements across geospatial and industrial enterprise applications.
www.leica-geosystems.de // Stand 40

Marinestar

Marinestar high-performance positioning products and services delivered to you by Fugro Satellite Positioning BV, the Netherlands, are able to meet a varied range of applications in dredging & marine construction, wind farm installation, cable lay, naval and hydrographic oceanographic research survey's. Marinestar services deliver up to 8 cm centimetre (vertical, sigma 2) accuracy in high availability using eight overlapping L-band satellite beams.

With GPS, GLONASS, Beidou (and soon to come: Gallileo) constellations of customer choice combinations redundancies as well as precision gain are made available.
Our redundant infrastructure and 7x24 global customer service makes this precise positioning service the exact tool you need!
When positioning counts ... count on Marinestar!
www.fugromarinestar.com // Stand 20

MBT GmbH

MBT GmbH is a sales and engineering company for marine and underwater technology. Our expertise concentrates on the sales, integration and service of oceanographic and hydrographic systems. Our aim is to provide customers with operational plant-specific solutions. Liaising existing technologies, we create innovative systems matching individual requirements.
MBT GmbH operates a fully equipped manufacturer independent calibration and service facility for oceanographic instrumentation. In addition, we manufacture customised solutions in our cable- and engineering workshop.

Currently, MBT GmbH employs 20 members of staff with scientific and technical qualifications. Especially within the division of hydrographic system sales, our staff has a strong background in practical hydrography based on long-term experience in the survey industry.
www.m-b-t.com // Stand 22

Meritaito Ltd

Meritaito is one of the Northern Europe's largest marine survey companies. Meritaito provides hydrographical, geophysical and geotechnical survey services in offshore, near shore and inshore waters as well as inland water areas.
Our home market is Northern Europe but we provide our services in all European seas. Meritaito's SeaHow Mobile Survey Platform is available for assignments worldwide.

Our certified services meet the highest international quality standards (IHO S-44) and the most demanding customer needs and charting authorities' expectations. We survey with our state-of-the-art equipment and versatile vessels yearly more than 10,000 km² full density hydrographic data. We also perform several dozens of route survey, site survey and structure inspection projects annually.
Meritaito has a team of highly skilled professionals in hydrographic surveying, marine geology, engineering and data processing. This team of internationally certified hydrographic surveyors and shallow-water experts provides tailor-made surveys for your needs.
www.seahow.fi // Stand 64

Nautikaris BV

Nautikaris is your best address for your needs for Hydrographic and Oceanographic Systems, Meteorological instrumentations and system solutions, Acoustic 3D Imaging Systems, Subsea communication, Positioning Equipment, Underwater Connectors, Rugged Data Collectors, Marine LED Navigation Lights and Wireless Small band Radio telemetry networks. Additionally, we have Acoustic Real-Time 3D Imaging Systems for rental with experienced operators. Our customers count on us for the high quality of our products combined with ease of use and a flexible and professional support team.
www.nautikaris.com // Stand 71

Nautilus Marine Service GmbH

Nautilus Marine Service GmbH (NMS) is a German company that was founded in 1985 to represent the interests of some of the world's leading manufacturers of marine technologies by sales and advisory activities for their product lines. Moreover, the company rapidly developed into a leading supplier of hydrographic and marine technology to the German research, survey and monitoring community.
NMSs' business segments comprise:

- Hydrography
  - R2Sonic – Multibeam Echo sounder
  - Gabri S.r.l. – SeaStick AUV
- Ocean Technology
  - RBR – Submersible data loggers, recorders, and sensors for water quality measurement
  - MetOcean – Beacons and Flashers (Iridium)
  - Wave measurement and drifter buoys, floats, profilers, weather stations
- Marine Safety and Rescue Gear

www.nautilus-gmbh.com // Stand 72

NORBIT Subsea AS

NORBIT Subsea is a manufacturer of wideband FM, curved-array multibeam sonar sensors for high-resolution bathymetry. NORBIT's multi-sensing concept combines multiple integrated sensors into one hardware platform with a single LAN connection to survey laptop. Simple setup and simple operation yet provides repeatable high-quality remote sensing from any survey platform (surface, USV, ASV, ROV, AUV, etc.). Supported sensors include any combination of single/dual bathymetric multibeam echo sounder, obstacle avoidance sonar, forward looking inspection sonar, and LiDAR.

www.norbit.com // Stand 82

NORBIT

NOVACAVI Srl

Established in 1975, Novacavi designs and manufactures in-house bespoke cables for a variety of specialised applications, including harsh and demanding environments in terrain and underwater.
Highlighted products at HYDRO 2016:

- Aquancable®, bespoke cables for maritime and underwater technologies: high-performance Tow cables, ROV cables, Fiber Optic hybrid cables, umbilicals, armoured cables, as well as subsea detection and instrumentation cables
- Transversally and/or longitudinally water blocked cables
- NEK 606 mud resistant cables
- Marine Data Communication IT Cabling System cables

Specialities: material expertise, engineering versatility & production flexibility to match customers' exact requirements; great experience in subsea and oil & gas applications; custom reliable cables in fit-for-purpose quantity, lengths and packaging.
Quality system certified in compliance with ISO 9001.

www.novacavi.it // Stand 54

NOVACAVI
Cables for advanced technology

Ocean Business 2017

Ocean Business is being held at the NOC in Southampton, UK from 4 -6 April 2017. Firmly established as one of the most important international events in the ocean technology calendar, Ocean Business is FREE to attend and is expected to attract more than 5,000+ visitors from over 60 countries.
At the very heart of Ocean Business is an exhibition of 300+ companies, bringing together the world's leading manufacturers and service providers in the industry. More than just a static exhibition, Ocean Business 2017 provides visitors with an opportunity to test-drive equipment with 180+ hours of training and demonstration sessions, on vessels, at the dockside, in the test tank and in seminar rooms.
Ocean Business also offers a selection of associated events, a technical conference and Ocean Careers providing advice on career opportunities within the industry.
www.oceanbusiness.com // Stand 92

QPS bv

Acquire – Process – Visualize – Share; QPS makes industry leading software (QINSy, Qimera, Fledermaus and Qarto) for collection, post processing and visualisation of maritime geospatial data.
Our offices are in the Netherlands, USA, Canada and UK, and globally we have a partner network.
Since 2012, QPS is a member of the Saab (Sweden) group of companies.
www.qps.nl // Stand 65

R2Sonic LLC

R2Sonic, LLC is the innovator behind Multibeam Sonar Technology solutions and Forward Looking Sonars. The Sonic Series of broadband/wideband Multibeam Echo sounders represent that innovative spirit, with unique technology, that provides superior performance and flexibility in a reliable, light weight, power efficient, and space saving package.
Headquartered in Austin, Texas, R2Sonic's mission is to utilise industry relevant research and experiences to bring high quality, leading edge underwater acoustic products to the private and public sectors with a focus on customer needs.
Along with a customer centric training and support team, R2Sonic's sonar solutions bring compelling value to the customer.
www.r2sonic.com // Stand 62

RIEGL Laser Measurement Systems GmbH

RIEGL is a performance leader in research, development and production of terrestrial, mobile, bathymetric, airborne and UAS-based laser scanners and scanning systems. RIEGL's innovative hard- and software provides powerful solutions for multiple fields of application in surveying.
For combined hydrographic and topographic surveying RIEGL offers the fully integrated airborne laser scanning system VQ-880-G. Providing a measurement range of 1.5 Secchi depths it is ideally suited for coastline and shallow water mapping, river bed profiling, measurement of aggradation zones, hydro-archaeological surveying, etc.
Additionally, RIEGL's topo-hydrographic airborne laser scanner engine VQ-820-G is available for customers preferring the small form factor and/or flexibility of integration.
For generating profiles of rivers or water reservoirs RIEGL has developed the BathyCopter, the world's first Small-UAV-based surveying system capable of measuring through the water surface.
Visit our booth #75 at HYDRO 2016 and get more detailed information from our experts!
www.riegl.com // Stand 75

SBG Systems

SBG Systems is a fast growing supplier of miniature, high performance and innovative motion sensing solutions. SBG Systems headquarters are based in Rueil-Malmaison, France.
SBG Systems offers a complete line of inertial sensors based on the state-of-the-art MEMS technology such as Attitude and Heading Reference System (AHRS), Inertial Measurement Unit (IMU), Inertial Navigation Systems with embedded GPS (INS/GPS), etc.

Our sensors are ideal for industrial, defence & research projects such as unmanned vehicle control, antenna tracking, camera stabilisation, and surveying applications.
www.sbg-systems.com // Stand 30

SevenCs GmbH

SevenCs GmbH is located in Hamburg, and for decades has been "the Expert" in developing maritime software applications.
Global business experience for nearly 25 years have led to a reliable product family such as the S-57 and S-100 chart display Kernel, professional navigation software (ORCA-Series) and ENC production tools.

In addition to our software we provide a complete range of complementary services, including training, consultancy, and customer support.
www.sevencs.com // Stand MS4

SMC Ship Motion Control

SMC (Ship Motion Control) is a producer of the SMC IMU range of Motion Sensors used in the Hydrographic Survey, Dredging and Subsea markets. SMC produces also a range of Marine Monitoring Software Systems used in the Offshore & Marine markets.
SMC offers high-quality solutions, integration of marine monitoring systems and high-performance products which are efficient, flexible and economically sound.
SMC have gained worldwide success due to the motion sensors functionality and robust design along with standard compliant, and custom adaptable software systems.
www.shipmotion.eu // Stand 43

Synergetik GmbH

admodus®MARITIME DEVICES represent robust and reliable density measurement technology at the highest level of engineering excellence.
In many of the world's largest harbours, appropriate hydrographic survey is a necessary requirement in order to keep dredging costs low. The admodus®USP pro is an innovative „in situ" measuring probe for online monitoring of the density in harbours and waterways. The system provides a depth-dependent density profile quickly and reliably, as well as a variety of other indicators for characterising suspended matter and sediments.
www.admodus.de // Stand 90

Teledyne CARIS

For over 35 years, Teledyne CARIS™ has been making software designed for the marine GIS community. Not only renowned for its product, but also for outstanding customer service, Teledyne CARIS offers a comprehensive level of support through training sessions and consulting, online technical support, email, and multilingual telephone support.
The CARIS™ toolset provides clients with resource optimisation and a true operational advantage. Known for the Ping-to-Chart™ solution, we offer a comprehensive portfolio of products, from the processing of the echo-sounder ping to the production and distribution of the chart.
The newest product in the toolset, CARIS Onboard™, is a near real-time and autonomous data processing package developed for AUVs, USVs and survey vessel platforms.
Find out why CARIS software is selected by national mapping and charting agencies, survey companies, port and waterway authorities, oil and gas companies, and academic institutions worldwide by visiting **www.caris.com** // Stand 45

TELEDYNE CARIS
Everywhereyoulook™

Teledyne Marine

Teledyne Marine is an organisation comprised of 23 leading-edge undersea technology brands that have been assembled by Teledyne Technologies Inc. Through acquisitions and collaboration, Teledyne Marine has evolved into an industry powerhouse, providing the widest breadth of marine technology in the industry, now available through a single supplier. Each Teledyne Marine brand is a leader in its respective field, with a shared commitment to providing premium products backed by unparalleled service and support.

The Teledyne Marine companies now include: Teledyne AG Geophysical, Benthos, BlueView, Bolt, Bowtech, CDL, DGO, Gavia, Geophysical Instruments, Impulse, ODI, Odom Hydrographic, RD Instruments, Real Time Systems, RESON, SeaBotix, Storm Cable, TSS, VariSystems, and Webb Research.

www.teledynemarine.com // Stand 32

terra4 GmbH

terra4 GmbH represents 5 companies in Germany that manufacture instruments and loggers to record oceanographic data: Nortek AS from Norway, Rockland Scientific International Inc. from Canada, NKE Instrumentation from France, and Precision Measurement Engineering Inc., and Turner Designs from the USA.

Nortek is a scientific instrumentation company that develops and distributes instruments for water velocity and wave measurements (combined wave height and direction). All Nortek products are based on the acoustic Doppler principle and span from single-point turbulence sensors to long-range current profilers.

Rockland Scientific is dedicated to the measurement of turbulent flow in the marine environment.

NKE Instrumentation delivers autonomous and connected data loggers for physicochemical parameters in oceans and continental waters.

Turner Designs is specialised in fluorometers for the measurement of natural and artificial fluorescent substances.

Precision Measurement Engineering (PME) provides data loggers for environmental monitoring in rivers, lakes, and estuaries.

www.terra4.de // Stand 33

Triton Imaging Inc.

Triton Imaging Inc. is a global provider of high-performance software tools for seafloor mapping and underwater imaging applications.

Triton software offers a complete offshore survey solution for mission planning, multi-sensor data acquisition, real-time vehicle tracking and QC processing, with a single post-mission analysis package including a suite of processing and interpretation tools for an unparalleled insight into your combined data sets.

Since opening in 1983, Triton's software has been used by commercial, scientific, and government organisations with thousands of systems sold around the globe.

www.tritonimaginginc.com // Stand 61

Unique System (UK) Ltd.

As an independently owned global company, Unique Group leads the way in providing engineering expertise, sales and rental equipment and the latest technology for the marine, diving, pipeline and subsea market sectors. Unique Group delivers bespoke, off-the-shelf engineering solutions and cost efficiencies across the oil and gas supply chain – onshore and offshore, surface and subsea.
Unique Group employs over 500 people worldwide through its six multi-site divisions: Survey Equipment; Marine & Subsea; Diving & Life Support; Buoyancy & Ballast; On-Site Engineering; and Specialised Boats.
Its 200-plus dedicated engineering specialists work across nine strategically important global oil and gas regions – USA, UK, Europe, Singapore, India, South Africa, Kingdom of Saudi Arabia, Qatar and UAE.
www.uniquegroup.com // Stand 80

Valeport Ltd

Valeport manufacturer Hydrographic instrumentation which include Sound Velocity Probes / Sensors, Altimeters, Radar Level Sensor, Current Meters, Tide Gauges, CTDs, and GPS Echo Sounders.
Supporting Hydrographic surveys with the latest in technology is always our prime aim and the SWiFT SVP does not disappoint. Designed from the outset with the intention of a seamless workflow, the SWiFT SVP has integral GPS to geo-locate every profile. This new compact unit features high accuracy Sound Velocity, Pressure, Temperature, Salinity & Density measurement, plus integral GPS, re-chargeable battery and LED status indications for GPS, battery and communications.
A "twist and go" action ensures data can be easily and quickly downloaded, reviewed and translated to common SVP formats wirelessly via Bluetooth Smart using the SWiFT APP on iOS devices where data can be instantly shared via FTP, email and cloud services.
Valeport's DataLogX2 software is supplied for those wishing to use a PC.
www.valeport.co.uk // Stand 21

Wärtsilä ELAC Nautik GmbH

For hydrographic survey operations, Wärtsilä ELAC Nautik develops and manufactures state-of-the-art systems. Customers in the field of hydrography for survey of harbours, rivers and lakes as well as for oceanography, marine geology and marine biology appreciate the precise charting of the seafloor topography.
In close cooperation with hydrographic institutes and scientific authorities as well as commercial survey companies worldwide, Wärtsilä ELAC Nautik develops vertical echo sounders, multibeam systems as well as customer-specific hardware and software solutions.
The ELAC SeaBeam Multibeam Echo Sounders cover the complete range from shallow water to full ocean depths. For surveys in arctic conditions, ice-hardened components and configurations are available.
Scientific systems on modern research vessels require complex sensor and data management systems.
Wärtsilä ELAC Nautik fulfils these requirements from single components to complete turnkey-solutions. A competent service team supports the customer during installation as well as during survey operations and data processing.
www.wartsila.com // Stand MS1

Acknowledgements

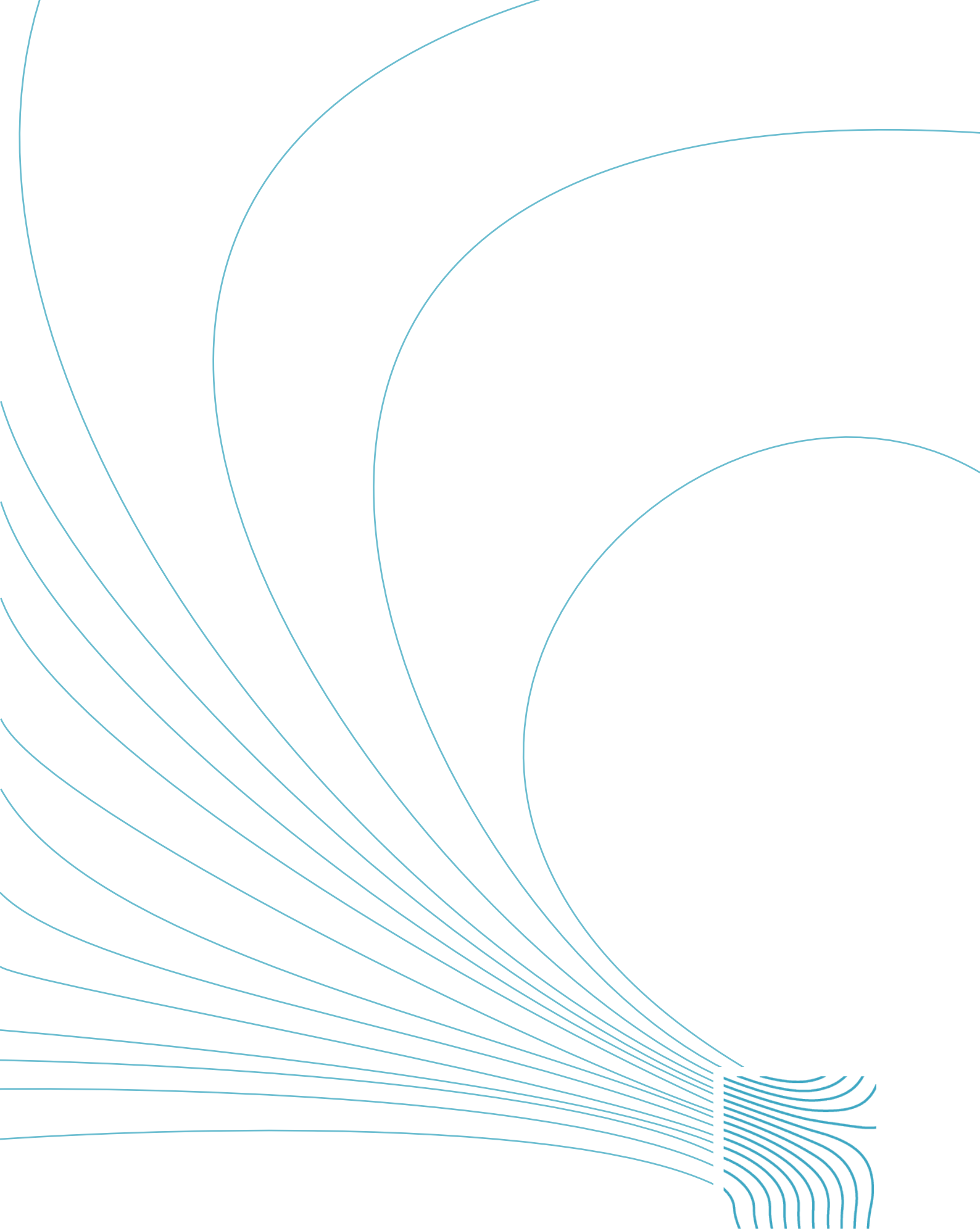
IFHS – International Federation of Hydrographic Societies
Rob van Ree (Maritime Institute Willem Barentsz) (IFHS President)
Helen Atkinson (IFHS secretary)

Organising Committee
Sabine Müller (Innomar Technologie GmbH)
Thomas Dehling (Federal Maritime and Hydrographic Agency)
Lutz Christiansen (LKN)
Dr. Jens Schneider von Deimling (University Kiel)
Christian Maushake (Federal Waterways Engineering and Research Institut)
Holger Klindt (Atlas Elektronik)
Lars Schiller (Zindel AG)
Caren Korte (Innomar Technologie GmbH)
Dr. Jens Wunderlich (Innomar Technologie GmbH)
Tanja Dufek (HafenCity University Hamburg)
Manfred Stender (Fugro OSAE)
Sylvia Spohn (Federal Maritime and Hydrographic Agency)

Event Managing and Travel Partner
Ines Lenz (vip hanse touring)

Fair Constructor
Marco Belger (Die Innendesigner)

Design and Layout
Lars Schiller (Zindel AG)
Konrad Rappaport (Kommunikationsdesign)



HYDRO 2016
ROSTOCK-WARNEMÜNDE
08.-10. NOVEMBER