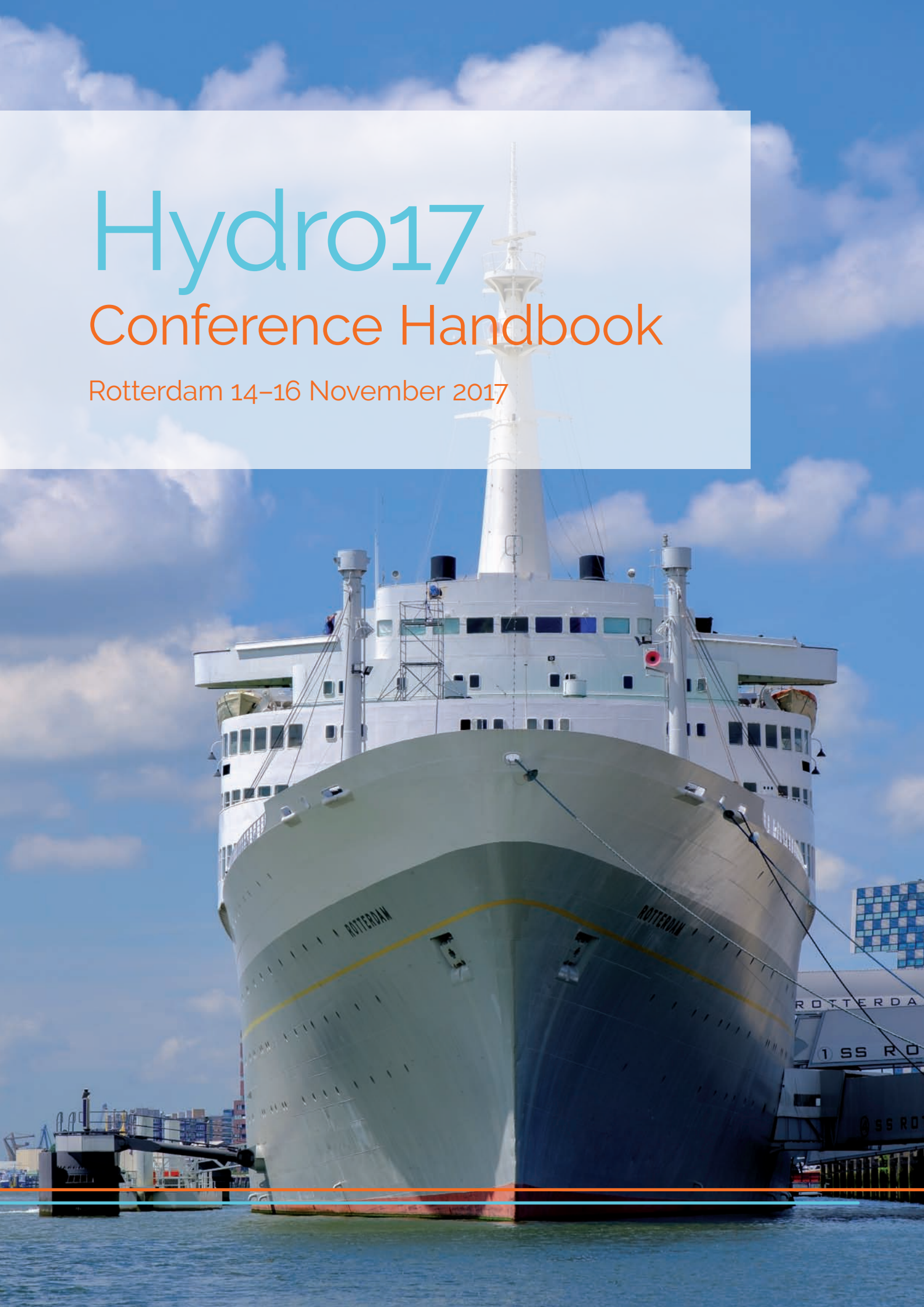
Hydro17

Conference Handbook

Rotterdam 14–16 November 2017



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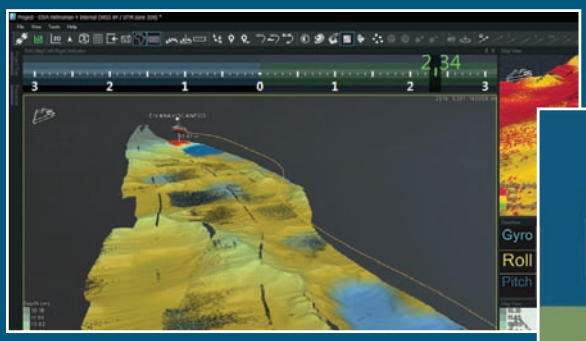

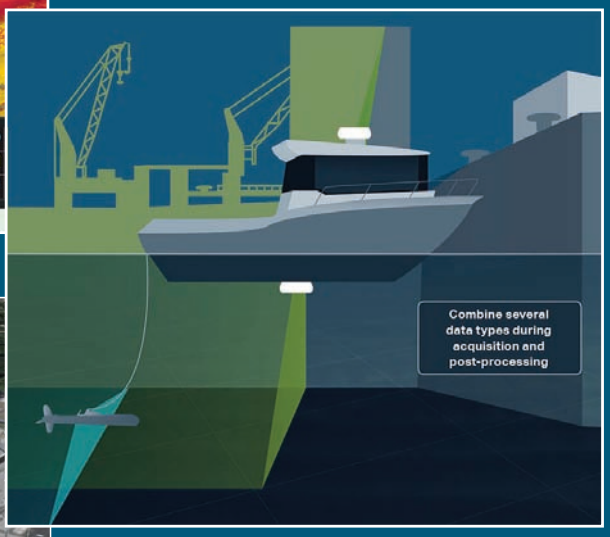

Do you represent a hydrographic office or an educational institution?

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EIVA
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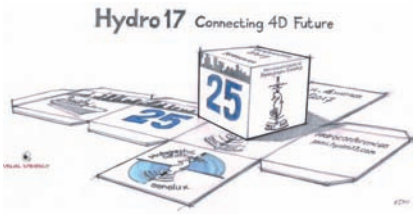
Welcome

Our team is very happy to welcome you at Hydro17 in Rotterdam! The 25th edition!

Hydro17's theme is 'Connecting 4D Future' and aims to stretch connection in space & time to other for hydrography relevant disciplines. Within the universe and therefore also on Mother Earth everything is connected, the 'Earth System Science' approach might help us to look at our survey challenges from a refreshing perspective. This could stimulate 'out of the box' innovation, subsequently leading to the realisation of technical creative and sustainable solutions.
I hope you will be inspired by our special keynote speakers, attractive programme and the maritime environment on board the 'grand old lady' ss Rotterdam.
Our programme offers you interesting presentations on state-of-the-art hydrographic techniques and scientific presentations on topics throughout the hydrographic spectrum, including education. A broad range of companies are presenting their products and services in more than 30 stands located in the conference lounge and outer promenades on two decks of this unique venue. Throughout the event workshops, commercial presentations and on water survey demonstrations may be visited.
At the beginning of each day a keynote speaker will take us away from our day-to-day rhythm on a short journey into their special world. They give us the opportunity to tune in and prepare ourselves for open minded & constructive debates on the presented papers.
During our Hydro17 socials and breaks, there will be enough space & time to connect, to inspire each other and to do business. Especially with the participating students, our future generation.
All these activities take place on board the ss Rotterdam and in the adjacent dock. The historic conference lounge is our main assembly room, the fully equipped central theatre our stage for the presentations and the 'ice will be broken' in the grand ball room. Connecting maritime history with today's innovation.
Our Hydro17 conference dinner on Wednesday will be served on board a harbour cruiser showing us mainport Rotterdam.
The on-board hotel accommodation completes the maritime touch of this 25th edition of the Hydro conferences. We hope you feel comfortable and at home during your Hydro17 cruise.
Fair winds & following seas.
This conference handbook is your guide for Hydro17. It gives you the detailed programme, including abstracts of the oral and poster presentations, and the plan of the exhibition and sponsors. You find the complete conference papers as E-book on our website Hydro17.com.
You are invited to connect with your colleagues and to all the professional presented topics/subjects/papers during our conference to create an inspiring, constructive & cooperative atmosphere 4 now and 4D future.
Share your views & ideas and let's make Hydro17 a wonderful success!

On behalf of the Hydro17 team I wish you a great conference on board the ss Rotterdam!

Floor de Haan
Chair, Hydro17 organising committee



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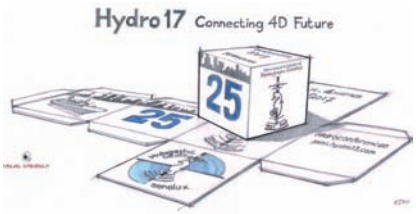

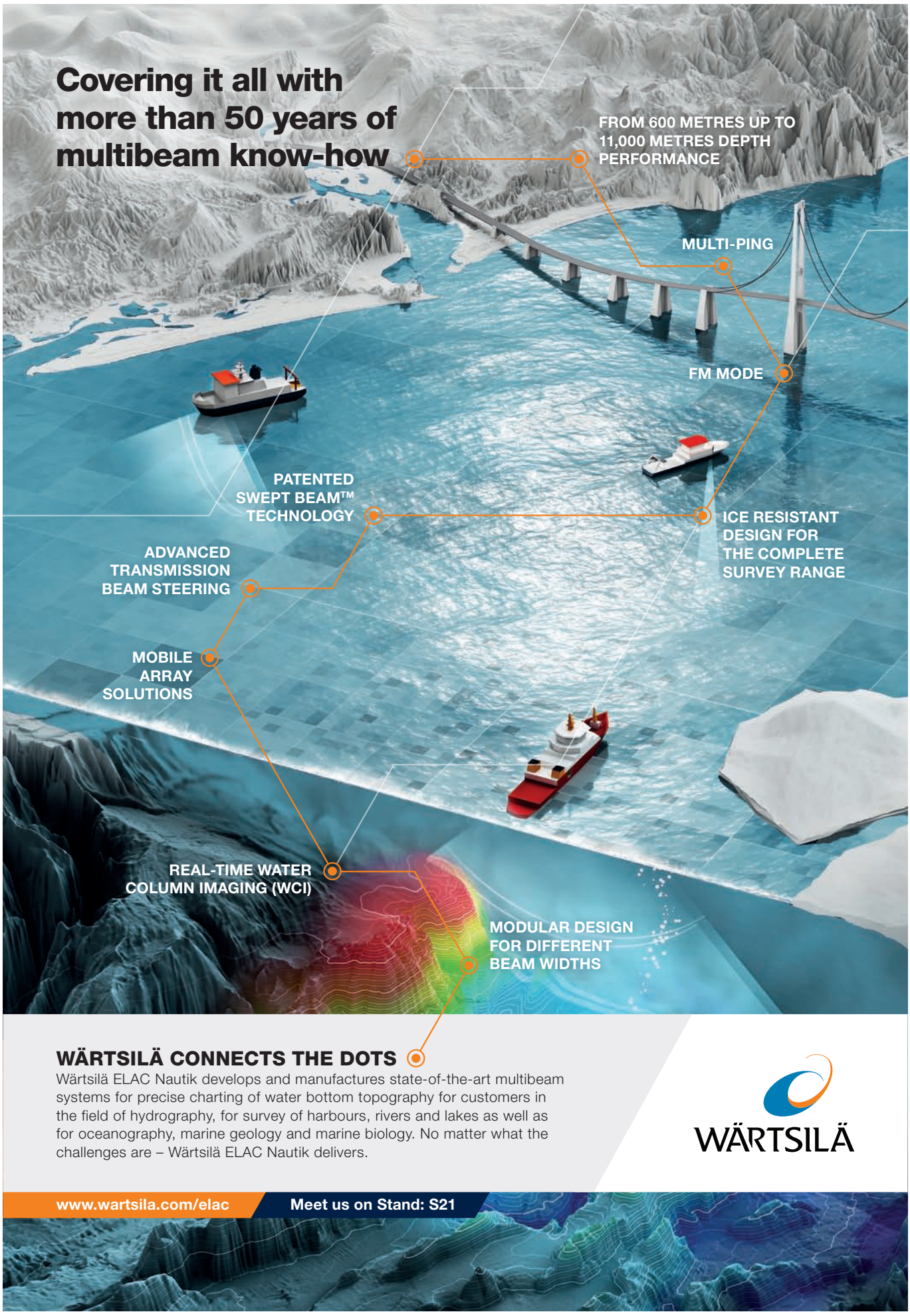

WÄRTSILÄ CONNECTS THE DOTS

Wärtsilä ELAC Nautik develops and manufactures state-of-the-art multibeam systems for precise charting of water bottom topography for customers in the field of hydrography, for survey of harbours, rivers and lakes as well as for oceanography, marine geology and marine biology. No matter what the challenges are – Wärtsilä ELAC Nautik delivers.

WÄRTSILÄ

www.wartsila.com/elac **Meet us on Stand: S21**

IFHS and Hydro conferences

The Hydrographic Society (later to become International Federation of Hydrographic Societies) was formally established forty-five years ago as a direct result of discussions in the early 1970s designed to explore the rapid expansion of the world's oil and gas industries, and the inherent need for suitably skilled personnel to supply this new demand.
The Society which rapidly adopted its, now familiar, seahorse logo was granted charitable (not-for-profit) status in 1974 and was formally incorporated as Company Limited by Guarantee in 1982.
The Society's principal aims were the promotion of the science of surveying over water and related disciplines as well as the fostering of recognised standards of education and training for those engaged in, or intending to engage in, the hydrographic profession. These were achieved through the organisation of international symposia, seminars and technical workshops (including the, then, biennial 'Hydro' series which began in 1976), and by representation on, or liaisons with other major learned and professional bodies associated with surveying and the marine sciences. A quarterly journal, The Hydrographic Journal, was distributed worldwide free to members and via subscription to others.
It could be argued that just four years after its foundation the Society sowed the seeds of the Federation with its first Regional Meeting, held by the Home Counties West Region in the, now infamous, Magpie Hotel, Sudbury-on-Thames. Almost immediately similar Regions then sprang up around the UK in East Anglia, Merseyside and the North West, and Scotland.
Membership continued to flourish throughout the 1970s whilst simultaneously adopting an increasingly diverse and international profile, with members eventually being drawn from almost 70 countries. In 1980 the Society took its next significant step towards federation with the foundation of the first national Branch in the United States; the next year it was joined by a sister organisation in the Netherlands (later to become the Benelux Branch) and followed by Branches in the UK (1985), Denmark and Australasia (1986). The process of decentralisation continued as several of the Branches went on to create their own Regions and Chapters.
After three decades as a highly successful independent, learned organisation operated within an international Council-led framework it was almost inevitable the Society's success would become the undoing of its established format. The success of its international Branches and their Regions ultimately resulted in their desire for domestic self-governance. Towards the end of 2001 members voted in favour of a proposal to start a process of change; the five existing Branches evolved into autonomous national/regional hydrographic societies and, over the next few years, the Society evolved into the International Federation of Hydrographic Societies (IFHS).
Incorporated in 2004, the IFHS is a unique partnership of learned national and regional hydrographic societies acting as an umbrella organisation to facilitate:

- an international voice for hydrography
- appropriate education and training for those engaged in or intending to engage in hydrography through the distribution of information, involvement in the definition of international standards relating to education and the delivery of educational awards
- scheduling of international hydrographic conferences
- the establishment and development of new national and region hydrographic societies.

Through its worldwide membership, IFHS is able to address every specialism within the hydrographic profession and related disciplines, at all levels of experience and expertise. It has considerable international influence, and is respected by hydrographic professionals and other organisations up to governmental and intergovernmental levels. It has IHO Observer status. Members of IFHS-affiliated societies have the chance to contribute to, and benefit from being part of, a strong and united international voice for the global hydrographic community. They can also lobby for and assist in the development of the most appropriate international standards for education and accreditation of hydrographic education and professionals.
The Federation's objectives are primarily achieved and communicated via its web site and e-publication IFHS News. These are complemented by an established series of technical Special Publications and its programme of annual international Hydro conferences, together with the informal national and regional seminars, workshops, evening meetings and networking events organised by our member societies.
The Federation's annual Student Award Scheme – which is linked to the Hydro conferences – recognises the author of the best dissertation paper by a full-time undergraduate or post-graduate student or recent graduate from within the countries or regions represented by the IFHS-affiliated societies. As well as receiving a substantial cash prize, the winner is invited to present their paper at that year's Hydro conference. In addition, a separate prize is also awarded to the candidate adjudged to have given the 'Best Student Presentation at Hydro' during the dedicated Student Presentations session at each year's conference. The first presentations of both prizes took place during Hydro14.

The International Federation of Hydrographic Societies current members are:

- Australasian Hydrographic Society (AHS)
- Hydrographic Society Benelux (HSB)
- Hydrographic Society Denmark (HSD)
- Association Francophone d'Hydrographie (AFHy)
- Italian Hydrographic Society (IHS)
- German Hydrographic Society (DHyG)
- Hydrographic Society of Korea (HySK)
- Hydrographic Society of South Africa (HSSA)
- The Hydrographic Society UK (THS UK)

For further information about the Federation, its members and activities visit
www.hydrographicsociety.org

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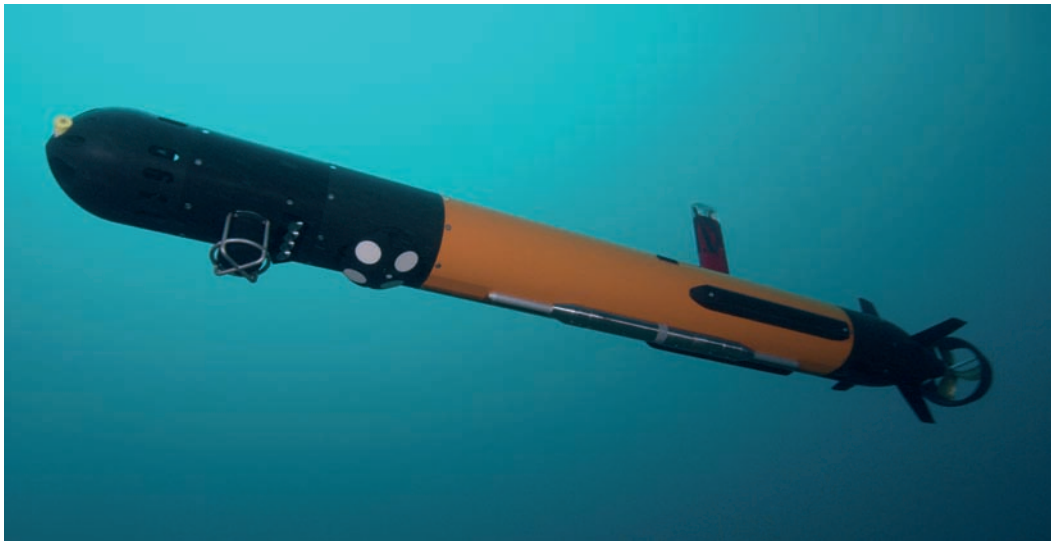
Why do professional users depend on Nortek's DVL for precision navigation?



The quality and accuracy of a navigation system depends largely on the quality and reliability of the DVL.

Our DVLs are field-proven and documented by leading navigation specialists. These specialists demand a modern platform offering state-of-the-art bottom tracking.

HSB and Hydro17

Dear participant,

Great you are attending, therefor a warm welcome from the Hydrographic Society Benelux (HSB), which is organising this Hydro17. The International Federation of Hydrographic Societies (IFHS) asked us (our Hydrographic Society Benelux) in summer 2016, if we could organise Hydro17. In a short time an enthusiastic team was formed to do so and despite the relative short preparation time we could give a positive "yes we can", although our internal planning was heading for organising a Hydro one year later in 2018.
Some information on our Hydrographic Society: The first firm contacts of the hydrographic community in The Netherlands with the Hydrographic Society (UK) were in the end of the 1970s This resulted in a new branch to the UK Hydrographic Society: The Hydrographic Society Netherlands Branch in 1981. Renamed later on in Hydrographic Society Benelux, to show that not only Dutchmen were interested in hydrography but our good neighbours from Belgium as well. The composition of the board of HSB resembles this cooperation with Belgians and Dutchmen working close together with workshops in both countries.
After having Hydro's organised in Amsterdam (1988), Rotterdam (1996), Antwerp (2006), Rotterdam (2012) we again selected Rotterdam. Not only because it is an example of the importance of hydrography in an area with shifting sands in a shallow sea area, a growing port with land reclamation, storm surge barriers, dredging works, etc., but also as the very special conference venue of Hydro12 was appreciated by the participants: the former Atlantic liner ss Rotterdam, completely refurbished to her original character of the 1950s–1960s. The slogan of the shipping company Holland Amerika Lijn owner of ss Rotterdam was at that time "It is good to be on a well run ship": nothing has changed since then! No doubt you will enjoy this very special venue, completely different from just another conference building.
Hydro17 will be focusing on strengthening the internal connection within the Hydrographic world, but also seeking connection with adjacent disciplines. Therefore, 'Connection 4D Future' will be the common theme throughout the conference. Our objective is traditionally connection within the hydrographic community. This to stimulate business & innovation and realisation of creative technical solutions – for survey challenges. Hydro17's theme 'Connecting 4D Future' aims to stretch our connection in space & time to disciplines relevant for hydrography. As everything is connected, this 'Earth System Science' approach might help us to look at our challenges from a new perspective, how to cope with present hydrographic challenges and prepare us for a more sustainable future. As with UNCLOS: for the benefit of mankind.
During Hydro17 we will also be celebrating our 25th anniversary of Hydro conferences! Hydro17 will be the 25th edition of the International Federation of Hydrographic Societies' Hydrographic Conferences.
On connection to the theme of Hydro17: You are on a special venue: an Atlantic liner build to connect the New and the Old World. A communication from which both worlds benefitted.

Wishing you an inspiring Hydro17!

Leeke van der Poel
Chair Hydrographic Society Benelux

Jan De Nul GROUP

WHAT'S YOUR DESTINATION?

Those who want to explore the world do not only go sightseeing. They dive in, map out their own route, and defy the waves. Always further and more adventurous.
With this passion our employees turned Jan De Nul Group into an expert in its field.

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We are looking for enthusiastic new colleagues for the ongoing expansion of our department! You will be involved in one of the various projects all over the world.

EXPLORE YOUR TALENT, EXPAND YOUR BOUNDARIES!

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ss Rotterdam

The art of travel is to enjoy every day, every hour and every minute while heading towards your destination. Today this message from Stoomschip Rotterdam (1958) is still alive and kicking.

Dutch pride

Steamship Rotterdam is the fifth ship with this name, put into service by the Holland America Line. It is the largest passenger ship ever build in the Netherlands perfectly representing Dutch craftsmanship when shipbuilding is involved. Special maritime aspects are everywhere and when it comes to architecture and interior design, again there is much to admire. A magnificent view of the Maas and Rotterdam's spectacular skyline guarantee an unforgettable experience.

Royal visit

There is no overlooking the ship's rich history. The ship has welcomed many celebrities including Frank Sinatra. It was inaugurated by Queen Juliana back in 1958, crown princess Margriet celebrated her 21st birthday on board in Monaco in 1969.

The start of new memories

After spending many years crossing the oceans and sailing to far-away destinations, the ship has headed back to his roots to the Port of Rotterdam. A worldly view of the river Maas and the spectacular skyline is guaranteed an unforgettable experience. It is here where people and cultures meet, where adventures begin.
You will know once you step off the gangway, this is an entirely different world. You can join us for an exquisite dinner, a sparkling party, a dynamic conference, the best wedding, a luxurious night at the hotel or simply to marvel at the ship and its impressive interior. ss Rotterdam is perfectly easy to reach, open to the public and today it is a unique location with endless possibilities.
In fact, on board the ship you can do whatever you might fancy doing in a big city, it is just that you prefer a unique spot. Enjoy the experience. The ship regained much of its authentic requirements in mind. Our proud crew will be delighted to make your visit a memorable event.


ROTTERDAM

Organising committee

Floor PJ de Haan

Floor is a retired Captain (Navy). During his operational career in the Royal Netherlands Navy he specialised in navigation and hydrography (Cat A surveyor). Highlights are Commanding officer of the survey vessel HNLMS Buyskes and Chief Hydrographer of the Navy. Today Floor is a part-time lecturer of the study Ocean Technology at the Maritime Institute Willem Barentsz (Terschelling), and a passionate beekeeper.

Floor is the chairman of the Hydro17 organising committee.

Rob van Ree

Rob is a Geodetic Engineer from Delft University of Technology. He is senior lecturer hydrography for the IHO Cat A education Ocean Technology at Maritime Institute Willem Barentsz on Terschelling, the Netherlands. He is board member of the Hydrographic Society Benelux (treasurer) and co-director of the International Federation of Hydrographic Societies.

In the Hydro17 organising committee Rob is responsible for finances, as he was for Hydro12.

Andrew Devlin

Andrew started his career as an offshore geotechnical engineer at Fugro. Some 15 years ago he shifted his attention to inshore hydrographical and geophysical surveying. He founded the Dutch company Delta Marking about 10 years ago. Recently he became board member of the Hydrographic Society Benelux. In his spare time he plays the electric guitar in a very loud rock band.

In the Hydro17 organising committee Andrew is responsible for sponsoring.

Matthieu Vrakking

Matthieu graduated as a Bachelor of Maritime Operations in Hydrography from the Maritime Institute Willem Barentsz. After that he started working at Periplus Group where he gained experience in data processing, automation of tasks and working with GIS. He is also the webmaster of the Hydrographic Society Benelux. Matthieu likes to play various kind of sports.

In the Hydro17 organising committee Matthieu is responsible for communications.

Tina Mertens

Tina graduated in as a civil engineer at Ghent University and wrote her Master Thesis about the potential of wave energy at the Belgian Continental Shelf. She started her career as coastal manager at the Flemish government responsible for the set-up and implementation of a Master Plan for Coastal Safety. In 2012 she started as assistant director at Flanders Marine Institute where she is responsible to assist the General Director in implementing and coordinating the policy and objectives of the institute. She is also Vice-President of EurOcean.

In the Hydro17 Scientific committee Tina is responsible for reviewing of papers and planning of the scientific part of the conference programme.

Wilbert Brink

Wilbert graduated as a Master of Science in Geodetic Engineering from Delft University. After that he worked as a field surveyor for Racal Survey for 4 years. He then moved to Fugro where he held various office positions in operations management. Since 2015 Wilbert works in one of the R&D Centres of Fugro as an Innovation Manager. In that role he deals with in-house developments that provide Fugro's clients with unique solutions in the field of offshore construction and inspection activities.

In the Hydro17 Scientific committee Wilbert is responsible for reviewing of papers and planning of the scientific part of the conference programme.

Angelique van Tongeren

Angelique represents the conference organising bureau of The Royal Netherlands Society of Engineers (KIVI) as a manager of all operational aspects of the conference.

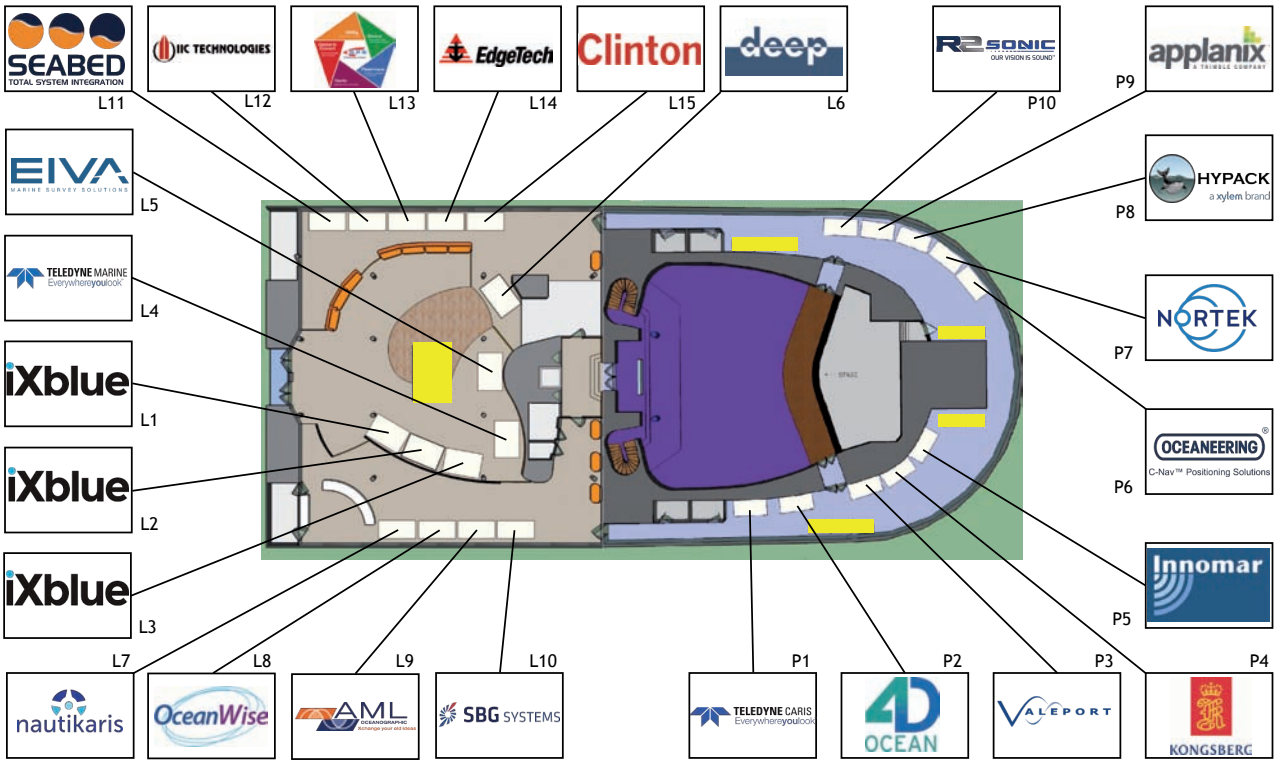
Marjolein Akkerman

Marjolein represents the conference organising bureau of The Royal Netherlands Society of Engineers (KIVI) as an employee of the conference office.

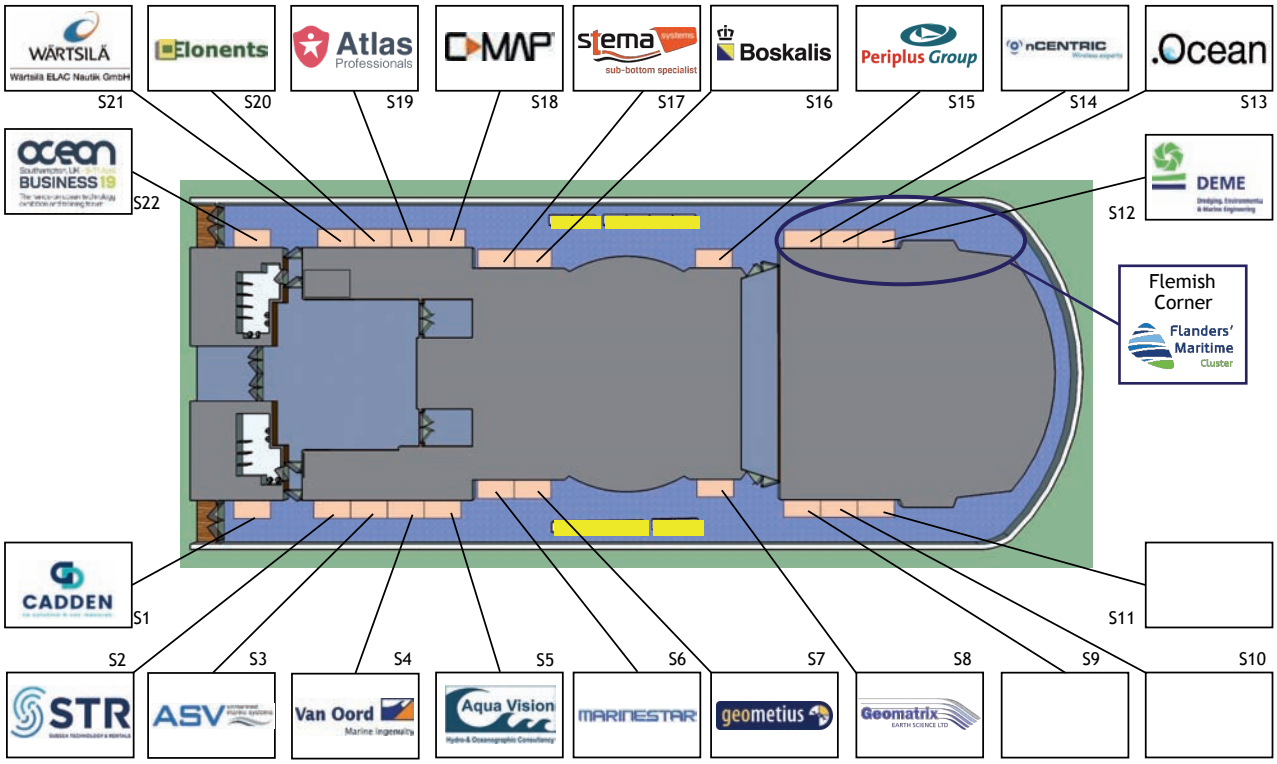
KIVI is the Dutch association for engineers and engineering students. With more than 20,000 members KIVI is the largest engineering association in the Netherlands. All engineering disciplines are organised within KIVI.

Floor plan

Queen's Lounge, Theatre and Atlantic Promenade



Glass Enclosed Promenade



Programme

Monday 13 November

19:30	Icebreaker event

Tuesday 14 November

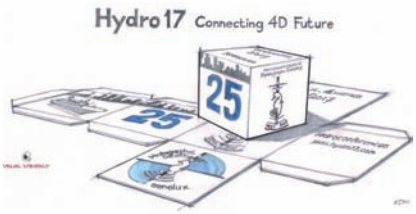
9:00–10:20	**Opening**
	Opening addresses
9:05–9:15	**Official Opening – Capt. Marc van der Donck**
9:15–9:30	Intermezzo: The story of the ss Rotterdam
9:30–10:00	**Keynote 1 – Professor Emeritus Peter Westbroek**
10:00–10:20	Activity pitches: 90 second pitches of tutorials, demonstrations, and excursions
10:20–10:40	*Coffee- and tea break*
10:40–12:25	**Session 1 — Airborne/LiDAR**
	Presentations 1.1/1.2/1.3/1.4/1.5
12:25–13:30	*Lunch break*
13:30–14:00	**Keynote 2 – Dr. Mathias Jonas**
14:00–15:45	**Session 2: Data Processing**
	Presentations 2.1/2.2/2.3/2.4/2.5
15:45–16:15	*Afternoon break*
16:15–18:00	**Session 3: Bathymetry (1)**
	Presentations 3.1/3.2/3.3/3.4/3.5
18:00	*End of Conference Day 1*

Wednesday 15 November

9:00–9:30	**Keynote 3 – Rob Luijnenburg**
9:30–10:55	**Session 4 — Autonomous Survey**
	Presentations 4.1/4.2/4.3/4.4
10:55–11:05	**Poster Pitches (1) (pitches of 90 seconds)**
11:05–11:25	*Coffee and tea break – poster sessions (1)*
11:25–12:50	**Session 5: Bathymetry (2)**
	Presentations 5.1/5.2/5.3/5.4
12:50–13:45	*Lunch break*
13:45–15:10	**Session 6: Backscatter**
	Presentations 6.1/6.2/6.3/6.4
15:10–15:40	*Afternoon break*
15:40–16:10	**Keynote 4 – Alok Jha**
16:10–17:55	**Session 7: Construction Support**
	Presentations 7.1/7.2/7.3/7.4/7.5
17:55	*End of Conference Day 2*
19:00	*Departure Spido from ss Rotterdam*
	Conference Dinner & Best Student Paper Award

Thursday 16 November

9:00–9:30	**Keynote 5 – Martijn Manders**
9:30–10:55	**Session 8 — Morphology**
	Presentations 8.1/8.2/8.3/8.4
10:55–11:05	**Poster Pitches (2) (pitches of 90 seconds)**
11:05–11:25	*Coffee and tea break – poster sessions (2)*
11:25–13:10	**Session 9: Education**
	Presentations 9.1/9.2/9.3/9.4/9.5
13:10–14:00	*Lunch break*
14:00–15:45	**Session 10: Cross-border Challenges**
	Presentations 10.1/10.2/10.3/10.4/10.5
15:45–16:00	*Afternoon break*
16:00–17:00	**Closing Ceremony**
	Best Paper Award
	Announcement of Hydro18
	Festive Closure
17:00	*End of Conference*



Welcome address by

Marc van der Donck

Captain (Navy) Marc van der Donck is an operational career officer of the Royal Netherlands Navy. As a junior and later as a warfare officer he served seatime on many (air defence) frigates. Marc has been Commanding officer of the minecountermeasure vessel HNLMS Willemstad and of the multipurpose frigate HNLMS Van Speyk and participated in NATO peacekeeping operations. Furthermore he has a wide range of managerial experience both international as within Netherlands Ministry of Defence. Marc is presently Chief Hydrographer of the Navy and the Netherlands representative to the International Hydrographic Organisation.

Official Opening
Tuesday 14 November, 9:05

Keynote speakers

Peter Westbroek

Peter Westbroek is Emeritus Professor in Geology. He actively participated in the creation of the new science – "Earth System Science" and is author of the book "The discovery of the planet Earth".
After Erasmus, Peter Westbroek is the first Dutch Professor to be appointed to the "College de France" in Paris and is the first to be honoured with the Vladimir Vernadski medal by the European Geophysical Society.

Keynote 1: A New Look at Gaia
Tuesday 14 November, 9:30

Mathias Jonas

Dr Mathias Jonas was elected as Secretary General of the International Hydrographic Organization (IHO) at the 1st IHO Assembly in April 2017. He took up his appointment at the IHO Secretariat in Monaco on 1st September 2017.
Prior to this election he held the posts of Vice President of the Federal Maritime and Hydrographic Agency and National Hydrographer of Germany with responsibility for sea survey and sea cartography. Being a mariner, Dr Jonas has been involved in integrated navigation matters since the beginning of the nineties. In addition he has completed the world's first ECDIS type approval in 1999 and has continuously contributed to IMO and IHO standardisation activities for navigation equipment, survey and cartography. In his former position as Chairman of the IHO Hydrographic Standards and Services Committee (HSSC) he supervised altogether ten different technical standardisation Working Groups. One of the core projects of the IHO, the S-100 concept, was developed during his term as Chair.

Keynote 2: Data Centric Hydrography – Bringing Knowledge to Action

Tuesday 14 November, 13:30

Rob Luijnenburg

Rob Luijnenburg's passion for hydrographic survey and offshore constructions originates from an education in offshore engineering at Delft University of Technology and military service at the Hydrographic Department of the Royal Netherlands Navy. In the course of his career of more than 40 years, offshore survey was always close to Rob's day to day activities.
Initially active as a consultant in pipeline design and installation, followed by a commercial role at NeSA, Head of Survey at Van Oord Dredging and Offshore Contractors. Rob joined Fugro as a Resource Manager in Survey 17 years ago. At Fugro he has been Regional Director and Corporate Strategy and Communication Director. Rob also served as Chairman of the Hydrographic Society Benelux in the period between 2002 and 2009.

Keynote 3: Future Ocean Survey: For Science or for Business?

Wednesday 15 November, 9:00

Alok Jha

Water may seem the most ordinary of substances – it pours from our taps and falls from the sky – but you would be surprised at what a profoundly strange substance it is. It bends the rules of chemistry and defies easy scientific understanding. Without this rebel behaviour, however, none of us would exist. Alok Jha will change the way you look at water – showing how it has shaped life on earth, and how this molecule connects you and everyone else to the birth (and death) of the universe.

Alok Jha is the science correspondent at ITN, working on news and current affairs for ITV. Before that, he was at the Guardian for more a decade, where he wrote news, features, comment and presented the award-winning Science Weekly podcast. He has also reported live from Antarctica and written and presented several TV and radio programmes for the BBC.

Keynote 4: Water – The Extraordinary Story of our Most Ordinary Substance
Wednesday 15 November, 15:40

Martijn Manders

Martijn Manders is maritime and underwater archaeologist and Head of the Maritime Programme at the Cultural Heritage Agency of the Netherlands (RCE).
His research interests also include underwater cultural heritage management on a global scale, specifically on in-situ preservation, sedimentation erosion processes and monitoring. Within Europe Martijn has initiated and worked on several innovative EU projects to develop new methods and techniques for geophysical and underwater research. The results contribute to making the Netherlands one of the leading countries in managing maritime heritage and conducting high-quality maritime archaeology research on a professional level.
As a maritime heritage expert Martijn has travelled all over the world to cooperate with many countries managing cultural heritage underwater. He also works for Leiden University where he teaches maritime archaeology at Masters level, and he trains young professionals worldwide, mostly in cooperation with organisations like UNESCO and ICOMOS/ICUCH.

Keynote 5: Digging into the Problems of Corruption
The Excavation of the 18th Century Dutch East Indiaman (VOC) Ship the Rooswijk
Thursday 16 November, 9:00

IFHS Student Awards

Studying or recently graduated in hydrography?

Like to present a paper to an international audience?

Keen to meet some of the industry's leading names?

Would a cash prize help to pay off your student debts?

Are **you** the world's premier hydrography student?

The International Federation of Hydrographic Societies (IFHS) owns the acclaimed annual series of Hydro conferences which are hosted by its member societies situated around the world. Hydro conferences attract over 300 delegates from up to 40 countries who come together to learn about the latest techniques and developments within the profession.

Each IFHS member society may nominate one candidate* for the annual **IFHS Student Award**, who if successful **must** be willing and able to present their proposed paper at the next Hydro conference. From these submission IFHS will select the Award winner who will also receive:

- free delegate registration at that Hydro conference
- up to £1,000 (GBP) towards travel and subsistence costs
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Efficient management and integration of big data for topobathymetric applications: case studies from Lake Constance and Bavaria in Europe

Frank Steinbacher[1], Werner Benger[1&3], Wolfgang Dobler[1],
Ramona Baran[1], Markus Aufleger[2]

The demand on topobathymetric data is growing quickly due to availability of newly developed airborne LiDAR sensors capturing high quality and resolution data. The data amount acquired is thereby increasing drastically. If the area of interest covers several hundred km^2, the data amount can quickly reach up to several terabytes, which is on the edge of storage device capacities and efficient data use with available software packages. For example, the topobathymetric point cloud of Lake Constance consists of approximately 10 billion points, which is equivalent to about 700 gigabytes in classical LAS format. Moreover, the digital surface model for Bavaria with a grid size of 40 cm (data from Bavarian mapping agency) comprises about 460 billion grid points equivalent to approximately 3 terabytes in LAS format. These examples illustrate the requirement of an appropriate file format and software framework to store, visualize, process and analyze topobathymetric data efficiently. We employ a block-structured hierarchy to organize arbitrarily large unsorted point clouds and place them in a spatially ordered level-of-detail scheme allowing for recursive on-demand queries on data sections of interest. As data are much larger than available RAM, our out-of-core technique only loads the minimum amount needed for visualization to achieve interactive rendering rates of 30 frames/sec regardless of zoom level or placement within data set during 3D camera navigation. The Hierarchical Data Format V5, designed for processing and archival of massive data generated high performance computing, is well suited to describe the complex relationships between data blocks and their metadata, and to handle arbitrarily large files or file sets transparently and efficiently, optionally providing a multitude of compression schemes crucial for such large data. Interactive rendering is performed by the HydroVISHTM Visualization Shell based on OpenGL Shaders allowing to display various point-based attributes combined with cartographic information like contour lines.

1 AirborneHydroMapping Software GmbH, Innsbruck, Austria
2 Unit of Hydraulic Engineering, University of Innsbruck, Austria
3 Center of Computation & Technology, Louisiana State University, USA

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

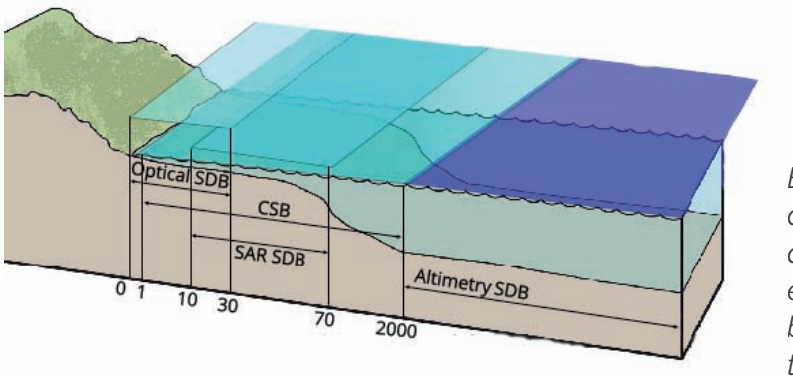
Stefan Wiehle[1], Bernat Martinez[2], Knut Hartmann[3], Martin Verlaan[4], Tim Thornton[5], Simon Lewis[6], Dick Schaap[7]

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 is available off-the-shelf as well as on demand. Adequate metadata is provided along with the bathymetry so usability by the end user is ensured.



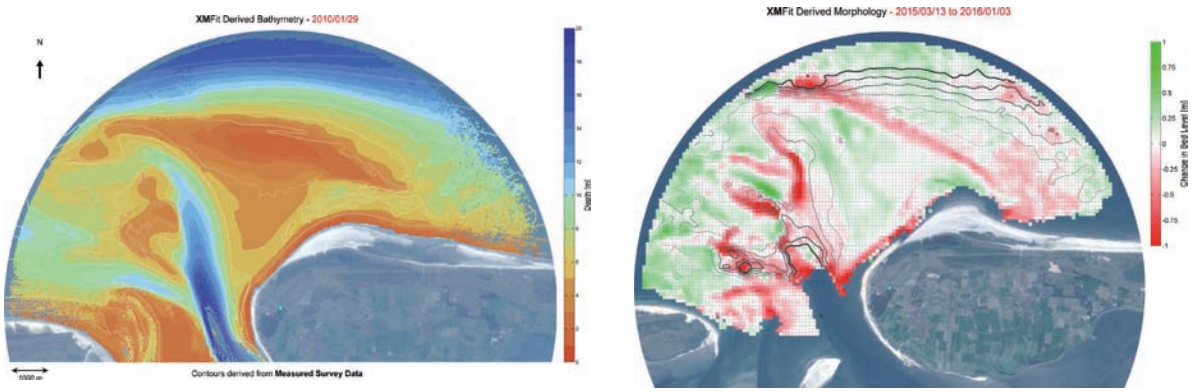
BASE-platform combines data from altimeter, SAR, and optical satellites as well as crowd-sourced bathymetry, all corrected for tides. A merged bathymetry data set is created from these sources

1 German Aerospace Center (DLR), Remote Sensing Technology Institute, 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

Estimating ebb tidal delta bathymetries using X-Band radar

Matthijs Gawehn[1], Josh Friedman[1], Roderik Hoekstra[1], Ap van Dongeren[1]

The Dutch ebb tidal deltas are important nearshore morphological features on the Wadden Sea coast. They cause dissipation of North Sea waves in storm and extreme conditions, which reduced the wave loads on the sea defenses on the main land. Furthermore, ebb tidal deltas are thought to be conduits through which sediment is passed from one island to the next. However, there is sparse field data to support this, because obtaining bathymetric data with high resolution and at large intervals is expensive. It would require small-draft vessels to survey a large area in sometimes energetic conditions (especially along the outside margin). Therefore, ebb tidal delta bathymetries are obtained only once every 3 years, or are surveyed only partially in each campaign.
It is now possible to estimate bathymetries using remote sensing equipment. In particular, it is possible to use the information obtained with existing and operational radars, for example the one at the Ameland Lighthouse. From bursts of radar images, we can estimate the dominant wave lengths in the sea spectrum. By using the XM-FIT method we can then acquire information on the bathymetry, wave and current directions.
The radar image covers a large area (a radius of about 7 km) including the entire ebb tidal delta and produces the same quality image regardless of weather and light conditions. A proof of concept is shown in the figure below. A radar-estimate of the bathymetry (left picture) shows distinct bed forms such as a flood channel to the west, a large shoal to the north, but also more delicate bar features near the eastern radar boundary. By comparing depth estimates over time, bathymetric changes can be observed (right picture), demonstrating the potential value of X-Band radar for monitoring and research.



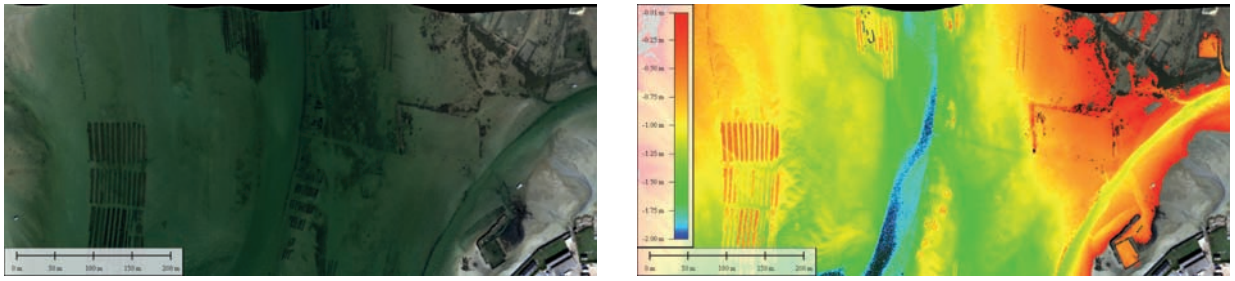
XM-FIT results for Ameland X-Band radar. Bathymetry derived from radar images compared to measured depth contours (left). Bathymetric change within a 10 month period suggesting eastward shoal movement (right)

1 Deltares, Delft, The Netherlands

Airborne Hyperspectral Bathymetry (AHB): concepts and performances

Marc Lennon[1], Nicolas Thomas[1], Simon Guéguen[1], Guillaume Sicot[2]

The description of simplified models of light propagation in water opens the way to the analytical inversion of these models, based on the observation of light coming from the water column, thus allowing estimating the parameters of the model, including the height of the water column, under certain conditions.
The observation of the water surface by hyperspectral imaging which allows to acquire the spectral radiance observed for each pixel of the image, thus allows the estimation of bathymetry, independently of the other parameters of the model characterizing the absorption and diffusion into the water column and the bottom.
A software chain called SWIM (Shallow Water mappIng using optical reMote sensors) was developed by Hytech-imaging for the production of bathymetric data from hyperspectral images using original model inversion methods, thanks to programs supported by French organizations: the National Agency for Biodiversity, the MoD, and the national hydrographic service SHOM.
The concepts of bathymetry estimation from hyperspectral images, as well as the elements composing the SWIM chain, will be discussed. Results of bathymetry estimation using AHB will be illustrated. The precision classes that can be reached by SWIM will be discussed in accordance with IHO S44 standards. Complementary products from AHB, such as its ability to produce seafloor reflectance and seabed habitat maps from the same data set will be highlighted, making it possible to position AHB as a general hydrographic tool for the production of bathymetric data with very high spatial resolution in depths of up to several tens of metres depending on turbidity, over large geographical areas with relatively low surface costs.
The conditions of employment of AHB will be discussed. Its performances and complementarity with other conventional means of hydrography, by acoustic and laser means in particular, will be discussed from the technical and financial points of view.



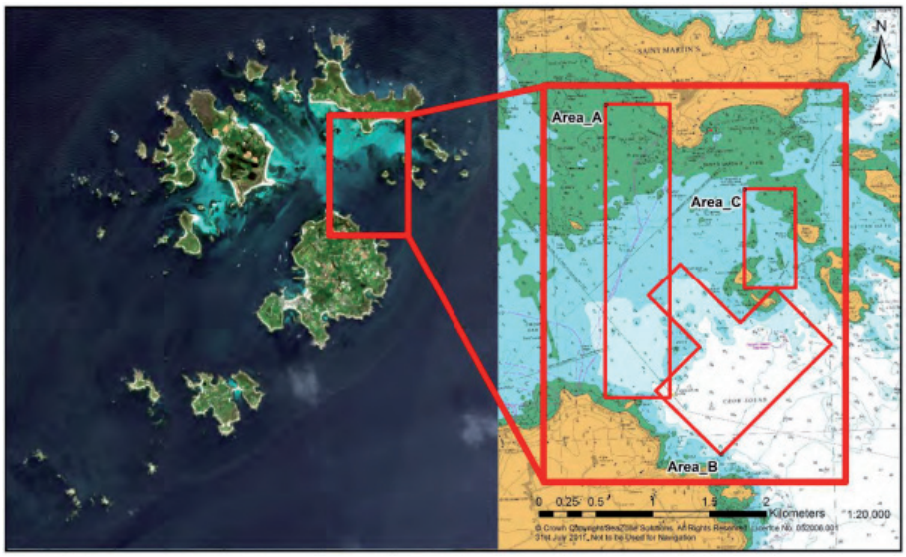
Original airborne hyperspectral image (left); bathymetry computed from SWIM (right)

1 Hytech-imaging, Brest, France
2 ENSTA-Bretagne, Brest, France

Bathymetric data derived from free source satellite imagery

William Dann[1]

An investigation into satellite-derived bathymetry from free source satellite imagery and its potential use in nautical charting. This emulates methods employed by the United Kingdom Hydrographic Office during their own investigations.
The areas of study were in the Isles of Scilly, due to the optical properties of water in this location. Three survey sites were selected: Area A, over bright sand; Area B, a deeper section and Area C, over dense kelp. The Stumpf et al. (2003) band ratio algorithm for depth extraction was employed, utilising a ratio of green/blue reflectance accounting for attenuation within the water column.
Compared to IHO SP-44 Order 1B LiDAR data, Area A achieved a RMSE of 1.686 m, whereas Areas B and C only achieved a RMSE of 2.476 m and 2.483 m respectively. The quality of data produced in this study is not suitable for charting and could only be used for reconnaissance.



ESA Sentinel-2 image (left) atmospherically corrected with survey area extent highlighted. Edina Digimap marine chart via ArcGIS (right), showing survey areas A, B and C

1 University of Plymouth

Minimum depth, mean depth or something in between?

Tannaz Haji Mohammadloo[1], Mirjam Snellen[1], Dick G. Simons[1], Ben Dierikx[2], Simon Bicknese[2]

Reliable information about the sea- and river-bed bathymetry is of high interest for a large number of applications. The Multi-Beam Echo-Sounder (MBES) system is able to produce high-resolution bathymetry data at a relatively limited cost. In general, these measurements, providing a depth for each beam in every ping, are processed to obtain a more ordered structure, such as a grid. Approaches for assigning a depth to the centre of a cell (in a grid) often use the shallowest or the mean depth in each cell. However, while the grid derived from the latter might be too deep compared to the shallowest depth, using the former approach can result in an artificially shallow grid, affected by outliers. This paper introduces a number of alternatives to the current methods by combining the mean depth with statistical properties derived from the point cloud of the MBES data, i.e. both the uncorrected and corrected standard deviation. While the standard deviation reflects the variations of the raw depth measurements in each cell, the corrected standard deviation accounts for the effect of slopes in easting and northing directions and hence in general it provides a more realistic description of the depth uncertainty in a cell. In addition, the possibility of assigning a depth based on the regression coefficients of each cell is considered. The methods introduced have been tested on data acquired in different survey areas with different MBES. The resulting grids have been compared to their shallowest and mean counterparts to obtain a better understanding of their advantages and limitations. A detailed overview of the findings will be presented.

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A comparison of different algorithms for a seamless merged bathymetry

Sandra Gaytán Aguilar[1], Martin Verlaan[1&2]

Bathymetry is a key element for a wide range of fields and applications, like physical oceanography, marine geology, geophysics, biology, navigation safety among others. Bathymetric maps are increasingly important as scientists learn more about the effects of climate change, setting up hydrodynamic models to study beach erosion, sea-level rise or subsidence for example. Nautical charts are based mainly on data acquired during bathymetric surveys. Recently, the use of remote sensing derived from optical and radar-altimeter and SAR sensors are more and more accepted as an addition to the traditional survey methods. Remote sensing has several advantages, e.g. it is possible to collect data of dangerous or inaccessible areas. However, the quality of remote sensing data is often variable and difficult to quantify. Also, a single sensor often covers only part of the area of interest. Our study aims to explore different merging techniques in order to have a seamless merged bathymetry data set from multiple sensors in addition to traditional survey data. A number of techniques, such a linear regression, weighting averages and kriging interpolation are studied and presented here.
In this study high and low resolution bathymetry data from different sensors have been used. High-resolution optical data provides very detailed bed geometry at high spatial resolution but limited to shallow water. Low resolution bathymetry data can be obtained from SAR or Altimeter data, covering larger parts of oceans. To quantify the accuracy before and after the merging, crowdsourcing data has been used in this study to validation all individual data sets and the seamless merged bathymetry.

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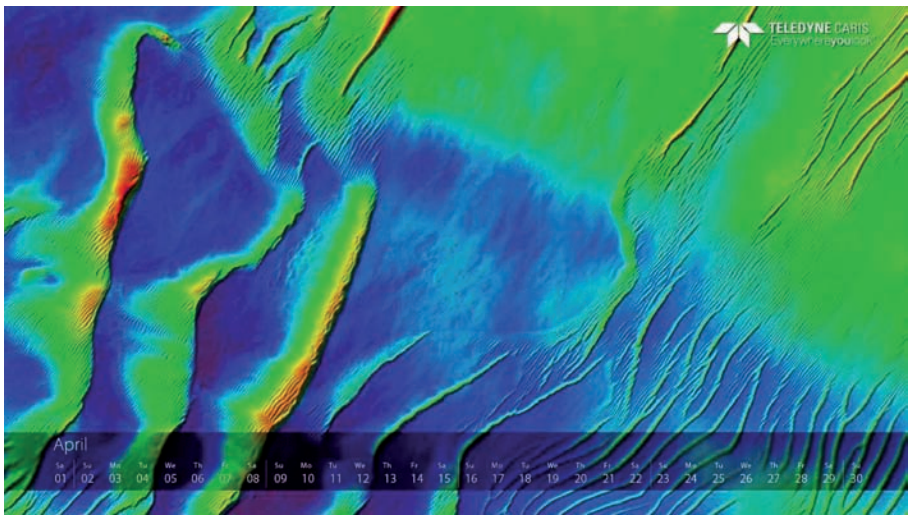
2 Delft University of Technology, Delft, The Netherlands

A new era for hydrographic surveying – The hydrographic surveyor ashore

Mark Pronk[1]

Developments in autonomy and robotics are also making their way now into the hydrographic world. Our traditional way of performing hydrographic surveys is changing rapidly. Autonomous vehicles, such as AUVs and USVs, are providing us with new opportunities, though presents us with some challenges at the same time.
Often, the demand on making results available is high for data processors. Various types of users require several different end-results as fast as possible. With the increasing popularity of autonomous operations the volumes of survey data processing are also increasing. The delivery of the various end-products in a timely manner is therefore even more challenging and prone to errors.
Traditionally, only upon recovery of unmanned vehicles and once the data has been downloaded the survey processing can be started in autonomous survey operations. Teledyne CARIS investigated the missing link and developed a technology, which can process the hydrographic data autonomously, i.e. on the platforms itself. This processed data can be viewed and used while the autonomous platforms are still in operation. The CARIS Onboard software allows anyone, anywhere in the world, to access the processed data during the survey mission. The quality of the processed data can be monitored and critical decisions can be made while the mission is still taking place. In order to prevent vital errors and obtain repeatable results, sophisticated workflows can be designed that automatically create multiple deliverables for a magnitude of users.
From now on, surveying is no longer just a task executed at sea, but can be executed from onshore locations. Autonomous vehicles provide a wealth of opportunities and affect the role of the surveyor. When we can let go of our traditional methods, a new era with huge possibilities awaits the survey industry.

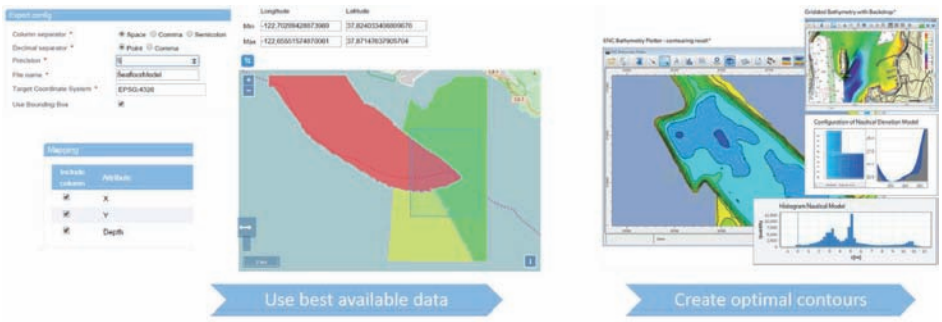


1 Teledyne CARIS, 's-Hertogenbosch, The Netherlands

Innovative approach in automated contour generation and sounding selection based on the Seamless Point Surface concept

Milan Uitentuis[1], Friedhelm Moggert-Kägeler[2]

The paper focusses on new practical and now available approach of creating contours and selected soundings for integration into nautical charts.
Typically the bathymetry that is incorporated into nautical charts (e.g. ENCs) is based on data from a variety of different hydrographic survey campaigns. The Seamless Point Surface (SPS) concept makes automatic and flexible compilation of seamless data models based on multiple point cloud and raster data sets originated from different measurement areas possible. Based on the metadata attributes of the data sets users can configure priority rules. Based on these rules the overlap between the data sets is removed by means of a de-confliction process. The hull of the data sets in the SPS determined resulting to the best available data on any location. Bathymetric data that is to be used for nautical chart production can be retrieved directly from the SPS database. A new approach has been developed that is intended to reduce the amount of manual work for the creation of contours and selected soundings: Before contour lines are generated a Nautical Elevation Model is created. A Nautical Elevation Model is shoal-biased smoothed-out and generalized underwater terrain model. While some aspects of the concept are similar to the Navigation Surface approach there is also a significant difference since mechanisms were integrated to dynamically configure the degree of generalization at different vertical levels.
This new concept of automated contour generation can be smoothly integrated into existing workflows of standard ENC production as well as for the production of high density S-57 bathymetry charts.



1 IntellinQ BV, Rotterdam, The Netherlands
2 SevenCs GmbH, Hamburg, Germany

Automated hydrographic surveying and latest technology in Eiva NaviSuite

Jeppe Nielsen[1], Ole Kristensen[1]

Automation is a key focus for the strategic product development at EIVA as we wish to provide competitive advantages and efficiency gains to end clients in offshore and subsea segments. With more and more data being gathered, it is critical that this data is processed as cost-efficiently as possible, i.e. requiring as little manpower as possible.
EIVA is part of several leading-edge endeavours that deal with massive data amounts, including the OCEAN INFINITY project using six AUVs simultaneously with only a normal size crew, which further increases the requirements on processing approaches.
This presentation will cover EIVA's latest product developments focused on automation, both in connection with survey planning, acquisition, data processing and interpretation of data.
This includes sensor-assisted automatic runlines, new data cleaning approaches, automated processing of massive data with high performance, on-board processing, remote processing and monitoring, machine learning-based interpretation of data, and several other new developments.

1 EIVA A/S, Skanderborg, Denmark

Prospects of uncertainty propagation for hydrographic surveys

Thomas Artz[1], Robert Weiß[1], Yvonne Schulze Tenberge[1], Thomas Brüggemann[1]

The aim of hydrographic surveys is to reliably measure the seafloor or the river bottom and to create a digital terrain model (DTM) of the underwater structures. The DTMs are used in subsequent analyzes to, e.g., ensure safety of shipping or to investigate the morphologic variations of waterbodies. The quality and reliability of the initial measurements and the DTM have to be known to be considered in any further investigation. The work presented in this paper is primarily done to fulfill the requirements of the German Waterway and Shipping administration (Wasserstraßen- und Schifffahrtsverwaltung, WSV) as this is the main focus of research and development at the Federal Agency of Hydrology in Germany (Bundesanstalt für Gewässerkunde, BfG).
In this paper, we focus on multibeam echosoundings performed on a survey vessel. The outcomes of such surveys are three dimensional coordinates. These are derived by the raw soundings, and further observations, such as GNSS- and IMU-measurements as well as local vectors between the individual instruments in relation to the ships body frame. Furthermore, calibration parameters such as velocity of sound determination have to be taken into account. Thus, we have to deal with combined uncertainties which can be assessed in according to the Guide to the Expression of Uncertainty in Measurement (GUM). The uncertainties are derived based on Hare (1995), however, several modifications have been done to adapt the methodology to today's technology and processing chains. In addition, we propagate the deduced uncertainties to subsequently derived products. In this way, the effects of thoroughly considering variable uncertainties instead of neglecting them are demonstrated.

1 Bundesanstalt für Gewässerkunde/Federal Institute of Hydrology, Koblenz, Germany

A comparison of 12 and 40 kHz multibeam echo sounder (MBES) for deepwater seephunter surveys

Matthijs Verschuren[1], Arjan van Vliet[1], Steve Keedwell[1], Hannes Swiegers[1], Ronald Cash[1], Oyvind Ruden[1], Pieter Van Rensbergen[1], Jim Gharib[2], Marco Gilissen[2]

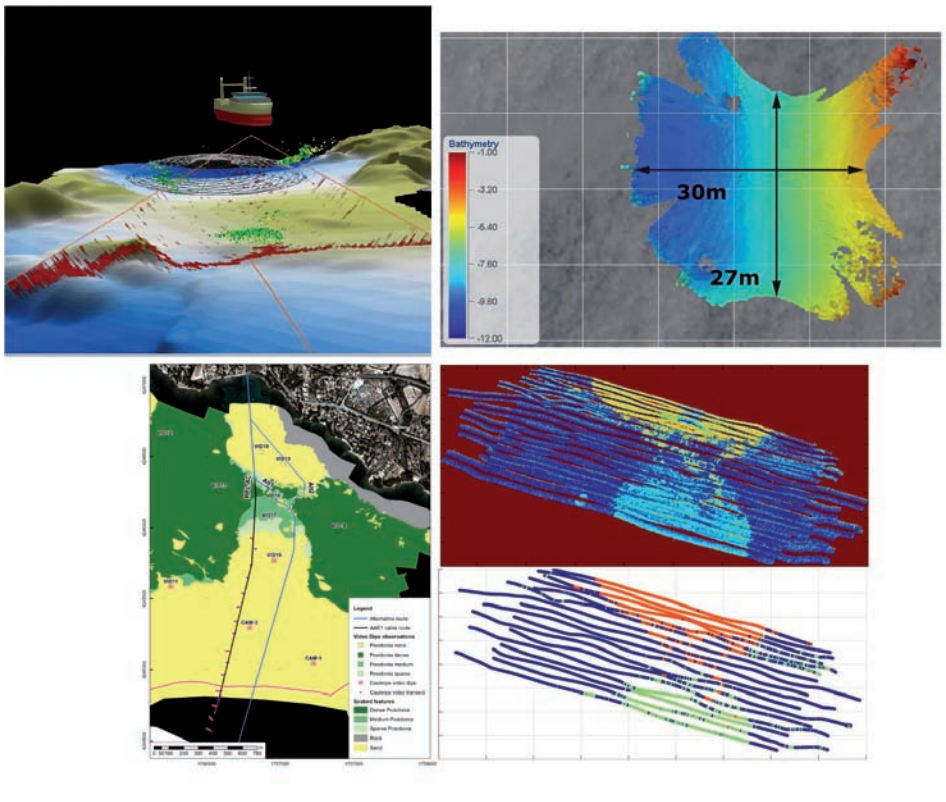
In March 2017 a deepwater multibeam echo sounder survey was conducted in water depths ranging between 500 to 2,000 m for the purpose of identifying seafloor seepage for geochemical coring (colloquially called seephunting). A Fugro vessel fitted with a Kongsberg EM122 (12 kHz) and Kongsberg EM712 (40-100 kHz) was utilized for acquiring the multibeam echo sounding data to identify features derived from bathymetry, seafloor backscatter and interpreted acoustic anomalies within the water column.
Having both multibeam systems on board provided an opportunity to compare the data results of the two systems with one another. The 40 kHz system would provide a high resolution multibeam data set with the resolutions of the bathymetry and backscatter being in the range of a ca. 5 m grid size. The 12 kHz system would provide a deeper penetration into the seabed, allowing for the potential identification of buried geological features to a greater depth. Additionally, the 40 kHz system was expected to identify additional (smaller) water column anomalies (e.g. gas bubbles, an indication of potential active seepage) compared to the 12 kHz system. It is the combined application of these two systems that would provide the best of both worlds with multibeam data collections for the purposes of geological interpretation. To the author's knowledge, this is the first time both an EM122 and EM712 has been deployed for this type of operation.
This presentation will discuss results and learnings from the project, and suggest recommendations for future development.

1 Shell Global Solutions International B.V., Rijswijk, The Netherlands
2 Fugro, Nootdorp, The Netherlands

SEAPIX: an innovative multibeam multiswath echo sounder for water column and seabed analysis

Guillaume Matte[1], Didier Charlot[1], Olivier Lerda[1], Trung-Kien NGuyen[1], Maxence Rioblanc[1], Frederic Mosca[1]

Seapix is a reversible Mills Cross multibeam echo sounder composed of two arrays, each of them stabilizing beams with a mems sensor included in the sonar head. This multibeam SONAR provide metrological target strength (TS) and volume backscattering strength (SV) on multiple swathes. Among others environmental variables, indicators like TS or SV are exploited for fish discrimination. Each detection referenced in 3D in the water column and is automatically reported on a map built in real time including local bathymetry. According to IHO standards, Seapix bathymetry is special order when coupled with external high quality motion reference unit.
Additionally, innovative methods used to classify seabed type from backscattering (BS) measurements will be presented. The first method takes benefit of the transverse steered beam in order to avoid specular reflection from the nadir that causes artefacts. In this way, the measured BS is compared to classified BS values in order to discriminate bottom type. The second method exploits signal from the longitudinal swath to finely fit typical BS profiles in the axis of the boat route. Both methods reach classification accuracies from 85 to 100 % on tests performed upon sparse posidonia, dense posidonia, sand and rock.
In static conditions, Seapix is also able to construct a bathymetry by steering beams over a region of interest in very turbid conditions as encountered in dredging or dragging. Acquisitions have been performed on 10 m depth, reaching a coverage of 27 x 30 m under the barge.



1 iXBlue, Sonar System, La Ciotat, France

Evaluating high-density swath bathymetry sonars against IHO-S44 specifications: Ping DSP 3D sidescan, a case study

David Dodd[1], Paul Kraeutner[2]

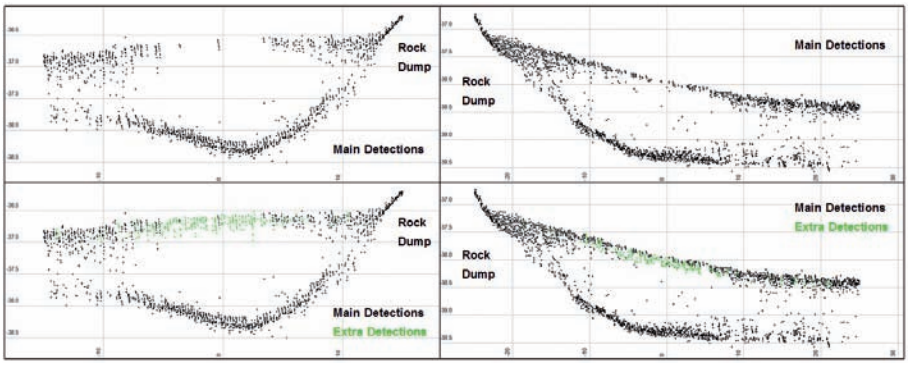
Evaluating modern bathymetric systems against IHO-S44 specifications can be challenging. One method looks at the comparison of a sample sounding set (i.e. crosscheck line) against a reference bathymetric surface. Uncertainty estimates derived from this method includes bottom roughness that is not accounted for in the reference surface. For a realistic estimate of system uncertainty, it is important that the reference surface be created to a 3D spatial resolution finer than that of the system being evaluated, and free of artifacts.
3D sidescan is a new sonar technology that provides wide swath bathymetry and previously unachievable high resolution 3D imagery. 3D sidescan is based on a new signal processing methodology called Computed Angle-of-Arrival Transient Imaging (CAATI) that separates and accurately resolves multiple simultaneous backscatter arrivals from different directions on a sample by sample basis. Phase based interferometry, on the other hand, is restricted by its use of phase differencing to resolve only one angle per sample and this measurement is highly erratic when arrivals from multiple directions such as the seabed, the sea surface, the water-column and multipath, interfere. Thus, CAATI may extend interferometry the way multibeam extends single-beam.
Since 3D sidescan accurately resolves multiple three dimensional locations for each and every backscatter sample, a 3D point cloud image can be generated and this point cloud extends over a swath width of 8-14 times the water depth. 3D sidescan represents a new high resolution 3D imaging/bathymetry capability and there is reason to believe that it offers advantages over traditional multibeam technology in cases where either high resolution spatial information is desired or where wide swath bathymetry coverage is a primary consideration. This paper examines the methods used to develop a reference surface for the evaluation of high-resolution sonars and presents the results of an investigation into the capabilities of the Ping DSP 3DSS-DX-450 3D sidescan sonar, in relation to IHO S-44 specifications.

1 IIC Technologies Inc., North Vancouver, British Columbia, Canada
2 Ping DSP Inc., North Saanich, British Columbia, Canada

Use of Kongsberg Extra Detections to support pipeline inspection surveys

Bart-Jan Tijmes[1]

A Kongsberg EM2040 dual head MBES was installed on a bracket in the moon pool of the newly built Fugro Pioneer geophysical survey vessel in late 2014. During various high detail pipeline inspections in early 2015, it became clear that the EM2040 had difficulties in detecting large diameter pipeline freespans at water depths beyond ±35 metres. In these situations, the pipelines were not detected at all. The residual detections suggested they were the actual seabed underneath the pipeline. The unacceptable loss of critical asset information resulted in numerous discussions with various clients questioning the validity of the MBES data collected by the Fugro Pioneer. Fugro worked with Kongsberg to explain this phenomenon, collecting various data sets using a wide variety of acquisition settings without significant improvements. During the summer of 2015, Kongsberg released a new feature called Extra Detections which was expected to detect the top of pipe when the main detections fail. In October 2015, the new feature performance was tested on two known freespans of a 36 inch pipeline. All data were analysed by Fugro and Kongsberg. The Extra Detections proved to be a successful backup to restore the top of pipe in at least 95 % of the situations where the main detections failed (see below figure).
Remarkable performance was observed from the cross-lines as no main detection failure was observed. Additionally, Kongsberg informed Fugro that the soundings underneath the pipeline are actually projected soundings from the seabed adjacent to the pipeline. This seabed generates a more powerful return within the -10 dB limit than the top of pipeline and therefore overrules the weaker pipeline return. The Extra Detections were used successfully throughout various pipeline inspection campaigns in 2016.



1 Fugro, Nootdorp, The Netherlands

Fully autonomous hydrographic surveys – a first year's experience

Duncan Mallace[1]

Driven mainly by the remarkable technological progress in Unmanned Aerial Vehicles surveys (or drones) and military requirements, 2017 proved to be the first year when it was possible to conduct a fully autonomous hydrographic survey. USVs and UAVs enable survey companies to reach coastal areas which have either been too hazardous or too shallow to reach with normal vessels or terrestrial means. As well as collecting the topographic and bathymetric data to low water neaps, the UAV photography is essential for mission planning of the USV.
4D Ocean was the first survey company to perform a fully autonomous survey and this paper presents the acquisition and processing methodologies, issues that were found and benefits that compared with traditional means. It presents the data and discusses improvements and future challenges.

1 4D Ocean, Banbury, United Kingdom

Maritime broadband radio – Expanding operations over the horizon

Ove Hognes[1], Vegard Haugen[1]

Autonomous platforms have been increasing in number and sophistication in recent years for both military and civilian applications in the marine sector. Maritime autonomy platforms are generally intended for the acquisition of data from many sensors to be used together to inform decision makers, either in real-time or post-mission. With each platform design are common goals of efficiently utilizing robotics for an overarching task, either as a replacement (labor cost reduction), an extension (the 'force multiplier' concept), or as an expansion of capabilities (doing something new). By focusing on the capabilities within the overarching task, the platform manufacturers can be sure the sensor payloads will adequately meet the needs of the end-user. On the other hand, questions of scale can't simply be answered with more platforms. The simplicity of network interfacing across multiple platforms, already in wide use among sensor manufacturers on a single platform, allows for the shared use of real-time data to expand autonomous operations. In the development of multiple platform operations, current telemetry methods are limited by range, bandwidth, and cost. In this paper, we present examples illustrating the potential of a phased array smart antenna to maximize coordination amongst manned, semi-autonomous, and fully autonomous platforms. Utilizing a flexible, long-range, high bandwidth solution empowers integrators and end-users to expand the capabilities of their platforms in single or multiple operational modes.

1 Kongsberg Seatex AS, Trondheim, Norway

Accuracy in depth

Peter Dugge[1]

In hydrography new survey methods become possible as unmanned underwater vehicles (UUVs) are getting more affordable and efficient.
UUVs have been widely used in oceanography, with the off-shore industry and for military applications for years. They come

- either as remotely-operated, tethered underwater vehicles (ROVs)
- or as programmable or even autonomously operating untethered underwater vehicles (AUVs).

The hydrographic pros (such as a higher resolution) and cons (such as a potentially lesser accuracy in position) of UUVs compared to surface vessels have been discussed for a while. Most of them result from the distinguishing characteristic of underwater vehicles:

- the closer proximity to the bottom of the water body and
- the greater distance to the water surface

A topic which has received less attention so far is the considerable gain in accuracy of depth measurements achievable when using UUVs rather than surface vessels.
This is caused by the very different characteristics of pressure measurements and hydroacoustic measurements and their contributions to the error budget of the measured total depths.
The way of designing and producing UUVs to actually take advantage of this situation leads first through the fulfilment of the well-known requirements for hydrographic surveys specified in IHO S44 Special Order, and then second to exceeding them.
It is now up to the hydrographic survey industry to develop new survey methods in order to profit from the possibilities offered by AUV products which are in-line with this approach.
The ideas behind this paper are

- to indicate how AUVs need to be designed to actually achieve high accuracies of depth measurements and
- to stimulate the discussion in the survey industry for the profitable use of such survey tools when serving safe navigation, efficient off-shore engineering and other maritime activities.

1 ATLAS ELEKTRONIK GmbH, Bremen, Germany

Automation at depth: Ocean Infinity and seabed mapping using multiple AUVs

Al Rumson[1]

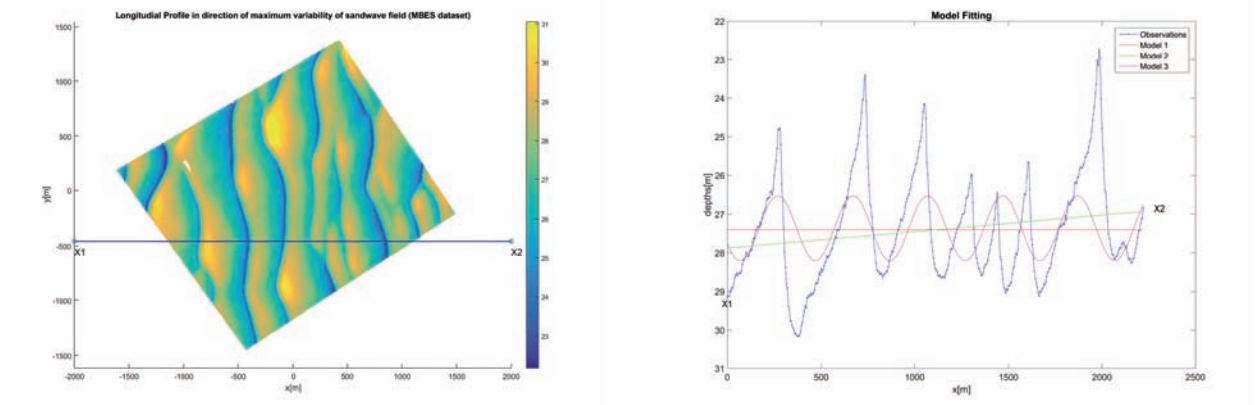
The purpose of this presentation is to present Ocean Infinity's novel approach to wide area sea-floor mapping with use of multiple Autonomous Underwater Vehicles (AUVs) from one single host vessel. Experiences from a challenging operation of combining a host vessel, multiple AUVs and multiple USVs in a simultaneous operation will be presented.
Ocean Infinity's approach to subsea mapping allows for an extensive coverage per unit vessel time thus achieving considerably-higher regional coverage while maximizing the daily cost of the vessel in the field.
The use of multiple AUVs, deployed from a single Host Surface Vessel (HSV) and tracked on a one-to-one basis by USVs, makes it possible to map a multiple of the survey area compared to the traditional "One Vehicle/One AUV" concept of operations, cutting the cost significantly. This is disruptive technology at its finest and a "Paradigm Shift" for the collection of seafloor data.
Using six units of the 6000 metre depth rated Kongsberg Hugin AUVs for detailed mapping of the ocean floor by use of MBE, SSS, SBP, magnetometer and a camera we are able to cover a large area per day with very accurate and detailed data. The focus for the presentation will be to show the result of such an efficient approach and share details of the challenges there are with such a complex operation.

1 Ocean Infinity, London, United Kingdom

Improved estimation of seafloor dynamics for optimising hydrographic resurvey planning

Reenu Toodesh[1], Sandra Verhagen[1]

Optimising the national hydrographic survey planning and monitoring scheme of the Netherlands Continental Shelf (NCS) towards an efficient and sustainable outcome requires a more comprehensive evidence-based approach to decision making.
The NCS is experiencing increasing economic activity across various sectors ranging from ports and navigation, tourism, renewable energy, coastal defence, submarine cables, mineral extraction, fishing and military activities among others. With limited resources for hydrographic surveying, to support these marine activities, the added knowledge and interpretation of seafloor dynamics is essential for prioritising resurvey frequencies.
A deformation analysis method is developed for detecting and estimating the seafloor parameters that attribute to the changing seafloor depths. Through exploratory data analysis, a library of basic mathematical models is set up for evaluating the reliability of the estimated parameters by assessing the residuals. This is done by developing a statistical testing procedure which investigates whether the residuals are due to the random errors in the measurements or model misfits.
Assuming the errors are due to the model misfits, the present study considers adapting the mathematical models accordingly by introducing more complicated models with additional spatial and temporal extensions for the characterisation of seafloor dynamics. As a result, it is expected that a more realistic and better fitting model will be selected as the representation of the seafloor. To validate the results of the parameter estimates using the final model, a synthetic data set of known dynamics using Monte Carlo simulation will be used as input. The final estimated parameters will be compared to the actual observations to determine the performance of the model.
Ongoing research will use the results of the improved estimated seafloor parameters to define indicators that will be useful in decision making and prioritisation of resurvey frequencies.

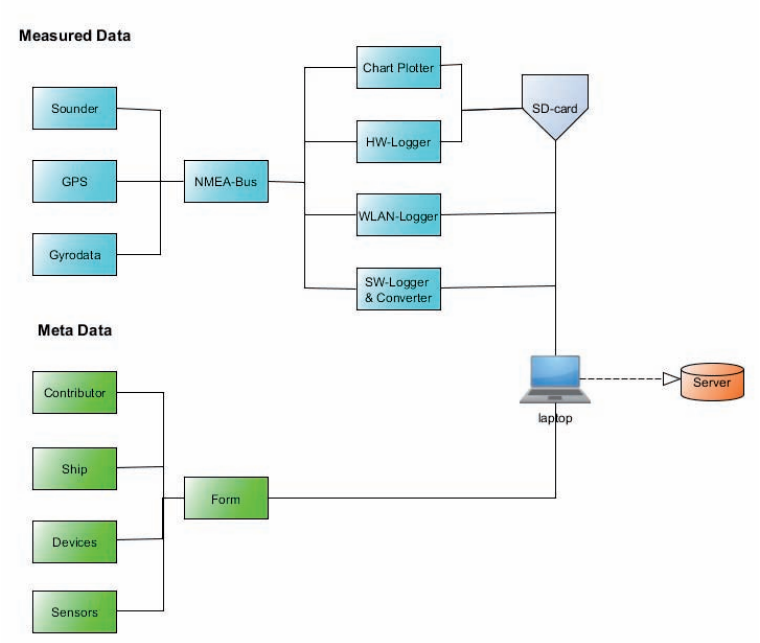


1 Delft University of Technology, Delft, The Netherlands

Development of a low-cost multi-sensor platform for recording shallow water depths

Sarah Diederichs[1], Harald Sternberg[1]

Many sailing and surfing hobbyists are interested in collecting depth values during their trips and sharing those. Like for terrestrial information on the OpenStreetMap website, the bathymetric version OpenSeaMap exists where collected data can be uploaded and retrieved as well. For enabling hobbyists to collect bathymetric data the creation of a multi-sensor platform is the focus in this paper. It should be able to measure autonomously shallow water depths with its low-cost components. The connection to OpenSeaMap should also be provided.
In order to succeed in building a low-cost measuring platform, the accuracy requirements need to be specified. In addition, it is examined which sensors and requirements from OpenSeaMap have to be met with the measurements and data through crowdsourcing. It is determined that for a working system an echo sounder, a GPS receiver, a motion sensor and a data logger are necessary for enabling the supply and usage of sufficient data to OpenSeaMap.
A market analysis deals with possible sensors that are available in the low-cost area at the time of the analysis and gives an indication of the devices used in the following steps.
The next section is the practical work. The combination of the sensors and devices, as well as the accessories, are very experimental. Problems are described and how they can be handled and remedied, so that the wiring of the sensors and interfaces is successful. Before connecting the GPS and the chosen fish finder some settings must be made and the fish finder signal must be received, decoded and transmitted in the NMEA-0183 format to the logger. After the complete assembly the sensor platform is tested in a pond.



Overview of all devices and information needed for OpenSeaMap

1 HafenCity Universität (HCU), Hamburg, Germany

Multibeam acoustic water column imaging: Fuelling real-time, post-processing and analysis applications with software

Jonathan Beaudoin[1], John van der Marel[2], Daniel Neville[1], Moe Doucet[3]

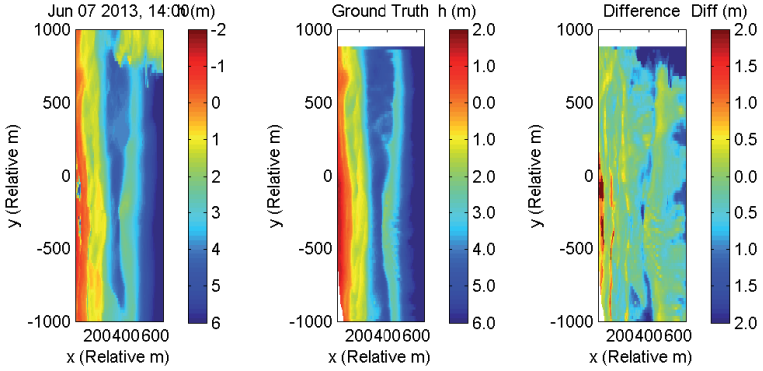
Multibeam water column imaging has been available for several years now and it has had early successful applications in areas like least depth determination over wrecks for nautical charting. More recent applications have been found in the oil and gas industries, particularly during the exploration phase through the detection of gas seeps emanating from the seafloor. New uses are emerging still, for example, real-time operations like monitoring cable touchdown, or near real-time planning of AUV missions for bottom sampling and coring, etc.
With new applications, come new challenges. For example, there is a growing need to move post-processing capabilities to the online environment. We touch on some of the challenges in transitioning post-processing techniques to real-time environments where automation and situational awareness are important design considerations that do not necessarily factor in when creating solutions for post-processing. With some capabilities moving to an online environment, this in turn brings about different needs in post-processing software and we explore these new challenges as well.
In post-processing, we face the challenge of satisfying rapidly diversifying user needs as requirements emerge and shift while users explore new ways to use the data and tools to meet their needs. Being able to rapidly transition research tools to operational tools is key, requiring agility on the part of software companies with early and ongoing partnerships with researchers and industry innovators being the first step in this process.
In this paper, we explore the above ideas with specific examples in QPS software being used to demonstrate key concepts and to showcase new ideas and innovations in all stages of acquisition, post-processing and analysis.

1 QPS, Fredericton, New Brunswick, Canada
2 QPS BV, Utrecht Area, The Netherlands
3 QPS, Portsmouth, USA

Optimisation of the bathymetry module within a rip current prediction system, operating in the area of Egmond aan Zee

Roman Schotten[1]

In the scope of the present work an algorithm to derive sub-tidal bathymetries was tested at the site of Egmond aan Zee in the Netherlands. During summer season the dynamic appearance of offshore directed currents leads to fatal incidents at the beach of Egmond. A prediction system was installed to support the local life guards with simulations, estimating localization and velocities of rip currents in order to prevent causalities at the beach site. This prediction system relies on a regularly updated and sufficiently precise bathymetry model. Therefore, video data from the Argus Monitoring System was derived. By yielding frequencies and wave numbers from the optical wave signal the wave dispersion relation is used to derive water depths within subtidal areas. The processing algorithm, cBathy, is refined by several parties. Two improvements are examined in the scope of this work and applied on the case of Egmond. One improvement deals with the optimisation of errors due to faulty input signals resulting in disproportionate sandbanks at boundaries. The overestimation of bathymetries close to the shoreline is investigated in the other optimisation. Different versions of cBathy are tested featuring, amongst others, the open-source version of cBathy launched in January 2017. Attempts are made to combine the profitable qualities of these optimisations in order to supply a stable output for the site of Egmond aan Zee. Supplementary problems to recreate results were resolved by optimising the documentation structure. The produced bathymetries are confirmed by comparison to ground truth surveys derived from an echo sounder. At the end of the work a well-documented and structured version of cBathy is derived with verified improvements for resulting bathymetries. The presented figure shows the result of the basic cBathy version and the simulation at the site in Egmond aan Zee for a 2 ½ month long period, displayed in the left plot. The plot in the middle shows the in-situ measurement which is allocated with the estimates from the left plot in order to gain the right plot illustrating the difference between simulation and measurement.



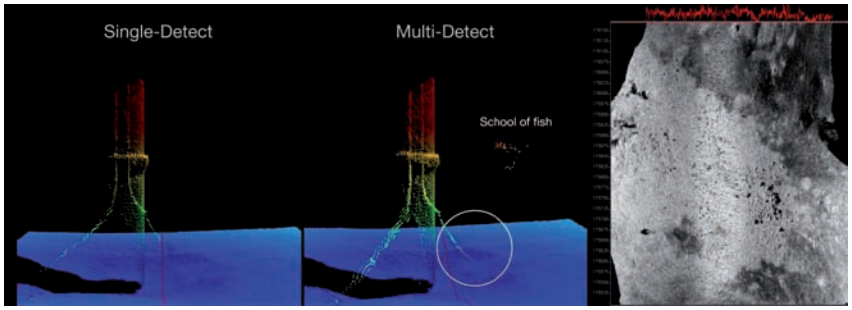
Bathymetry Jan van Speijk, Egmond aan Zee; Left: Estimates produced with a cBathy algorithm; Middle: Echo sounder survey from June 8, 2013;
Right: Difference = surveyed bathymetry – estimated bathymetry

1 Deltares, Delft, The Netherlands

Multiple data deliveries from on data source the multibeam system

Ellen Stuifbergen[1]

Multibeam systems are used to deliver bathy data for full coverage surveys. But besides the bathy data the systems also deliver other type of data of which the backscatter data such as SSS and snippets data are the most common outputs. For the SeaBat systems, Teledyne developed the multidetect mode: a method to detect more depths in one beam. The Pipe detection option in the SeaBat systems outputs a 5 points file with information about the pipe and the seafloor. But also water column data is available as an output of the multibeam systems. And the latest development is normalised backscatter data which eliminates changes in gain and power.
The question is what are the possibilities of these data outputs?
Bathy data is of course used for the depth measurements. Next to depth measurement it is also used to map underwater structures and monitor changes in the seafloor.
Multidetect is a method to detect more than one depth per beam. The method is known in laser systems but was never used in multibeam systems. Beams can hit targets partially and partial hit the seafloor. With the traditional bathy data the digitised depth could be either the target, seaweed, ships hull or the seafloor depending on the returned signal. With multidetect the bathy data shows all hits: the target, seaweed, ships hull and the seafloor. It can be used for different applications: to measure under a vessel, to measure seafloors in areas with gas seeps or seaweed.
The pipe detection algorithm in the multibeam system is developed to detect a pipe in the raw multibeam data and show the detection in the raw data. The pipe detection also provides a 5 points output. This includes the top of pipe position, 2 points next to the pipe and 2 points at a certain distance. This output can be used as as-laid route in the software.
Water column data is a deliverable of the full measured water column. Water column data is a lot of data but can provide different information than bathy data or backscatter. Water column data is used to find the least depth or gas and oil seeps.
The use of the backscatter data is not as widely spread as bathy data but it can be a valuable add-on for the user. SSS data and snippets data shows the difference in material.
To improve the backscatter data Teledyne RESON developed the normalised backscatter for the T50 systems. Normalised means that the changes in gain and power are eliminated in the data. When gain or power changes also the backscatter information changes. To normalise the backscatter output these differences are eliminated. It provides results that are repeatable for the area independent of the selected power and gain. As the normalised backscatter is not influenced by power and gain it is very useful for bottom classification.
The presentation provides more explanation about the use of the deliverables and possibilities



1 Teledyne RESON

Challenges in UXO-detection – An integrated approach

Liesbet Van der Burght[1], Alexander Cattrysse[1]

Developers of near- and offshore areas are confronted with the hazards of unexploded ordnance (UXO) on a daily basis and as a consequence the need for reliable and economically viable detection methods increases. Although geophysical techniques are generally designed to detect large scale subsoil variations (e.g. geological structures), they can be useful instruments for object detection, providing the user's familiarity with their potential and limitations. A range of common and innovative UXO-detection techniques will be discussed (i.e. magnetometry, electromagnetometry, sub-bottom profiling, side-scan sonar, electrical resistivity). By means of (a) case study(s) located in the North Sea and Rotterdam Harbour participants will be guided through the steps of a UXO-detection project: (i) analysis of expected object characteristics in relation to the survey area, (ii) pinpointing of survey technique(s) through discrimination and with respect to client objectives (economic viability), (iii) survey execution (instrument carrying vehicles, deployment techniques), (iv) interdisciplinary approach of data processing (interaction of survey team, UXO experts, geophysicist), (v) process-verification through object identification in the field, (vi) feedback and process-adjustment.

Tellermine (diameter ca. 32 cm) detected in the Netherlands

1 ADEDE bv, Gent, Belgium

An object based image analysis approach to rock counting in the Cleaver bank

Leo Koop[1], Timo Gaida[1], Tannaz Haji Mohammadloo[1], Mirjam Snellen[1&2], Dick Simons[1]

Identifying objects such as mines or rocks on the seafloor is an important and evolving research area. In this work, an object based image analysis approach is taken to find rocks in side-scan sonar (SSS) data taken in the Cleaver bank area of the Dutch Sector of the North Sea between 2013 and 2015. An automated algorithm would minimise expert interpretation time, a method used on this data previously.
In the raw SSS data, rocks down to a size of 30 cm are visible. For this research the SSS data is mosaicked at an appropriate resolution using the Fledermaus geocoder toolbox (FMGT). The mosaicked data is then imported in image format into the eCognition object based image analysis software. In eCognition, first the image will be segmented into image objects. Then, rule sets will be developed to automatically detect and classify rocks based on the textural relationship between the highly reflective rocks and the shadow that they cast within the image. Preliminary results show promise, but additional discrimination rules need to be implemented for the data close to nadir, where the mosaicking process leaves artifacts that can easily be interpreted as rocks by eCognition. It is expected that once the pitfalls of false positive identification close to nadir is solved, this rock-finding method will result in a fast, automated, and accurate method for future use.
The performance of the implementation will be examined related to the accuracy with which rocks are correctly identified. This will be done by first hand visual inspection of some of the data lines and by comparing all our results with results from expert interpretation of the same data. The performance of the algorithm will be further examined in relation to computing costs and hardware requirements.

1 Delft University of Technology, Delft, The Netherlands
2 Deltares, Utrecht, The Netherlands

Magnetic anomalies reveal prehistoric channels

Seger van den Brenk[1]

By using adaptive filtering, data from magnetometers can be used to reveal the presence of submerged prehistoric channels. This cost-effective technique can be used to provide detailed information about the shallow geology and prehistoric landscapes in offshore developments like wind farm zones.
To prevent disturbance of cultural heritage like ship wrecks, archaeological surveys are carried out prior to dredging and pipeline or cable lay operations. The commonly used techniques include side-scan sonar and magnetometer. The side-scan sonar is used to detect objects (like wreck remains) on the surface, while magnetometer provide information about (buried) ferrous objects like engines from Second World War airplanes.
In the past years the interest for submerged landscapes and prehistory has increased. Prehistoric animal and human remains are found on a regular base in the North Sea, providing information about the time when the area was dry land, connecting the United Kingdom with the European mainland. In 2007, the project Mapping Doggerland was carried out, where geophysical survey data from the oil industry was used to reconstruct the prehistoric landscape of the Southern North Sea.
In 2015, a high-density survey was carried out in the IJsselmeer near the city of Enkhuizen. When processing magnetometer, the background noise showed interesting alignments which could not be related to pipelines or cables. By using filters to enhance the alignments, clear patterns of what seemed complex channel systems became visible. The results from the magnetometer revealed a complicated network of channels, which did not match the seabed morphology.

1 Periplus Archeomare, Amsterdam, The Netherlands

Providing (hydrographic) services to marine construction

David Claeys[1], Alex Steffen[1], Daan De Munter[1], Marcel van den Heerik[1]

Hydrographic survey has always played an important role in the construction of marine installation like ports, offshore infrastructure and dredging projects. The connection between survey is becoming even clearer with modern day marine installations.
This paper provides a view of the important role of hydrographic survey and the connection it encompasses with various marine constructions. The paper will illustrate this connection by providing an overview of four different examples:
1. Ghana quay wall construction: In Ghana a quay wall is constructed by using Lego-block like construction blocks. The blocks are positioned, placed and measured by innovative techniques. Known tools and techniques are used in an innovative way to boost productivity.
2. Nobelwind monopile installation: For the Belgium coast Jan De Nul Group installed 51 monopiles and transition pieces. Each of the monopiles needs to be installed with tight tolerances for position verticality and orientation. Known techniques combined with ingenious software and procedures provided essential guidance to install the monopiles and transition pieces.
3. Dredging in an environmentally sensitive area: A land reclamation project in Monaco requires a layer of contaminated soil to be removed. The layer needs to be removed in an accurate way. By using new techniques, and combining them with conventional tools used in an unconventional way, the productivity is increased while assuring an environmental sound removal procedure.
4. Dry quay wall construction: In Panama a quay wall was constructed “in a dry excavation pit”. The entire works where followed up by conventional and new topographic equipment. Once the quay wall was finalised, the construction was flooded and hydrographic equipment was used to measure the entire installation. This made it possible to compare both the topographic results with the hydrographic results.

1 Jan De Nul Group, Hofstade-Aalst, Belgium

Cable detection using automated contact recognition in acoustics

Jasper Kwee[1]

As more and more wind energy parks are build offshore these days, the need for detecting and mapping of cables below the water bottom becomes increasingly vital. Active systems need a signal on the cable disrupting the operational purpose, causing delays and incurring cost. An acoustic sub-bottom survey is on the contrary a passive survey, thus not interrupting the above mentioned process. The low frequency enables an image of sub-bottom data, where pipelines and cables are identified by the display of hyperbolas. The top of the hyperbola indicates the top of the cable, which can be used to determine the depth of burial. These contacts can be determined manually, taking into account human error and inconsistency. A new development within the geophysical software package SILAS is the automated contact recognition technique for the detection of these hyperbolas. The contact recognition consists of the automated determination of two parameters: 1) the semblance of the apex of the hyperbola and 2) the accumulated power of the hyperbola. These parameters are quantifiable figures which enables a more objective classification of detected contacts. Besides the hyperbolas themselves, the sub-bottom data also shows geological structures within the bottom, including cable trenches. Recent studies show that the system can detect various types of objects located below the sea bed. These objects can be detected with a success rate of 75 % and higher both for objects and cables in the range of 25 cm diameter. Other data sets, as multibeam, side-scan sonar and magnetometer data, can be combined with the sub-bottom data within the software for cross correlation and clear imaging of the sea bed and below.

1 Stema Systems, Geldermalsen, The Netherlands

Optimising surveys for breakwater construction projects

Barry Grinker[1&2], Semion Polinov[1], Ariel Tarcic[1]

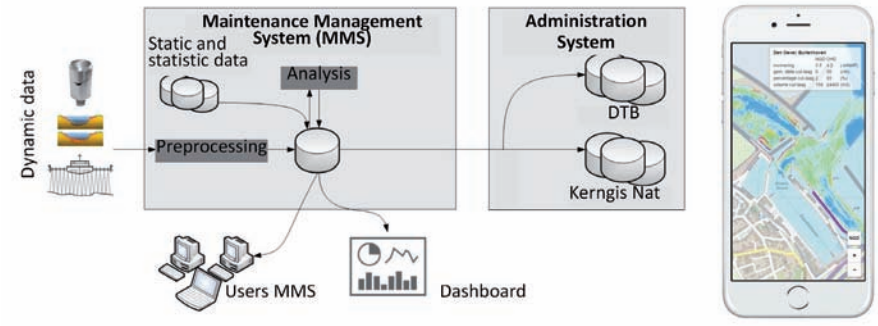
Port construction requires frequent surveying of breakwaters above and below the waterline. Multibeam systems are limited in surveying to depths around 3 m due to maximum angular ranges of about 160°, resulting in coverage limited by depth, while the survey vessel has to keep a safe distance from the breakwater. Therefore they do not insonify the shallow part of the breakwater slope which is usually surveyed by sounding ball and land survey levelling. Interferometric systems have a major advantage over regular multibeam systems as they transmit in an arc up to 240° resulting in insonification right up to the water surface (theoretically even out of the water). They receive return echos from throughout the above range and measure the phase differences as received in the transducer array.
Seafloor coverage is less dependent on depth and can be determined (almost) at will by the operator. The survey vessel can sail at a safe distance using a relatively large swath to insonify the entire breakwater up to the water surface. In fact returns from the sloping breakwater have better grazing angles in the outer beams than those on a flat bottom. However, the horizontal and above horizontal beams nearing the water surface meet the breakwater at more acute angles and may also suffer from reverberations at the air-water interface, depending upon sea state. With the above mentioned facts in mind, it is common practice to limit interferometric survey depths to about 1.5 m along breakwaters while still relying on costly sounding ball and levelling measurements to supplement the breakwater survey.
Lately drones with high definition digital cameras are being used for photogrammetric surveying. A few control points along a breakwater enable airborne photogrammetry to supplement the shipborne survey providing a high resolution seamless data set above and below the waterline.

1 Lia Engineering & Surveying Ltd, Ramat Hasharon, Israel
2 Haifa Technion, Faculty of Civil & Environmental Engineering, Haifa, Israel

Proactive dredging in the Dutch Waddensea

Mattijn van Hoek[1], Nicole Jungermann[1], Kees de Gooijer[1], Teun Lassche[2]

The navigation channels in the Dutch Waddensea require continuous maintenance due to unceasing sedimentation of sand and mud. The aim of this study is to develop a Delft-FEWS based maintenance management system (MMS) that is capable of providing insights in actual and forecast bottlenecks and contains report capability of dredged an dispersed volumes. The navigation channels are divided into 100 dredge fields, each having its unique required minimum and maximum depth. Frequential metre-resolution single- and multibeam bathymetric surveys provide bed level measurements that are translated into a custom made tiling scheme overcoming spatial and temporal variances. Morphological modelling of measurements and forecasts of wind are used to predict the bed level ten days ahead. The gross volumes, areas and average thickness eligible for removal (cut-operations) and potential infill (fill-operations) are computed using daily updated actual and forecast bed levels for both the minimum and maximum depth of each dredge field in the Dutch Waddensea.
In parallel the trailing suction hopper dredgers are equipped with a Monitoring And Registration System (MARS) capable of measuring dredged and dispersed volumes Tons Dry Solids (TDS). These automated measurements and a spreadsheet integration for manual recorded volumes are attributed in the MMS to the corresponding dredge fields and dispersion locations.
Preliminary findings show that the adoption of the custom tiling scheme is robust since its independence of location and dimension of the dredge fields. The current tiling scheme is so designed that potential small shifts of the navigation channels (within 50 metre) are possible within existing tiles. Where derivatives of the most actual bed levels are very important for day to day prioritisation of dredge activities, the forecast derivatives are still subject to further investigation to optimise the correlation of wind and sedimentation in the study area.
The adopted method for the developed MMS presents capability of producing alerts and warnings before bottlenecks become critical and can be incorporated for similar tasks elsewhere.



System architecture of the MMS and a map visualization on a smart-phone

1 HKV Consultants, Lelystad, The Netherlands
2 Gebroeders Van der Lee, Lelystad, The Netherlands

More uptime, less risk: performance of a real time on-board wave and ship motion prediction system

Peter Naaijen[1&2], Karel Roozen[1], Albert Rijkens[3], Bas Meijers[4]

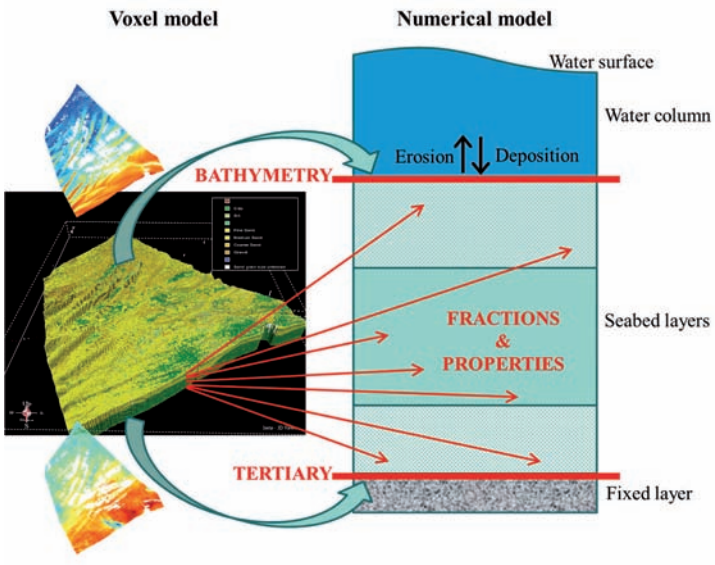
The installation and operation/maintenance of offshore wind farms requires many operations involving ships that move due to waves. Examples of such operations are: the installation of wind turbine foundations, transition pieces and turbine piles with cranes from installation ships, landing of helicopters on ships, transferring crew between ships or from ships to e.g. wind turbines.
One factor all these operations have in common is that there is a great risk involved due to an apparently unpredictable phenomenon: the waves, and the resulting ship motions. The traditional way of mitigating this risk is to restrict operation to wave conditions such that the probability of an undesired event is acceptably low. This however might result in high and often unnecessary down time.
However, it is a known fact that even in wave conditions that were rejected from this statistical point of view, time windows occur within which waves and ship motions stay well within operational limits.
Next Ocean is a young tech start-up originating from research at Delft University of Technology aiming to make available an on-board decision support system that predicts these workable windows some tens of seconds to minutes in advance, thus enabling crew to anticipate and grab a window of opportunity to perform the operation.
The prediction system uses raw data from the ship's navigation radar system and a data assimilation procedure to obtain a wave observation surrounding the ship. This information is fed into a real time wave propagation model in order to predict the waves arriving at the ship and finally the resulting motion response of the ship.
This paper presents the technology and the results of a trial campaign at sea during which motions of a 42 m patrol vessel were predicted by the system and compared to motions as recorded by a motion reference unit.

1 Next Ocean, Delft, The Netherlands
2 Delft University of Technology, Delft, The Netherlands
3 Damen Shipyards, Gorinchem, The Netherlands
4 Alphatron Marine, Rotterdam, The Netherlands

A continuum of knowledge from measurements to modelling to explore the future of our seabed resources, Belgian part of the North Sea

Nathan Terseleer[1], Vasilis Hademenos[2], Tine Missiaen[2], Jan Stafleu[3], Dries Van den Eynde[1], Vera R.M. Van Lancker[1]

An increased understanding of the seabed nature, behaviour and future evolution is a necessity in areas of marine aggregate extraction. In this study, an overall multidisciplinary assessment framework is set up that exploits a continuum of knowledge from in-situ geological measurements to a complex numerical modelling suite. Measurements include historically available cores, seismic profiles and sediment size distributions, and have been incorporated into a 3D geological 'voxel' model of the resource. This 3D voxel model simulates qualitatively and quantitatively the current state of the seabed by estimating the horizontal and vertical probability of occurrence of different lithological classes (see figure, left). It can for example be used to compute resource volumes for different sediment classes such as fine or medium sand. Innovatively, this model is fed into a numerical modelling suite that simulates hydrodynamics, sediment transport and seabed morphology over time as 4th dimension (see figure, right), thereby providing a 4D framework to assess and recommend on the sustainability of marine aggregate extraction. This coupling (see figure) provides an unprecedented level of realism for the initialization and parameterisation of the numerical model suite: comparison with a traditional approach considering a single sediment fraction with a homogenous distribution highlights the different behaviours of the sediment classes with regards to bed and sediment transport, providing an additional level of information. Moreover, while traditional modelling approaches usually consider an infinite quantity of sediment available for transport, the current framework ensures that only realistic sediment quantities are mobilised. This coupling framework allows performing scenarios over time, e.g. to simulate parameters related to the descriptors seafloor integrity and hydrodynamic conditions in the context of the European Marine Strategy Framework Directive.



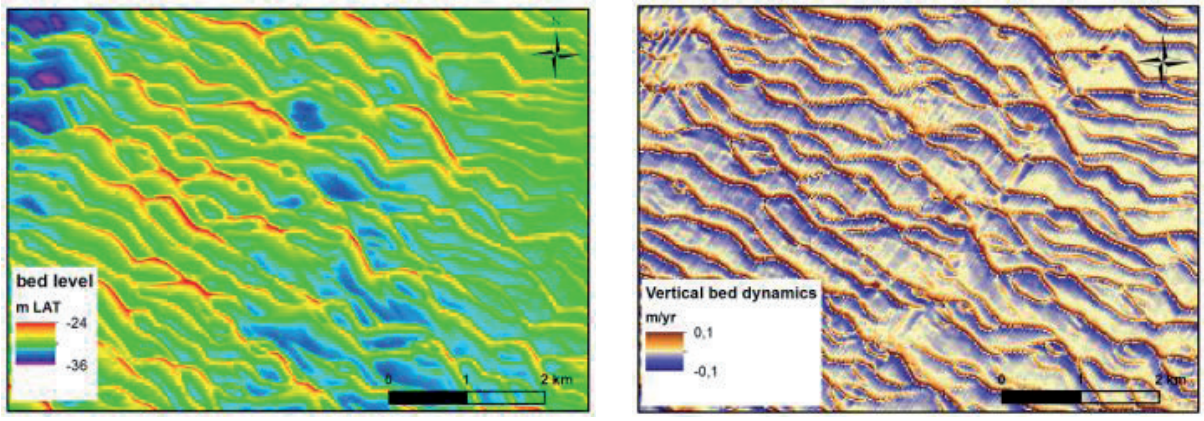
Coupling framework between the 3D geological voxel model (left) and the numerical model suite (right). The voxel model simulates the probabilities of occurrence of the different lithological classes in the three-dimensional space. It provides the upper (bathymetry) and lower (Tertiary) surfaces of the finite seabed in the numerical model, as well as the initial conditions and parameterisation of the sediment fractions whose erosion and deposition are simulated

1 Royal Belgian Institute of Natural Sciences, Brussels Belgium
2 Ghent University, Ghent, Belgium
3 TNO – Geological Survey of the Netherlands, The Hague, The Netherlands

Morpodynamics of sea- and riverbeds from high-temporal resolution bathymetric time series

Thaiënne van Dijk[1], Tommer Vermaas[1], Tim Raaijmakers[1]

High-resolution multibeam echo soundings reveal the detailed morphology of sea- and riverbeds, and when applied in time series, these allow for quantitative analyses of bed morphodynamics. Knowledge of morphodynamics is important for safe navigation, hydraulic engineering projects and management/maintenance of coasts and rivers. Although digital bathymetry becomes more readily available, time series remain to be investigated.
Deltares developed (semi-)automated methods to analyse bathymetric time series in offshore areas, dredged shipping channels and rivers. Vertical bed dynamics of the Netherlands Continental Shelf distinguish between the highly dynamic coastal zone and less dynamic shelf, where most bed dynamics are caused by the migration of sand waves (horizontal migration rates between 0 and 20 m/year). Sand wave migration results are used to advise on wind farm development and resurvey policies. Morphodynamic analyses were also applied to the lower shoreface to establish the isobaths dividing between zones for nourishments versus sand extraction, and to dredged harbour approach channels, being surveyed up to 12 times a year.
River dunes are much more dynamic and a 2-weekly multibeam time series appeared sufficiently frequent to analyse the migration of individual large dunes, with rates of 3–8 m/day (~1,100–2,900 m/y) at varying discharges.
Coupling results of net bedform migration to short-term events, such as storms at sea or floods in rivers, provides insight in temporal variations of bed morphology and may lower uncertainties in morphodynamic results. Highly dynamic beds and short-term events can only be studied from high-temporal resolution (weekly or 2-weekly) monitoring.



Bathymetry (left) and vertical dynamics (right) at the Netherlands Continental Shelf, 70 km offshore Zandvoort

1 Deltares, Utrecht, The Netherlands

Real-time validation of CoVadem derived water depths at locations with a fixated riverbed

Anke Cotteleer[1], Rolien van der Mark[2]

The actual water depth of inland waterways is being measured in a very cost-effective way by an increasing number of vessels participating in the CoVadem initiative. During their trips, the vessels measure and log underkeel clearance from a single-beam echo sounder, ship position from a GPS meter and ship draught from a ship cargo meter. These measurements are translated into water depth using a ship squat calculation. All data from all ships processed and combined, yields a chart of the actual water depth of waterways. Using hydrodynamic models, we enrich the data with a forecast of the water depth. As such, it becomes possible to optimise cargo volumes and sail more efficiently. By comparing the measured CoVadem data to multibeam data, we have shown earlier that the average absolute error is in the order of 20 cm. Sometimes, the measurements of the vessels are incorrect due problems with the equipment, or the measurements show a structural vertical offset, for instance due to equipment settings. To make sure that the depth chart is created based on accurate data only, we need a method that (a) automatically filters out erroneous data, and that (b) shifts the data such that the vertical offset minimises. This paper presents a method in which the CoVadem data are compared in real-time at river bed locations with a fixed layer. A fixed layer is chosen for this, as the multibeam data remain valid over time. After comparison, we are able to distinguish between ships that produce erroneous or non-erroneous data. Furthermore, we can calibrate track data such that the offset decreases. By applying such a validation method, we make sure that only accurate data are used in the analysis. Furthermore, the presented method can be used to further improve the ship squat calculation.

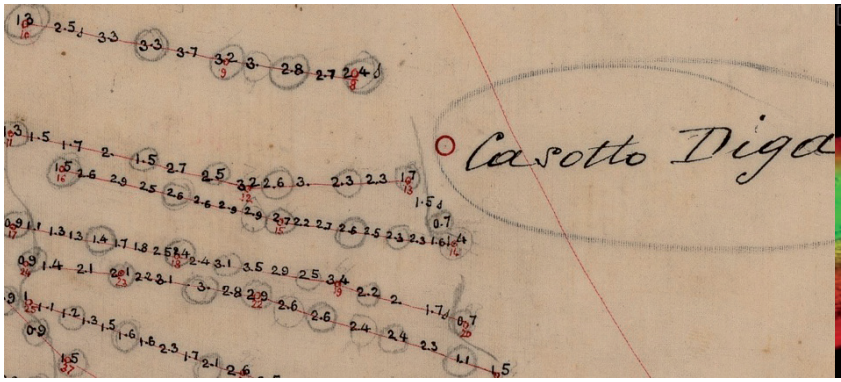
Comparison of CoVadem data with multibeam data for all measurements of the five ships passing the fixed layer in the river Waal near Nijmegen on October 29, 2016. Multibeam measurements above NAP: orange: 2.4 m, yellow: 1.9 m, green: 1.4 m. Difference between CoVadem and multibeam measurements: black: less than 20 cm difference, grey: more than 20 cm difference

1 MARIN, Wageningen, The Netherlands
2 Deltares, Delft, The Netherlands

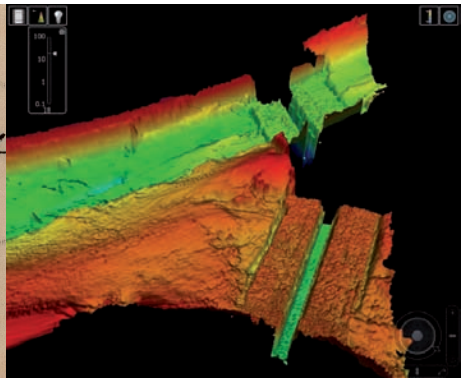
The hydrographic monitoring of Venice inlet channels: The gateway to the lagoon

Lamberto Orlando Lamberti[1], Nicola Marco Pizzeghello[1], Ottavio Patulli[1], Marta Pratellesi[1], Fabio Trincardi[2], Aleksandra Kruss[2], Fantina Madricardo[2], Carlotta Toso[2]

The "hydrographic monitoring" is an acoustic seabed characterisation method describing the evolution of an area of interest with a multi-temporal scale approach: "from the past to the future, looking at the present".
Highlighting the main opportunities related to underwater acoustic technology improvements and the increasing need of high resolution knowledge of seabed morphology and nature, this work compares Venice Lagoon surveys data sets acquired with diverse systems in a 130-years period, each of them following accurate hydrographic standards (from lead line to acoustic systems).
Starting from 1886 survey and local positioning system, the work highlights the key aspects of the latest survey conducted in 2016 with multibeam echo sounder (MBES) technology and global positioning system implementation. Finally, a future-oriented analysis approach was applied to the area of interest in order to combine the hydrographic monitoring factors: resolution, uncertainty, costs and update rate of data.
This study, conducted by a governmental hydrographic organisation – the Italian Hydrographic Institute – together with a scientific organisation – the Institute of Marine Sciences of the Italian Research Council – points out the fundamental role of knowledge, costs and data sharing in an increasing seabed characterisation scenario.
The surveys were carried out in the three tidal inlets of the Venice Lagoon. These tidal inlets (Lido, Malamocco and Chioggia from north to south) are highly dynamical and human impacted areas. Through them, the lagoon exchanges water, sediments and biota with the Adriatic Sea. They represent the main navigation gates to the Venice harbour that were also severely modified over time by anthropogenic interventions: long jetties were built in the 19th and 20th century, whereas the most recent modifications are related to the ongoing construction of the mobile barriers to protect the historical city of Venice from flooding.



Detail of 1886 survey



3D model of 2016 MBES survey

1 Italian Hydrographic Institute, Genova, Italy
2 Institute of Marine Sciences CNR Italy, Venezia, Italy

Knowledge leads to connections

Johan Stam[1], Huibert-Jan Lekkerkerk[2]

E-learning is a growing requirement in various markets. Only in the USA the e-learning market has a turnover of over 5 billion USD which means that the younger generation expect to have easier access to the Basics of Hydrography. E-learning supports the learners development, courses can be accessed anytime, anywhere, and learners can focus on elements of a programme they need to learn and can skip what they already know. But e-learning also supports the organisation's goals; its flexible students can do their e-learning during down times, it also decreases time travelling and time away from the workplace. One more advantage is that the student can immediately apply the new knowledge on the job, he will be able to make connections and learn more effectively.
So we developed five modules as part of our Cat B curriculum, all supported by our Handbooks of Offshore Surveying. Our e-learning platform is not a one way road, we add interaction and make it personal. The student can connect with the experts and fellow students from all over the world. The student has the option to e-mail questions and the student will also receive feedback on the assignments. We welcome them every two weeks at the scheduled tele-conferencing sessions.
Upon acquiring acceptable results a student will be issued a Skilltrade certificate. After completion of the full e-learning programme the student is welcome to participate in the 13 week training of the Hydrographic Survey Category B Course in the Netherlands.
In 2008 our programme first received recognition by the FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors. We received continued recognition for 6 years for our updated curriculum, including the e-learning, in April 2016.

1 Skilltrade, Voorschoten, The Netherlands

Ocean Technology – hydrography education in the Netherlands

Rob van Ree[1]

In November 2016 the bachelor education programme Ocean Technology at the Maritime Institute Willem Barentz was visited by an audit panel of NQA representing the Dutch Ministry of Education. The four year OT programme is based on Terschelling. The panel judged the education programme as good, with two of the four categories even as excellent. Earlier in 2016 the programme had received extension of its Cat A recognition by the International Board on the Standards of Competence for hydrographic surveyors. Among more then twenty other Cat A programmes worldwide, Ocean Technology and a Chinese programme take the longest time to complete with their 208 weeks.
The OT programme contents is largely determined by the Standards of Competence for hydrographic surveyors formulated by the International Hydrographic Organisation. Companies employing graduates are satisfied that these SoC and Cat A recognition fulfil their requirements. Through traditional lecturing and project based training, students develop their knowledge and skills; this package is judged as being of high level and complying with modern industry requirements. At least one day per week is spent on practical work, which is individually reported in a workbook. Students get to know their future work environment by a half year apprenticeship, while their final work consists of a graduation assignment defined by one of the companies or government bodies. Integrated practical assignments, such as the Oosterom survey and the oil spill prevention project, require meticulous preparation and reporting. Apart from 30 m survey vessel Octans, OT students conduct their practical work with two smaller craft, which may be used autonomously.
An OT staff international commitment is to have students building a Wikipedia tree of hydrographic subjects, whereby hydrography students worldwide are invited to partake and continuously maintain and improve the information provided.

1 Maritime Institute Willem Barentz, Terschelling, The Netherlands

Hydrographic education (FIG/IHO/ICA Category A) at the HafenCity University Hamburg (HCU)

Tanja Dufek[1], Harald Sternberg[1]

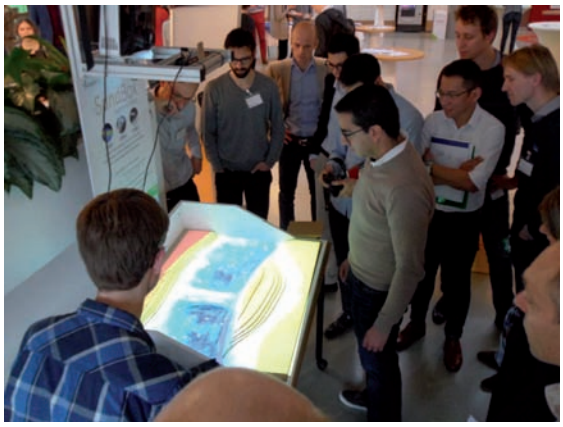
For thirty years a hydrographic study programme has been offered in Hamburg. In 1990 it has been first recognised by the FIG/IHO International Advisory Board on Standard of Competence for Hydrographic Surveyors at Category A (Academic) with "Specialization in Nautical Charting". In 2017 the last recognition by the FIG/IHO/ICA International Board on Standard of Competence for Hydrographic Surveyors and Nautical Cartographers (IBCS) at Category A for Hydrographic Surveyors has taken place. The programme was recognised against the new standard S-5A (First Edition, August 2016) and the corresponding "Guidelines for the Implementation of the Standards of Competence for Hydrographic Surveyors" (First Edition, July 2016).
Since 2006 the hydrographic study programme is taught at the newly founded HafenCity University Hamburg which follows an interdisciplinary approach. The programme is integrated into the 2-year Master of Science in "Geodesy and Geoinformatics" (formerly "Geomatics") as specialisation in hydrography. It is completely taught in English as it is addressed not only to German but also to international students.
This article presents the hydrography study programme at the HafenCity University Hamburg with emphasis on its latest developments and an overview of some of the latest projects and research.

1 HafenCity Universität (HCU), Hamburg, Germany

SandBox-FM: Augmented reality visualisation of hydrodynamics

Cilia Swinkels[1], Arjen Luijendijk[1&2], Fedor Baart[1], Jurjen de Jong[1], Willem Ottevanger[1], Pieter Visser[1], Bas van de Pas[1], Jan-Willem van Velzen[1&2], Jos Ooms[1], Gerben Hagenaars[1&2], Jesse Metz[1&2]

Presently, visualisation of the impact of hydraulic structures or reshaping of the land in rivers or coasts on hydrodynamics is static and often difficult to interpret by laymen. An underlying cause is the two-dimensional canvas on which results are shown, even where it concerns three- or fourdimensional features (three spatial components and time). Besides, the hydrodynamic computations required for designing interventions in water systems are traditionally performed by scientist and engineers, leading to a low involvement of stakeholders in the design process. To facilitate the communication with stakeholders and design process, an improved method to compute and visualise the hydrodynamic effects of measures is presented.
Technology developed by the LakeViz3D project (US) already allowed for interactive bathymetry visualisation in a sandbox using a Kinect camera and a beamer coupled by open-source software. In the current study, this approach was extended by coupling the measured bathymetry to a Delft3DFlexible Mesh (FM) model.
The resulting SandBox-FM is a rectangular shaped domain of roughly 1.0 x 0.8 m, containing a scale model consisting of a 3D printed landscape and sand, which is used to represent the bathymetry and hydraulic structures. The sand can be shaped into different planforms to represent various measures, e.g. a nourishment or groyne construction. The bed change is fed into a continuously running model and computed effects are real-time projected in the sandbox, resulting in an augmented reality version of the Delft3D-FM model. Currently three different SandBox-FM applications have been developed, namely a coastal nourishment (the Sandmotor), a tidal inlet (Ameland) and a river case (River Waal).
The SandBox-FM offers an innovative way of visualising hydrodynamic results, which are no longer static, but 3D, real-time and interactive. It can be used as an educational tool and as tool for stakeholder discussions on the hydrodynamic impacts of hydraulic structures and planform changes.



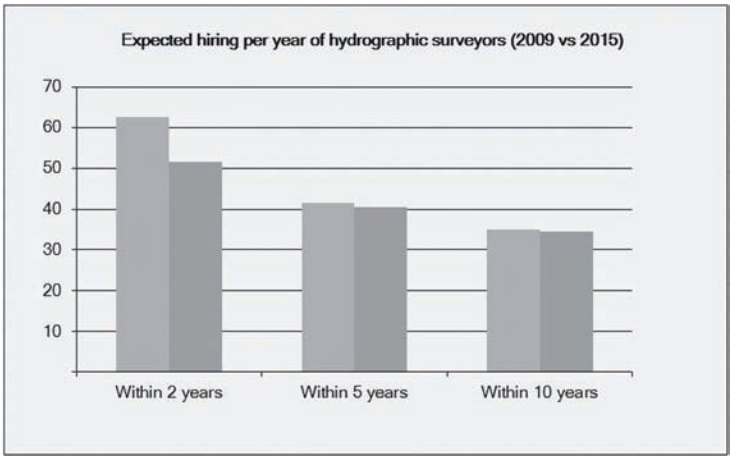
SandBox-FM River Case at the NCR days 2017 in Wageningen

1 Deltares, Delft, The Netherlands
2 Delft University of Technology, Delft, The Netherlands

Recent evolutions of the demand for hydrographic surveyors in the Benelux

Alain De Wulf[1], Philippe De Maeyer[1], Cornelis Stal[1&2], Annelies Vandenbulcke[1]

The hydrographic world is in permanent evolution, resulting in a variable demand for hydrographic surveyors. This is even more the case in the Benelux, where several of world's largest dredging companies are located, as the dredging market is known to be very dynamic. These evolutions are equally important for the planning of the hiring policies of private hydrographic companies as for the educational institutes providing Cat A and Cat B IHO accredited hydrographic surveyors, optionally combined with a Bachelor and/or Master diploma.
A new study of the demand for hydrographic surveyors in the Benelux is proposed, in order to update profoundly the former study of February 2015 and to discern recent trends between 2015 and 2017 in this demand for hydrographers. Therefore, the Hydrographic Society Benelux (HSB), in cooperation with the Department of Geography of Ghent University (Belgium), will send a questionnaire to the most important hydrographic companies in the Benelux (Belgium, The Netherlands and Luxemburg). On the one hand, the aim of the questionnaire is to research the demand for the preferred level of hydrographic surveyor, allowing a concise estimation of the demand for IHO Category A and Category B certified hydrographic surveyors. On the other hand, the required balance between hydrographic surveyors with a Bachelor versus Master degree will be questioned. It is also generally assumed that there is a shortage of hydrographic surveyors and/or of hydrographical educated employees in the Benelux. But does this hypothesis withstands a scientific analysis? All these questions will be investigated statistically in the paper.



1 Ghent University, Ghent, Belgium
2 Ghent University College, Ghent, Belgium

A Kalman filter approach to realise the lowest astronomical tide surface

Cornelis Slobbe[1], Julius Sumihar[2], Thomas Frederikse[1], Martin Verlaan[2], Roland Klees[1], Firmijn Zijl[2], H. Hashemi Faharani[1], Rogier Broeckman[3]

We present a novel method to combine a model-derived LAT-geoid surface with observation-derived LAT-geoid values at tide gauges. Whereas all other published methods known to the authors combine observation- and model-derived LAT in a post-processing step, we combine them in an indirect way by assimilating (using a steady state Kalman filter approach) tidal water levels derived from tide gauge records into the model. In doing so, the combination is guided by the model physics and we do not need to rely on questionable assumptions like isotropy or on the properties of the applied interpolator.
Using this new approach, the "Kalman-filtered LAT surface" has been realised. The surface is compared to i) the LAT surface obtained without applying data assimilation ("the model-only LAT surface"), ii) observation-derived LAT values at both onshore and offshore tide gauges, and iii) the "LAT2013" surface obtained by Slobbe et al. (2013a).
When validating the Kalman-filtered LAT surface using observation-derived LAT values at tide gauges, we obtain an overall rms difference of 15.1 cm in case all tide gauges are considered (Set A) and 17.9 cm in case we only consider the tide gauges not used in the data assimilation (Set B). For the North Sea and Wadden Sea, these numbers are 13.8 cm (Set B) and 27.7 cm (Set B), respectively. Compared to the numbers obtained for the model-only LAT surface, the overall rms difference is reduced by 31 % for Set A and 22 % for Set B. However, strong regional differences occur. For the Dutch waters, the rms differences are 6.6 cm and 14.8 cm for the North Sea and Wadden Sea, respectively.

1 Delft University of Technology, Delft, The Netherlands
2 Deltares, Delft, The Netherlands
3 Hydrographic Service of the Royal Netherlands Navy, Den Helder, The Netherlands

Building a digital bathymetric grid for European seas – the EMODnet High Resolution Seabed Mapping initiative

Leendert Dorst[1], Thierry Schmitt[2], Dick Schaap[3],

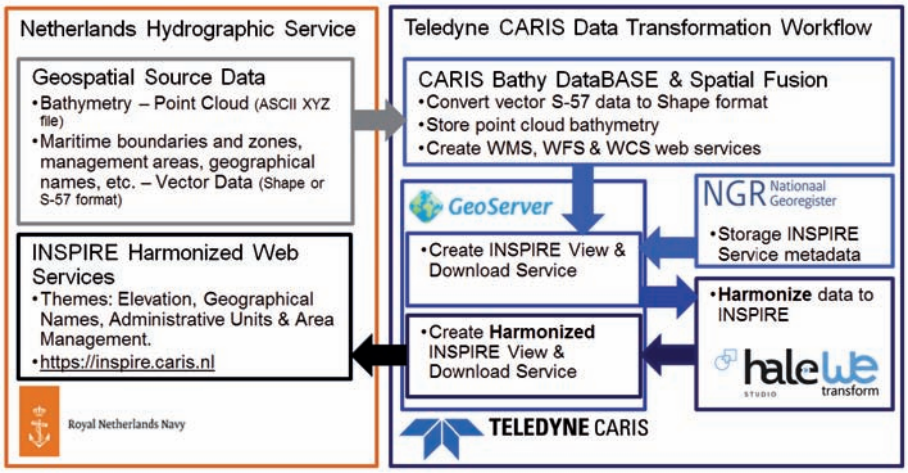
Access to marine data is key for the EU Marine Strategy Framework Directive and the EU Marine Knowledge 2020 agenda. The European Marine Observation and Data Network (EMODnet) initiative aims at assembling European marine data, data products and metadata from diverse sources in a uniform and coherent way. Currently EMODnet is entering its 3rd phase with operational portals providing access to marine data for bathymetry, geology, physics, chemistry, biology, seabed habitats and human activities.
During the second phase, the EMODnet Bathymetry project developed a Digital Terrain Model (DTM) for the European seas. The DTM has a resolution of 1/8 arcminute (approx 250 m). It has been produced from circa 7,800 surveys and aggregated data sets from 27 European data providers that are indexed with metadata by adopting the SeaDataNet Catalogue services. The GEBCO 2014 DTM has been adopted to fill areas without bathymetric coverage. The generated EMODnet DTM and the catalogue services are published through the dedicated portal which includes DTM viewing and downloading services.
As part of the third phase, since December 2016, the EMODnet Bathymetry was succeeded by EMODnet High Resolution Seabed Mapping. This new project will continue gathering bathymetric data with an extra focus on coastal waters. In addition, satellite derived bathymetry data will be included in order to experiment filling coverage gaps. This will provide relevant inputs for producing a DTM with a resolution of 1/16 arcminute (circa 100 m). Local DTMs with higher resolutions will also be produced, where data and data providers permit. The higher resolution DTMs will be used to determine best estimates of the European coastline for a range of tidal levels (HAT, MHW, MSL, Chart Datum, LAT).

1 Hydrographic Service of the Royal Netherlands Navy, Den Helder, The Netherlands
2 SHOM, Brest, France
3 MARIS BV, Voorburg, The Netherlands

Bathymetry as a keystone for the blue economy of the Netherlands: the implementation of INSPIRE at the Netherlands Hydrographic Service

Leendert Dorst[1], Charles de Jongh[2], George Spoelstra[3]

The central idea of the "Blue Economy", as formulated by the United Nations' Environmental Programme in 2010, is that investments in the development of sea areas have a strong positive effect on the economy of coastal regions. The European Union has applied this idea in 2014 to its sea areas using the words "Blue Growth", underlining the important role that open geospatial data of sea basins plays to realise those benefits. The series of EMODnet projects are used to unlock such data. Also, the Directives on INSPIRE (2007) and Public Sector Information (2013) aim to make government data sets open, where INSPIRE introduces data models for environmental geospatial data and PSI provides a general regulatory framework.
The two developments of implementing INSPIRE and EMODnet have run mostly in parallel for the Netherlands sea area. The most important data set that the Hydrographic Service of the Royal Netherlands Navy contributes is its bathymetric grid, which forms the basis for nautical charting activities. This has resulted in separate web services for bathymetry for each implementation, which are complementary in many aspects. For INSPIRE, the Hydrographic Service was supported by Teledyne CARIS, and for EMODnet by GGSgc.
Both implementations are currently going through important developments. This paper focuses on INSPIRE, as EMODnet is presented in a separate paper. INSPIRE data sets need to be harmonised according to a series of approaching deadlines. The authors aim to stimulate use of the provided services and, as a consequence, contribute to the blue economy around the North Sea.



Workflow of Teledyne CARIS for INSPIRE harmonisation of data sets (under development, version of September 2017)

1 Hydrographic Service of the Royal Netherlands Navy, Den Helder, The Netherlands
2 Teledyne CARIS, 's-Hertogenbosch, The Netherlands
3 GGS Geo Consultancy (GGSgc), Breda, The Netherlands

Computation of a consistent vertical reference datum in Europe using a Global Tide Surge Model

Maialen Irazoqui Apecechea[1], Martin Verlaan[1&2], Sandra Gaytán Aguilar[1]

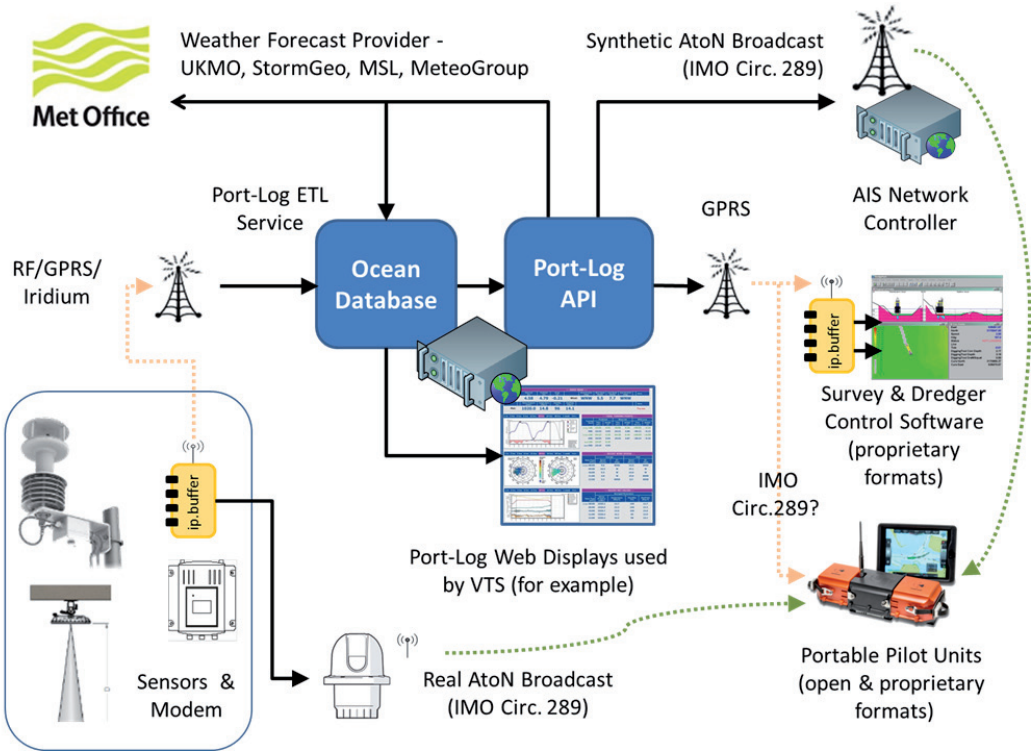
Currently there is no vertical reference datum that is defined consistently across Europe. Although the Lowest Astronomical Tide (LAT) has been designated by the International Hydrographic Organization (IHO) as the vertical reference surface for hydrographic charts some countries have not moved to LAT yet. Moreover, there are differences between the methods used in different countries, leading to a non-continuous surface across boundaries. Finally, there is no easy way to convert from LAT to another vertical reference for other applications than producing nautical charts. In the framework of the European Marine Observation and Data Network (EMODnet), the European Commission has initiated the High Resolution Seabed Mapping (HRSM) project with the objective to standardise the use of LAT and harmonise its definition for bathymetry and coastline mapping. The methodology consists on using the Global Tide Surge Model (GTSM) developed at Deltares to derive the conversion surfaces between the different reference levels used in the individual national bathymetric data sets in order to convert and connect them into a high resolution, spatially consistent and continuous LAT surface for Europe. The unstructured grid of the GTSM makes it suitable for a flexible local refinement at the coast. In this paper, the computed LAT surface is presented. A hydrodynamic run with astronomical forcing for a period of a nodal cycle (18.6 years) is performed using the GTSM. The data set will be validated for a large number of tide gauges across Europe.

1 Deltares, Delft, The Netherlands
2 Delft University of Technology, Delft, The Netherlands

Developments in the interconnectivity of tide and weather data

Mike Osborne[1], Mark Jonas[1]

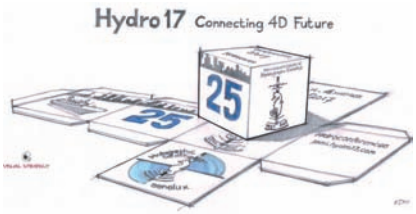
A port is a multi-faceted business requiring fit for purpose data and information to be readily available when and where it is required 24 hours a day, seven days a week. Tide and weather data comprising observed, predicted and forecast water levels (tides), wave heights and periods, wind speed and direction, and visibility are all key parameters for many ports. They are required in real time to support maritime operations and historically to support planning, engineering and environmental studies. Whilst all ports have access to this data for critical tasks e.g. VTS, often the ability to make this data available more widely is problematic. OceanWise has developed the concept of a port – or when considered more widely – a maritime information infrastructure which enables tide and weather information, for example, to be shared more easily, ideally using open standards and systems, underpinned by a framework for data governance (see Figure).
This paper explains how OceanWise has been working with Associated British Ports (ABP), Peel Ports, and numerous VTS, PPU, Weather Forecast and Dredging providers to integrate data from multi sources and to make it readily available in critical and non-critical applications. Although the cooperation of these providers has been excellent, one challenge faced in doing this work is the lack of a data standard that can be employed consistently no matter how the data is being transmitted, whether it be via VHF (AIS), GPRS or some other means. The result is a wide range of data formats from equipment vendors, data providers and governing bodies that need to handled. Consequently, this presentation also hopes to stimulate discussion on how a narrower range of standards might be established and how we can build on existing data specifications e.g. IMO Circ. 289 (Message 8), so they can be adopted more widely.



1 OceanWise Ltd, Alton, Hampshire, United Kingdom

Duikvaartuig / Tauchschiff Triton

Baars-CIPRO.nl gebruikt de Triton voor het duiken naar explosieven in de waterbodem (OCE).
TB-Unterwassertechnik.de verwendet die Triton für Kampfmittelbergung mit Tauchereinsatz (§20).



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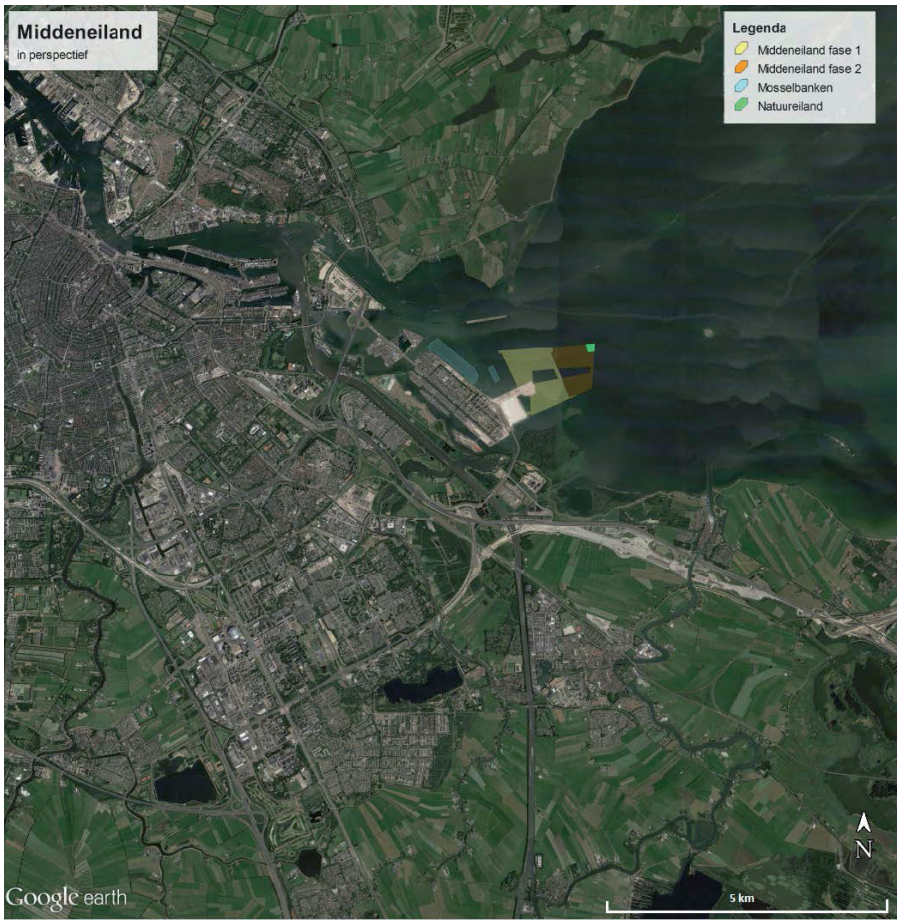
Land reclamation IJburg – Middeneiland in Amsterdam

Timor M.I. Post[1], Hans Monen[1]

In 2018, the municipality of Amsterdam will make the next step in its expansion into the IJ Lake. This newest island of the archipelago IJburg is called Middeneiland and is constructed in two phases. Currently, only the construction of the first phase is fully designed. This first part of the island has a surface of 82 ha and is mainly focused on housing, but will also contain a new public beach and a shallow wetland with a high ecological value. This island is part of the expansion which was initiated in 1996 when the local government decided that development on land alone would not be sufficient, or effective, on the long term. The islands that form IJburg are the result of that decision. The largest technical difficulties are caused by the very weak subsoil which is a result of withdrawing water eroding the soil at the end of the last ice age. Strong solid sand layers are mostly absent until 25 metres below datum. The soil above this layer is highly compressible, meaning that between 7 and 12 metres of sand must be added on top to create the island and speed up the consolidation process. Even though the water depth is ~2,5 metres. By putting the 8.5 million m^3 of sand in place in layers of 0.5 to 1 metres with 30 days consolidation time after each layer, while monitoring pore pressure in the weak subsoil, the calculations say that it will be possible to construct the first of 6,000 homes in 2021.



1 Ingenieursbureau Amsterdam, Amsterdam, The Netherlands

The Land Administration Domain Model (ISO 19152) in the marine environment

Peter van Oosterom[1], Ellen Vos[2]

Land Administration Domain model
The actual scope of the standard ISO 19152 the Land Administration Domain Model (LADM) includes marine areas, although the name of this standard suggests a narrower definition. In earlier publications, the applications on the land-side has received much attention. In this contribution, the focus is on LADM application at the marine-side and the transition zones.

Basic layers to (M)SDI
Land Administration is a fundamental pillar of legal certainty in both developed and developing countries. As one of the most detailed and most up-to-date spatial data sets, it forms the cornerstone of (national) SDIs. In these land registries, the surveyed space becomes a legal space by connecting to parties via RRRs (that is, Rights, Restrictions and Responsibilities). The spaces are defined via their boundaries, which may be shared among neighbour spaces in a topological structure. Recently, a study on Marine Cadastre in Europe states that the Marine Cadastre is likewise considered a base layer of an MSDI (Marine SDI) with fundamental information relating to maritime boundaries and associated rights and responsibilities.

Fundamental pattern: parties-RRRs-spaces
This pattern of a spatial object connected to a party via an RRR obviously appears in the underlying standards, both in land and marine related applications. Comparable structures show up in the land based standard LADM and in the marine based (developing standards) S-121 Maritime Limits and Boundaries and S-122 Marine Protected Areas.

Spatial plans generating legal spaces
The process of spatial planning results in legal areas to which certain RRRs are attached including their involved parties, which could be the government itself. Spatial planning processes have a long tradition on the land-side, but have similar relevance on the marine-side. Spatial planning has typically political aspects, where different stakeholders take part in a participatory process to come to an agreed spatial design. Information on space and RRR play an important role during this process, both at the input side (what is already there) and the output side (new spatial plans, trajectories, mining concessions, fishing areas, protected areas, etc.).

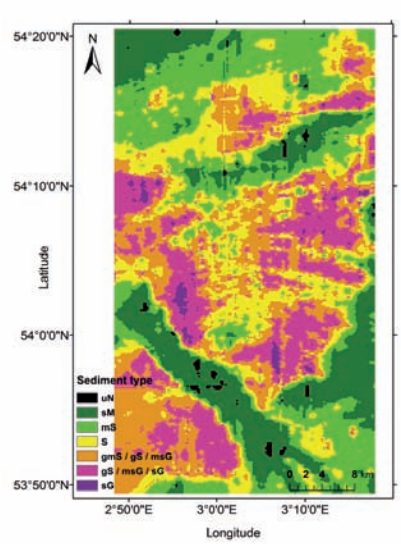
Common basis for a coastal approach
The European focus on the Blue Economy and more specific on Marine Spatial Planning (MSP) and Marine Cadastre are potential drivers of a better integration of both coastal developments and the underlying data infrastructures. The integration of information from the land and the marine environments is enabled by applying the same or similar modelling principles and standards, such as LADM. In this contribution, we will present a case study that illustrates this.

1 GIS Technology, Delft University of Technology, Delft, The Netherlands
2 Hydrographic Service of the Royal Netherlands Navy, Den Helder, The Netherlands

Dutch knowledge network on sea- and riverbed research: linking acoustic techniques of underwater mapping and geology

Thaiënne van Dijk[1], Peter Herman[1], Mirjam Snellen[1&2], Niels Kinneging[3], Timo Gaida[2], Dick Simons[2], Bob Hoogendoorn[1]

Sedimentary sea- and riverbeds are dynamic environments that host diverse biological communities. Knowledge of the morphodynamic, sedimentary and ecological characteristics of these beds is important for a sustainable use of our seas and rivers, for example for safe navigation, coastal management and maintenance (e.g. nourishments and dredging), marine aggregates, ecological values, marine spatial planning and hydraulic engineering.
High-resolution acoustic techniques and bed sampling allow for the detailed, comprehensive and yet efficient investigation of both bed and sub-surface structures. Bed classification from multibeam (MBES) backscatter data can map heterogeneous sediment compositions at resolutions (e.g. 3 m) unprecedented with classical mapping based on bed sampling. Bed-penetrating acoustics reveal geological layers and internal structures, such as reactivation surfaces in marine and river bedforms. Linking these methods will result in 3D-information that is essential in understanding and managing marine and fluvial systems.
To date, in the Netherlands, merely bathymetric data of MBES are used, whereas abroad, MBES-backscatter data are widely used in habitat mapping. Our knowledge lags behind and facilities, surveying experience and knowledge are fragmented.
We initiate a Dutch knowledge network on sea- and riverbed research, in which knowledge institutes, government and industry combine their forces in the development of underwater mapping in the Netherlands. We hope to improve the use of new techniques, promote data acquisition, jointly building a database, and exchange knowledge in research, applied and managerial issues in marine and river environments.



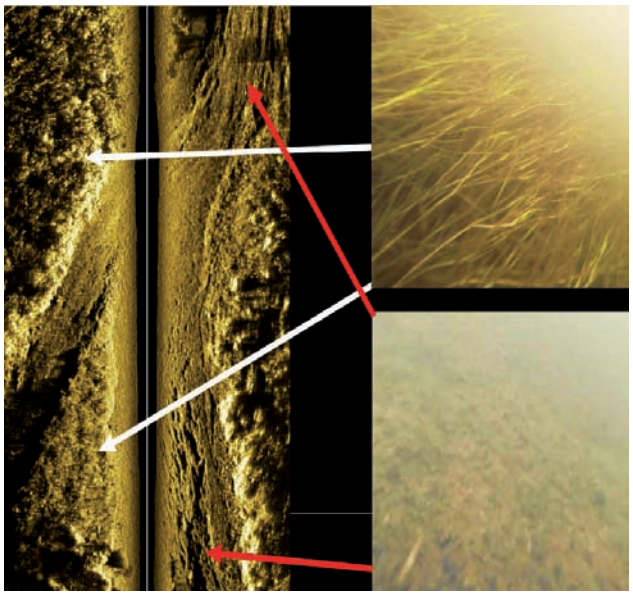
Bed classification at Klaverbank, North Sea

1 Deltares, Utrecht, The Netherlands
2 Delft University of Technology, Delft, The Netherlands
3 Rijkswaterstaat, Delft, The Netherlands

Mapping the estuarine seafloor with vessel-based acoustic instruments: The shallowest water survey

Evan Martzial[1], Mark Borrelli[2]

Estuaries are among the world's most productive ecosystems and mapping the estuarine seafloor can provide useful information with regards to benthic habitats, ecosystem state, sediment transport and other biological and physical characteristics and processes. Turbid waters in many estuaries prevent optical methods, such as LiDAR, from being used. In addition, LiDAR, as of yet, provides only elevation information, though experimental data layers similar to acoustic backscatter imagery are in the early stages of development.
A series of vessel-based acoustic surveys onboard a custom-built, shallow draft pontoon boat using an EdgeTech 6205 Multi Phase Echo Sounder and side-scan sonar in a very shallow, tidally-restricted estuary were conducted in June 2016. The instrument collects coincident, dual-frequency, side-scan imagery (op. freq. 550/1600 kHz) and swath bathymetry and back-scatter (op. freq. 550 kHz). This yields four distinct, yet co-located data sets. Underwater video and grab samples were collected to ground-truth the imagery and improve our understanding of the seafloor. The instrument could map in high salinities, fresh water and the transition zone with little to no loss in data quality. This instrument/platform combination makes vessel-based acoustic mapping in these types of systems more feasible, efficient, and desirable.



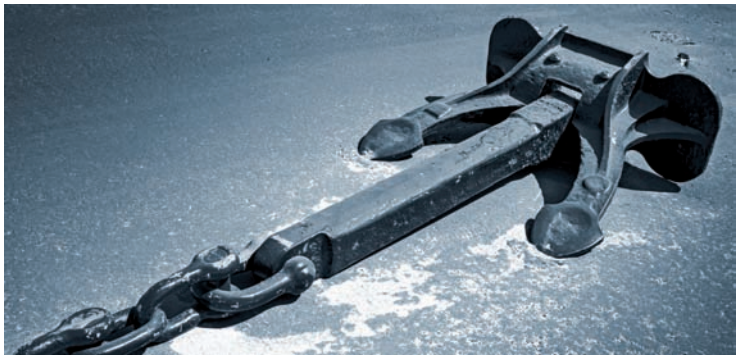
1600 kHz side-scan sonar imagery showing a 24 m swath. Tidal channels through vegetation/algal beds ground truthed with the GoPro Camera. Water depths are as shallow as 20 cm at the top and bottom of the image. The waters depths increase slightly toward the middle of the image (40–50 cm)

1 EdgeTech, West Wareham, USA
2 Seafloor Mapping Program, Center for Coastal Studies, Provincetown, USA

Penetration depth of ship anchors in view of pipeline crossing protection – A review

Victoria Monsma[1], Jan Spiekhout[1], Henk Harthoorn[2]

Larger ships, the use of high holding power anchors, deepening of canals and rivers by dredging or natural causes and more insight through testing and finite element calculation did cause a need to review the penetration depth of ship anchors against code requirements for burial depth of pipeline crossings in waterways. Nowadays pipeline crossing are mostly installed by means of Horizontal Directional Drilling (HDD) or similar and depth of cover is large and no problem. However, the majority of existing crossings was installed with other techniques such as sinker, bottom tow, microtunneling where cover is less. Those pipeline crossings are of great capital value, are very important in security of supply.
Quite a lot about penetration depth of ship anchors has been written and large scale testing with rock has been carried out in the past. In this study the penetration depth in sandy soils and penetration depth in case of rock cover has been investigated and evaluated and led to some surprising insights.
To control the remaining cover of buried pipeline crossings it is necessary to know the location of the pipeline and to measure regularly the depth of the bottom above the sinker. The yearly or biennial surveys are done from a vessel with a multibeam echo sounder. The results of the surveys have to be evaluated; if necessary the cover has to be repaired, for example by dumping gravel or stones.



1 DNV GL, Groningen, The Netherlands
2 LievenseAdriaens B.V., Hoogvliet, The Netherlands

Management of survey data using software package SAVA

Jeremy Van Ophem[1]

As of January 2017 the Flemish Hydrography uses an in-house software package called SAVA (Survey Acquisition, Validation and Archiving). The purpose of SAVA is to manage the transfer of data between several teams using a sophisticated wizard by which surveyors and cartographers are guided through the complete survey process, starting from the data acquisition up until the production of survey charts and archiving.
The following key features of SAVA greatly improve our current process:

- All directories used in the acquisition, validation and archiving process are automatically created by SAVA.
- Data can easily be copied from the survey PC onboard to the network drive in the office using an external hard drive. Metadata as well as acquisition data is transferred and stored.
- Multiple surfaces can be generated quickly using a batch tool provided by CARIS software.
- Charts can be generated automatically using the processed acquisition data and metadata available in SAVA.
- A surface can be archived in one or more databases using CARIS software.
- An extensive administrator tool guarantees an adaptive software package.

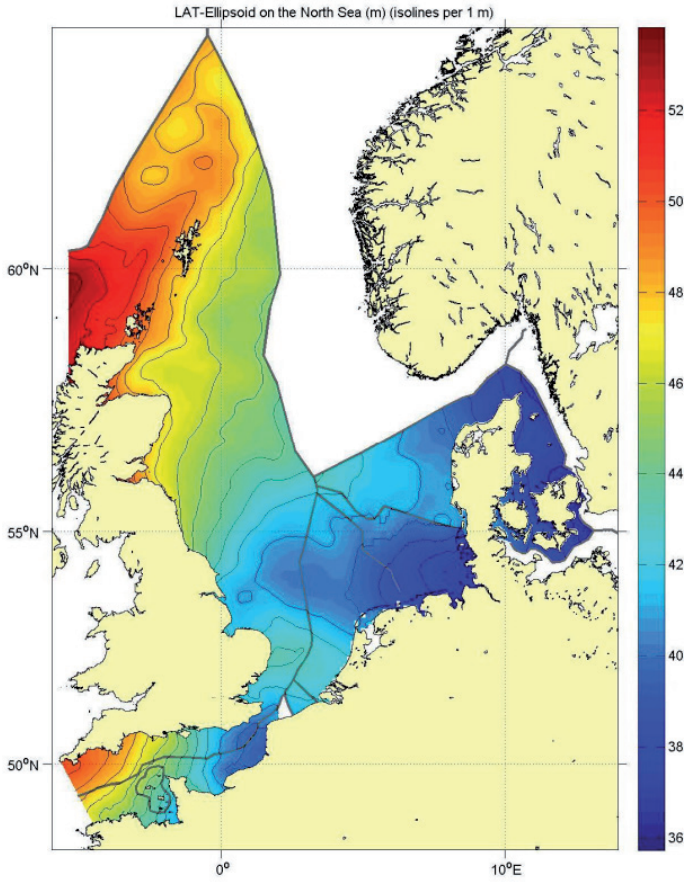
The initial goal of SAVA was to integrate the complete survey data management process, from acquisition to archiving, into one system, thereby improving efficiency, and providing teams with more time to concentrate on their core tasks. The automation of repetitive tasks should also lead to less human errors. Currently, it is still too early to conclude whether all these goals have been achieved, but we will have a better idea by the end of 2017.

1 Government of Flanders – Agency for Maritime and Coastal Services, Oostende, Belgium

Path to a seamless chart datum across the North Sea

Rogier Broekman[1], R. Kuilman[1], T. Ligteringen[1]

The Hydrographic Offices of the North Sea work together in the North Sea Hydrographic Commission Tidal Working Group to provide technical advice and coordination on matters related to tides, water levels, currents and vertical datums. In the North Sea basin, the Lowest Astronomical Tide (LAT) is used as chart datum by these offices as agreed by IHO resolution 3/1919 – Datums and Bench Marks. Each nation has their own realisation of LAT which does not necessarily match perfectly with its neighbour. The Tidal Working Group has made an inventory of the different Chart Datums in use and visualised the differences along their national maritime boundaries.
Chart datum was originally created as a vertical reference for the navigator. Changing of a chart datum has been done in the past, primarily for the mariners safety. Geo-information at sea is now more commonly used by others than only the mariner. Usage, quality and interoperability of a vertical references are becoming more important as data sets of land and sea are merged together.
How significant are the current differences of chart datum across the North Sea and should they be reduced? What should be taken into consideration when changing a national vertical reference? Can multiple references exist parallel to each other in the digital world of today?



LAT- ellipsoid separation on the North Sea

1 Hydrographic Service of the Royal Netherlands Navy, The Netherlands

The value of high-resolution imaging techniques for benthic habitat monitoring during offshore dredging

Henry Olatunbosun Odunsi[1]

High-resolution imaging technique is a modern innovative means of capturing detailed and accurate information of the environment. This imaging technique is a very effective tool for benthic habitat monitoring. It comprises a range of sonar systems that is suitable for high-resolution underwater real time 3D acoustic imaging. Offshore dredging is of high demand in the oil and gas sector and generally entails pre-sweeping, pre-trenching, sand wave removal and pre-pipe lay dredging. The basic underwater imaging equipment required for this type of dredging includes high precision dynamic positioning software, side-scan sonar and the imaging sonar which is suited for sub-bottom profiling. Sonar systems are known to be capable of generating ultrasonic pulses for capturing high-resolution images of the seafloor and sub-bottom details. They also possess the capacity for effective data collection, storage and retrieval analysis that is required for conservation of benthic aquatic resources during offshore dredging. Nevertheless, there are specialised tools and software required for creating, editing and analysing spatial and attribute data. Geographic Information Systems (GIS) applications are time and resource saving tools that are essential for every aspects of hydrographical and geophysical surveys. These specialised tools are crucial for benthic habitat monitoring because they provide real time updates of survey and progress monitoring during offshore dredging. Therefore, the significance of high-resolution imaging monitoring technique is the ability to provide detailed information for the protection and preservation of the delicate benthic aquatic species. This would help identify some of the physical and biological indicators that are required for effective mitigation of environmental impacts of the aspects of dredging. Because offshore dredging requires absolute precision and high standards for safety, environment and quality control, it is therefore pertinent to recommend this innovative monitoring methodology as a sustainable solution tool for dredging management.

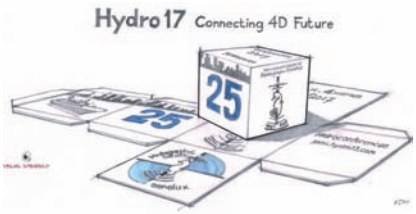
1 Earth Info Services, Lagos, Nigeria

Autonomous vehicles:
The Canadian Hydrographic Service Journey...

Roger Côté[1], Annie Biron[1], Éric Lebel[1], Ghislain Bouillon[1]

The Canadian Hydrographic Service (CHS) has entered in a positive and productive era with a significant increase of resources. This is an outstanding opportunity for CHS to innovate and revolutionise its operational model, especially in the acquisition and management of source data. The use of new technologies, crowd source information and new methodologies is a trend in the international hydrographic community and, as always, the CHS is willing to play a major role in the development and implementation of these new assets.
To support this initiative, CHS recently bought 2 AHSVs (Autonomous Hydrographic Surface Vehicles) and is in a process of acquiring 2 extra vehicles. The new AHSVs are equipped with complete multibeam and INS systems. In addition to this, CHS also converted one survey launch to make it autonomous, while preserving the ability to operate it manually (named: Autonomous Hydrographic Survey Launch (AHSL)). CHS is now collecting data with this equipment to experiment, identify limitations, propose improvements, and determine most appropriate areas in which they will be the most useful, in order to define the appropriate operational model and how they will be included in CHS current operations.
Short term primary goals of CHS are to familiarise with the technology, gain confidence in all aspects of operations, be actively involved in the development with manufacturers and partners to ensure that these tools will meet long term CHS and hydrographic community requirements. This poster will give you an overview of their capabilities, limitations, trials, results and the quality of the data.

1 Canadian Hydrographic Service, Ottawa, Ontario, Canada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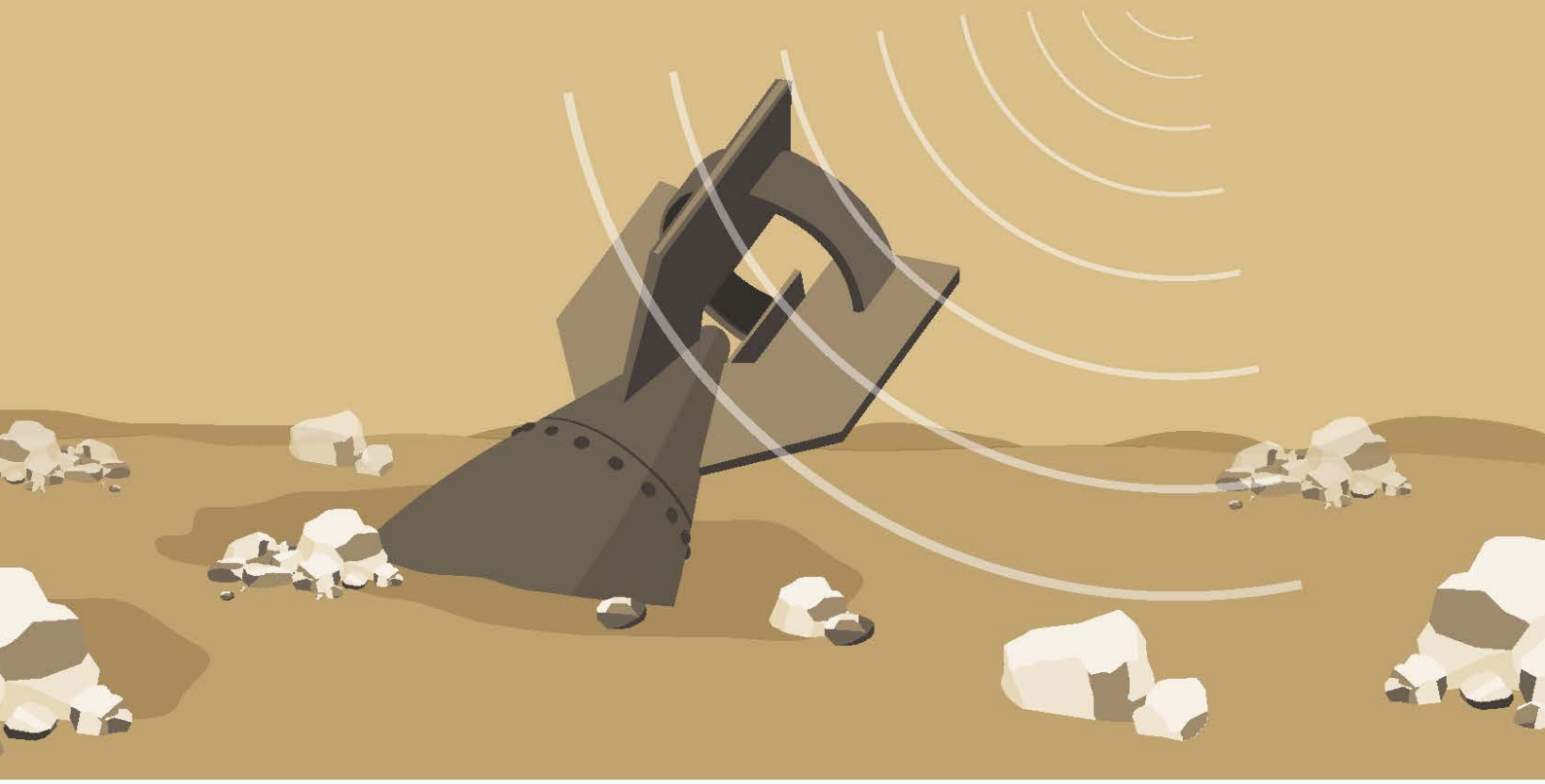

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