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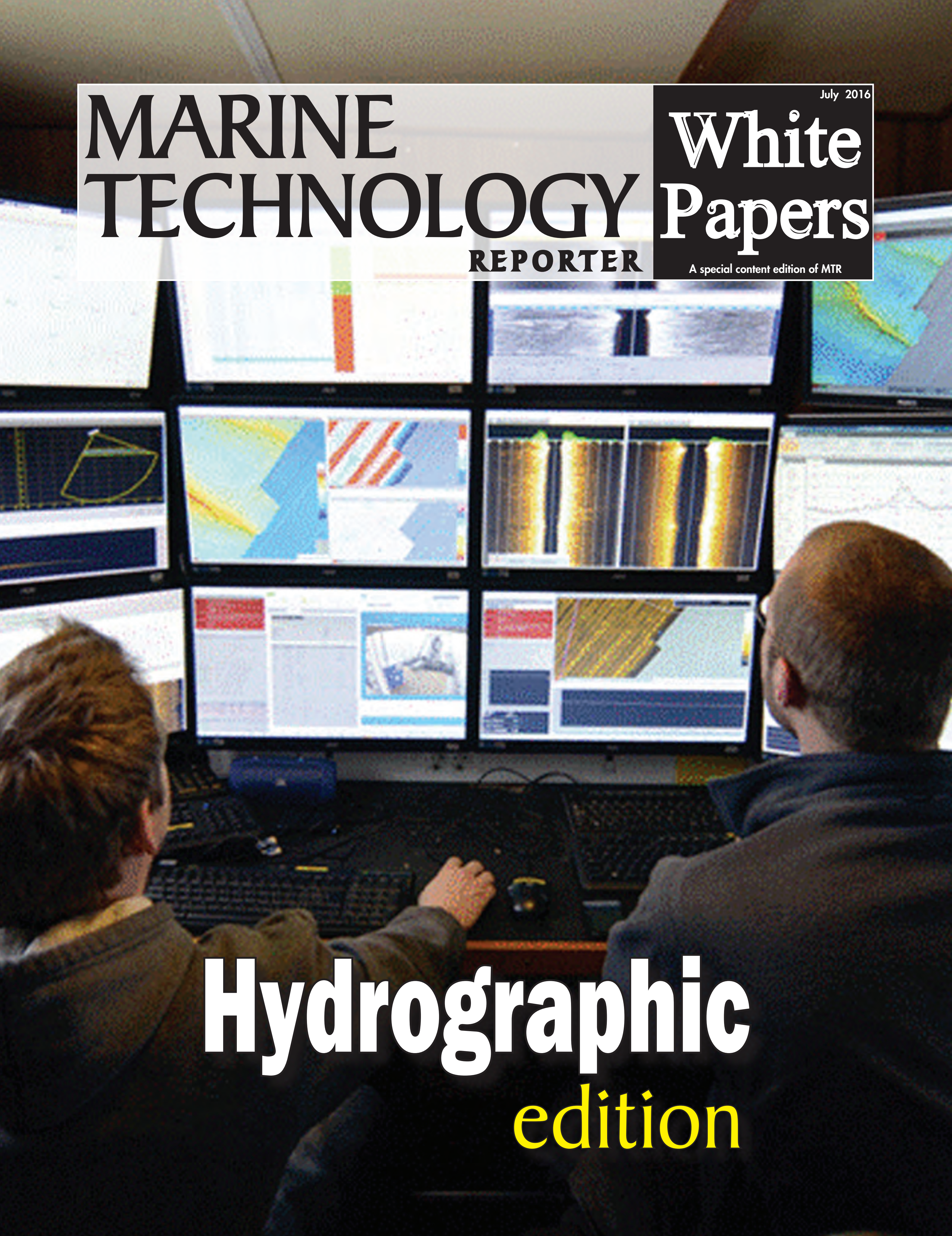

Hydrographic edition

MTR White Papers / No. 2

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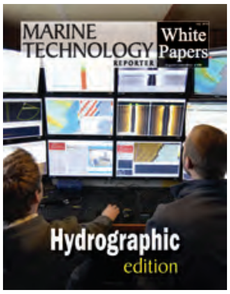

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Teledyne Marine Imaging Hydrographic Solutions

In the following article Teledyne Marine Imaging introduces its Hydrographic solutions and capabilities, analyses the rapid development of Hydrography over time and highlights the key Teledyne Marine markets, supported by case stories. Finally, we will describe the future trends within hydrography.

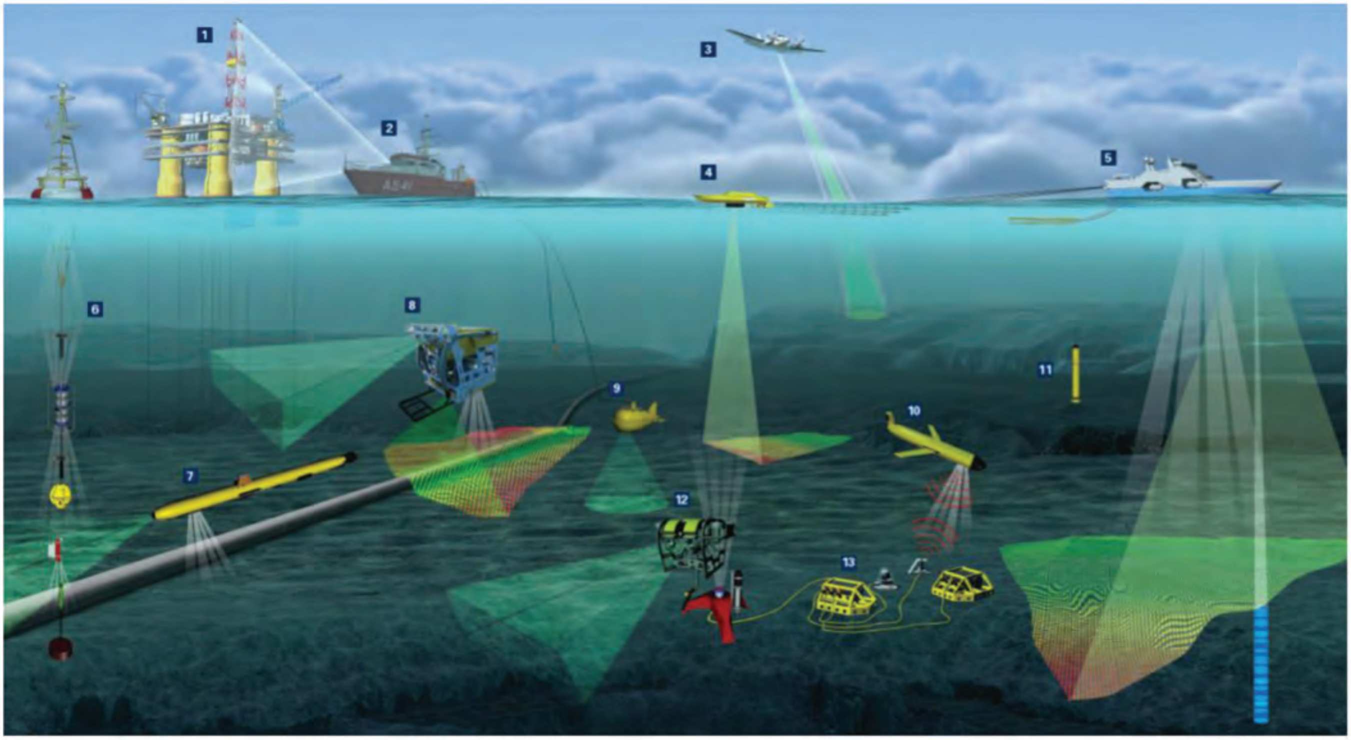


Figure 1: Teledyne Marine Imaging multibeam echosounder and sonar solutions

Introduction

Teledyne Marine Imaging provides acoustic imaging solutions (sonars) and optical solutions (underwater cameras and lights), which are developed by Teledyne RESON, Odom and BlueView and Teledyne Bowtech respectively. In this article we will focus on Teledyne Marine's advanced multibeam echosounder and sonar solutions servicing a variety of markets and applications. Singlebeam echosounders and entry level multibeam bathymetric echosounder systems are manufactured by Teledyne Odom Hydrographic, while high resolution multi beam echo sounders for deep and shallow water and long range forward looking sonars are manufactured by Teledyne RESON. 2D forward looking sonars, as well as 3D multibeam scanning sonars, are developed by Teledyne BlueView.

Teledyne Marine Imaging has facilities in Denmark, The Netherlands, Germany, U.K., the USA and China. For support, a global sales network of distribution partners in more than 47 countries in operation. The organization counts over 40 engineers and hydrographic surveyors working from six service centers.

Hydrography throughout History

The first hydrographic charts originated in the 13th century in Italy, Portugal and Spain. Known as portolans, these were produced to provide realistic descriptions of coasts and harbors and to aid navigation offshore. The earliest charts depicted routes, obstacles and wind directions, but contained no depth soundings like modern day charts.

In the 17th century, lead line markings were used in England for recording depth measurements. This method was slow, labor intensive and had limited accuracy due to water currents and low accuracy positioning techniques. By the 20th century, single beam echosounders came into use, using acoustic transmitters and receivers to measure depth based on the time difference between the acoustic transmission and received echo. However, single beam surveys still had many limitations compared to modern day surveys; namely low sounding density, which made for difficulties in finding accurate feature definition.

Technical advances in subsequent decades saw multibeam echosounders come into use, with the first systems developed for military purposes in the 1960s. Multibeam echosounders measure multiple depths over a wide swath perpendicular to the heading of the survey ship using advanced acoustic techniques and, when combined with accurate navigation data from GNSS systems, allow rapid generation of accurate seafloor maps.

The first multibeam echosounders were developed for shallow water bathymetry, but the range of applications and products has since expanded. Products are now available at a range of operating frequencies, allowing full ocean depth mapping, and may be installed on a variety of platforms. Moreover, systems are capable of outputting multiple data types simultaneously, including bathymetric point clouds, backscatter acoustic images and water column data. Common applications of shallow water systems include structure inspections (for example monitoring the condition of quay walls), dredge surveys, wreck surveys, hazard monitoring and marine research. Forward looking sonars, which illuminate a wide vertical as well as horizontal sector in the water column, are used for underwater surveillance and diver detection. Deep water systems are considerably greater in size and lower in frequency (<30kHz) and may be used for oceanography, cable route surveys, hydrography and submarine navigation.

This article highlights and addresses the most important markets served by Teledyne Marine Imaging with Hydrography, Dredge, Civil Engineering, Energy and Defense & Security.

Hydrography

Within Hydrography, Teledyne Marine Imaging provides a product portfolio for seabed mapping from full ocean depth deep water to shallow water. Within that range, Teledyne Marine Imaging can match the client's requirements for size, ease of use and performance with a quality package according to the budget specifications.

Major applications include seafloor mapping, port and harbor surveying, route surveys and ocean science.

Teledyne Marine Imaging also provides supporting sensors

Multibeam Echosounder and Sonar Overview

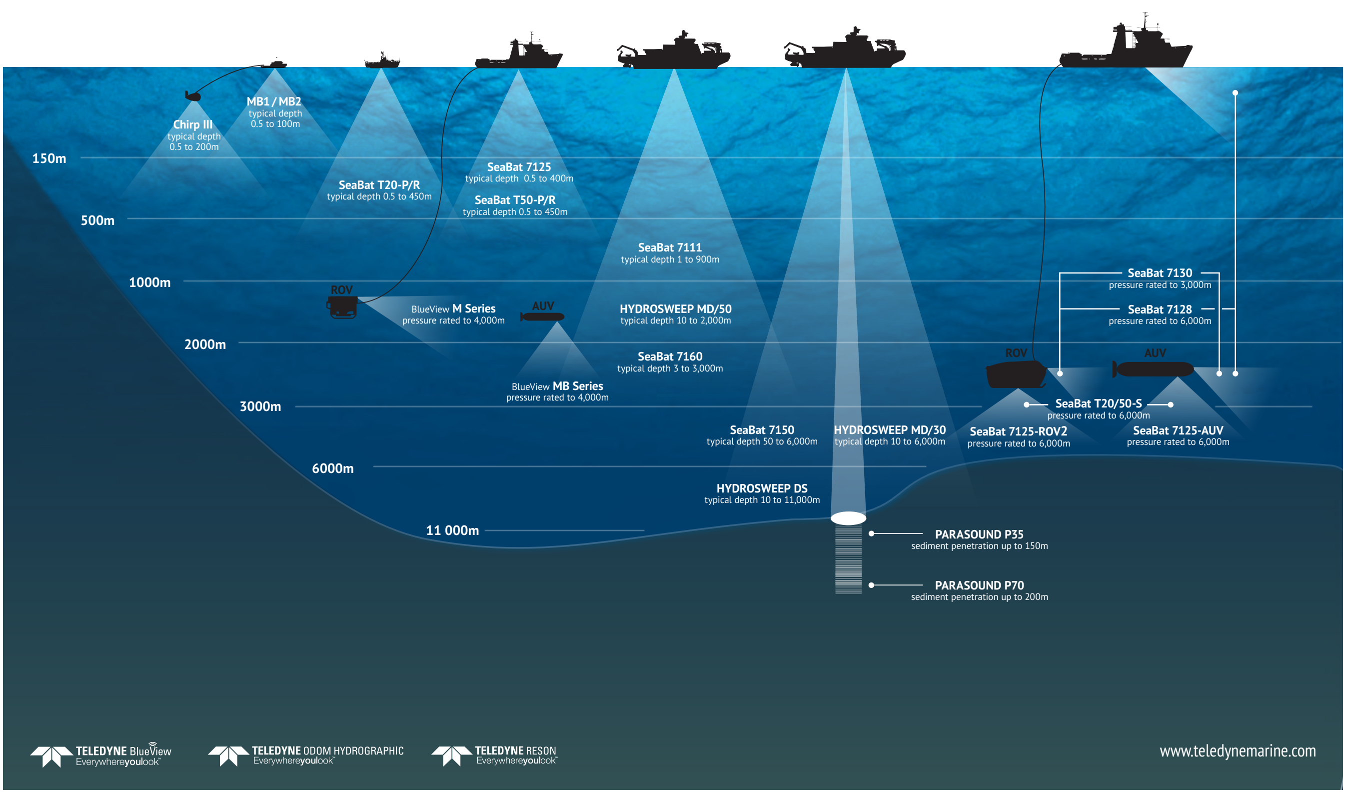


Figure 2: Teledyne Marine Imaging multi beam echosounder and sonar range overview

and accessories such as sound velocity sensors, brackets, mounting kits, gondolas, and cables, as well as motion compensation and INS systems.

Teledyne PDS's software solutions provide turnkey packages for Teledyne Marine Imaging's singlebeam echosounders, multibeam bathymetric sonar systems, and multibeam scanning sonars. All sonar solutions produce industry standard data to interface with all major hydrographic sonar data collection packages.

Energy

Energy is a primary focus in Teledyne Marine Imaging. The forward looking imaging sonar from Teledyne BlueView and the cameras from Teledyne BowTech assist ROV operators navigating around offshore subsea structure, and for pipeline surveying many companies use the SeaBat 7125 and T50-P. Features such as target detection systems for ROV station keeping and automatic tracking systems to detect and follow pipelines are Teledyne Marine developments. Main applications are pipeline surveying, metrology, inspection & monitoring, obstacle avoidance and leak detection.

Teledyne Marine Imaging's sub-bottom profilers look deeper. With a bottom penetration upto 200m the ParaSound can visualize structures from 15cm, buried objects can be localized prior offshore cable trenching, or geologically stable pipeline routes identified.

Civil Engineering & Dredge

Teledyne Marine Imaging offers a suite of solutions to support civil engineering & dredge operations. The product range includes hydrographic grade singlebeam echosounders, subbottom profiles and sound velocity profilers by Odom Hydrographic, 2D imaging sonars and 3D multibeam scanning sonar by BlueView and the SeaBat world leading range of multibeam echosounders all coupled with the power of Teledyne PDS software for hydrographic surveying and dredge guidance operations. The organization thus provides a range of acoustic and software solutions to meet the demands of the civil engineering and dredge market. Main application areas are, pre and post dredge surveys, dredge guidance, construction support, bridge dam & harbor inspection and scour and undercut monitoring.

Defense and Security

Teledyne Marine Imaging supports Defense & Security needs offering Commercial-off-the-shelf (COTS) products providing high performance combined with the cost of ownership through the product lifecycle typically much lower compared to bespoke products. Teledyne Marine Imaging is represented by products from RESON and BlueView including multibeam echosounders for tactical bathymetric mapping, 2D forward looking sonar and hydrophones widely used by navies and institutes around the world. Main applications include terrain mapping, obstacle avoidance, mine counter measures, diver detection and first responder support.

Surface vessels often rely on charts for safety of navigation, but for naval operations charts are often unavailable. Underwater vehicles must avoid objects in their path and are often fitted with singlebeam scanning sonars. Their slow update rate only covers part of the forward sector at any given instant. Long range SeaBat and HydroSweep systems can operate on surface vessels at down to 11,000m depth, whilst the most compact low-power BlueView 2D sonars arerated to 3,000m, thus covering a wide range of applications.

For the support of first responders, Teledyne Marine Imaging solutions include 2D multibeam imaging sonars such as the RESON SeaBat 7128 for surface vessel mount, to the more compact BlueView multibeam sonar, suitable for surface vessel use or on portable low logistics ROVs and diver hand units.

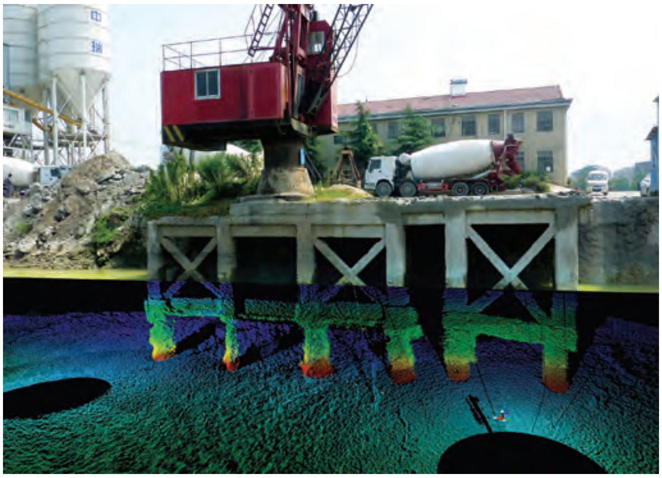


Figure 3: BlueView construction monitoring data image

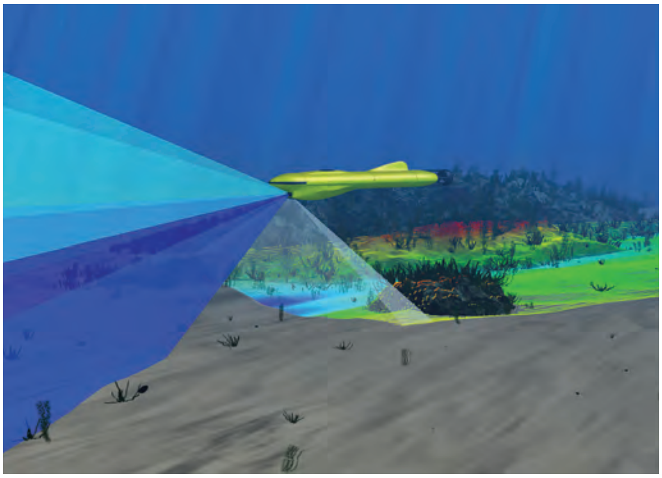


Figure 4: BlueView FLS, micro-bathymetry and gapfil sonar on AUV

Hydrographic Case Stories

Case Study 1

Port Authority of New South Wales - Integration of laser and multibeam echosounder equipment

Port Authority of New South Wales (PANSW) – formerly known as Sydney Ports Corporation – is responsible for monitoring bathymetry for both the safety of general navigation but also to ensure the safe berthing in the commercial harbor in and around Sydney. PANSW also maintain various oceanographic equipment such as tide gauges, wave rider buoys, current meters and anemometers.

For the purpose of asset maintenance of wharves and berths around the harbor, PANSW wanted to evaluate the use of a mobile laser scanner, as opposed to using more traditional means like manual GPS-fixes, total stations, terrestrial based laser scanners etc. – as a part of their daily routines. The potential uses of a mobile laser scanner are numerous. Besides monitoring berths and wharves, other types of surveys could add value to a potential investment. Beach replenishment monitoring and breakwater surveys being examples of potential environmental surveys – and in its nature a mobile laser scanner can also be used as a terrestrial scanner.

An OPTECH Ilris laser scanner was installed on the PANSW survey boat, Port Explorer. Port Explorer is already equipped with a state-of-the-art shallow water multibeam sonar system – the RESON SeaBat 7125 – and a well-accepted industry standard, the POS/MV, for positioning and orientation.

For the feasibility study PANSW had a dedicated laser mount manufactured and had accurately measured the offsets and angular misalignments relative to the POS/MV; essential details when trying to achieve high accuracy results.

Accessing bollards and certain quaysides can be challenging enough from a health and safety perspective but to get out on breakwaters and other fix points can be almost impossible – but they are all typically clearly visible from the seaside. Using a high-resolution laser scanner in combination with a high-accuracy orientation and positioning system could prove to be the tool required to monitor many of the above water assets,combined with monitoring the bathymetry below.

A traditional multibeam installation typically provides good quality seabed coverage of up to about 20-25° below the horizontal. For the purpose of this trial the multibeam sonar was installed with the sonar head tilted 30° providing good quality bathymetry data all the way up to the water line, especially on quay walls and other structures. The laser scanner was simi-

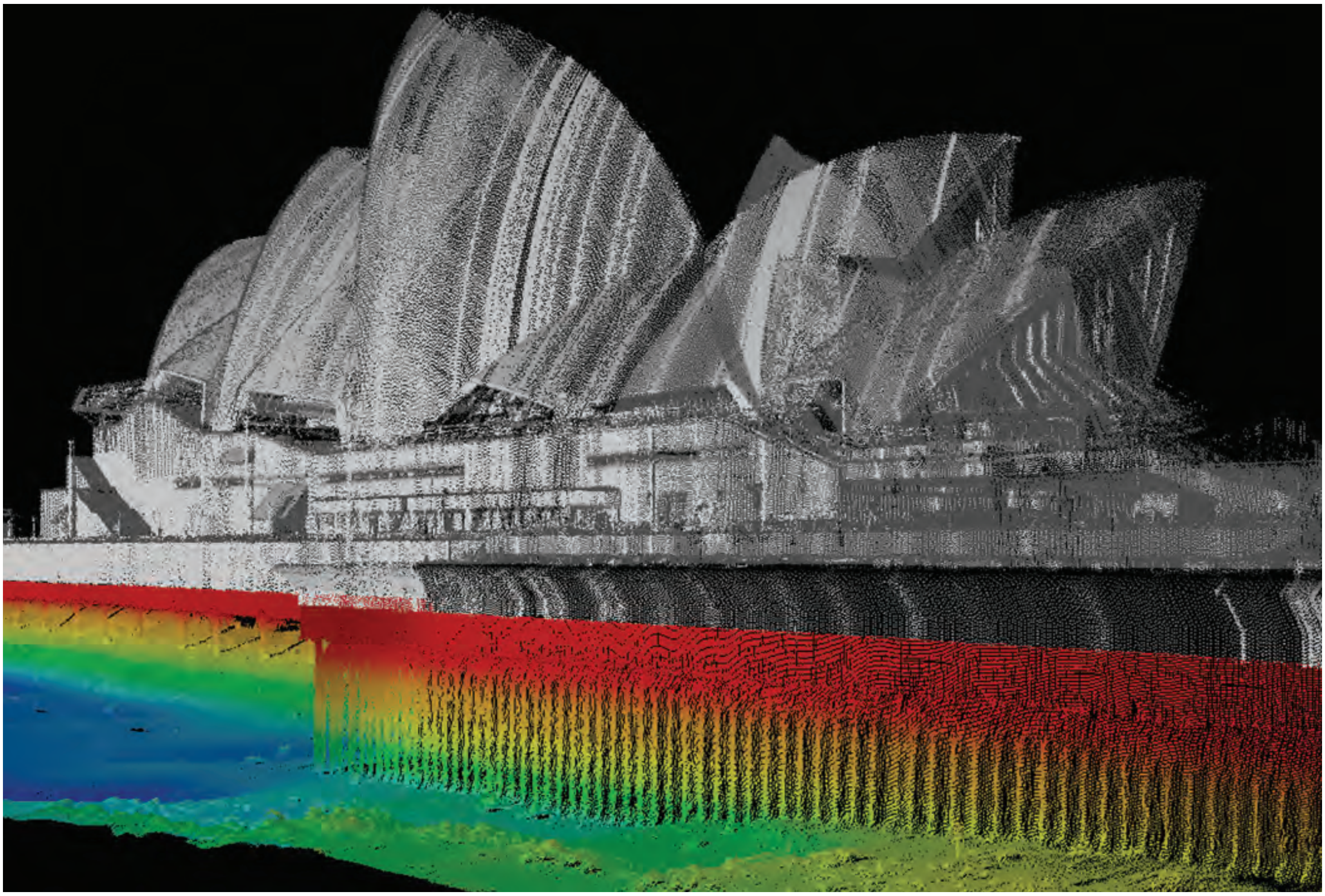


Figure 5: Seamlessly combined multibeam echosounder and laser scan data

larly installed and configured to cover the above water structures up from the water line

Teledyne PDS was used for the calibration, acquisition, initial processing and visualization of data.

One of the challenges is the noise which is generated close to the water line, both in the sonar data and in the laser data. In rough conditions it may be required to plan the survey in two stages: a bathymetry survey during high tide, and a laser scanner survey during low tide, ensuring sufficient overlap in the data sets.

Another challenge is horizontal and vertical accuracy of the laser data.

Both a mobile laser survey and a bathymetry survey depend on the accuracy of external sensors. The laser survey is potentially used to monitor minute changes in structures' absolute position and the laser scanner itself provides millimetric accuracy, but the final point accuracy is obviously no better than the achieved positioning accuracy – and add to this motion sensor accuracy which compensates for vessel movements experienced during the survey.

Real time positioning accuracy is typically centimetric and in order to improve positioning and motion data, raw data is usually post processed. However, even after post processing laser point cloud accuracy will typically be governed by the accuracy achievable by the external sensors.

The customer needs to evaluate whether the advantages of mobility and accessibility to remote structures takes precedence over the reduced accuracy.

The trial proved that it is definitely possible to achieve a virtually seamless surface between the sonar data set and the laser scanner data set.

It was often possible, in one run, to achieve full coverage between the two sensors and the data virtually combined into a seamless surface.

Case Study 2

Aberdeen University - Monitoring Basking Sharks

Scope: Biologists from Aberdeen University wanted to find out if sonar equipment could be used to learn more about the movements of basking sharks. Most of the current knowledge about basking sharks is based on what is visible at the surface and, as such, an investigation was sought to determine if surface observations matched what was happening below the surface. In particular, the scientists were interested to know if the sharks were 'stacking', and whether there was evidence of young sharks.

The challenge is to use a forward-looking sonar to observe the movements of basking sharks beneath the water surface, in order to better understand their behavior. Underwater visibility is poor in this location, thus standard underwater cameras are ineffective. Furthermore, the sonar provides a significant advantage over alternative observation methods with its long range detection capability, which makes it possible to observe the sharks from a long distance without impacting their natural behavior.

Figure 6: Basking shark in Scotland

The ultimate aim is to understand why Basking Sharks come to UK waters during summer. The problem is that our present understanding of Basking Shark behavior is based on what we observe at the surface. However, Basking Sharks spend most of their time below the water surface and we need to see below in order to fully understand their social behavior. As well as monitoring their general movements and behavior, scientists wanted to search for the presence of young sharks, as this could be evidence that the sharks are travelling to mate.

To achieve this aim, a SeaBat 7128 forward-looking multibeam sonar, with dual 200/400kHz frequency, was utilised. Only the 400kHz option was used, as ranges were typically less than 100 meters.

The SeaBat 7128 was mounted over the side of a small fish-

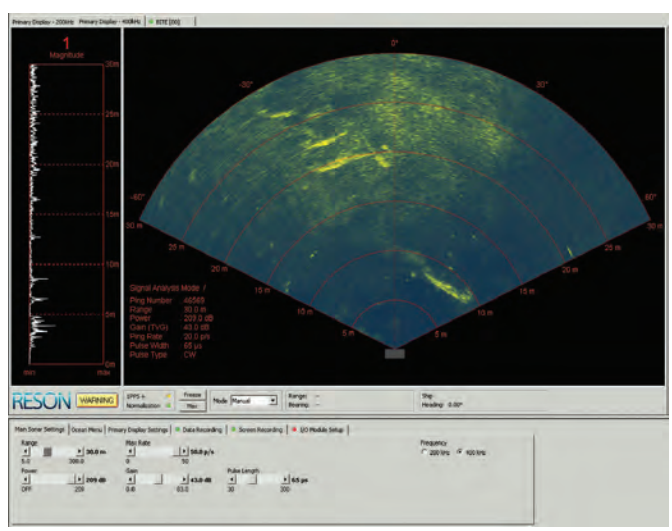


Figure 7: Sonar image of four Basking Sharks

ing vessel. The vessel transited to Basking Shark 'hotspots', where the real-time sonar image display was used to monitor shark activity. The sharks gave a clear response on the sonar display. It was possible to distinguish between different parts of the shark's body on the acoustic images. For example, the pectoral fins were visible, and the tail could be seen sweeping from side to side. In many instances, more sharks were visible on the sonar than appeared at the surface. Sharks were observed closely following each other, swimming parallel to one another, and swimming towards plankton (food) patches.

Case Study 3

Odyssey Marine–Deep Tow System

Odyssey Marine's primary aim is to find and identify large ship wrecks on the seabed, which are typically 50 – 80 meters in length, from the World War I and World War II eras. The exact location of the wrecks is unknown, thus the challenge is to map large swathes of seabed in a short time to allow fast identification of potential targets. The maximum depth is 6,000 meters, and the aim is to map over a 1,000 meter swath within a single pass.

The challenge was to design a system for mapping large areas of the seafloor, in very deep water, so that large targets may be identified. The system should be deployed at a sufficient altitude suchso that seabed coverage is maximized, while providing the necessary resolution to detect large objects in the data. The system needs to accommodate multiple sensors for recording georeferenced and motion compensated depth soundings. It must be able to be towed smoothly above the seafloor at a range of altitudes, typically 60 – 150 meters. The other challenge is that the only connection and contact with the vehicle is through a tow cable. Furthermore, since the water is very deep, the tow cable must be very long.

The TTV-200 vehicle was developed by Teledyne Benthos to accommodate all the instruments. Teledyne RESON supplied a dual head SeaBat 7125 system for mapping bathymetry and backscatter data, as well as being responsible for the software and hardware integration to make the system function as it should. Odyssey Marine supplied the 10,000 meter tow cable, deck winch and towing vessel.

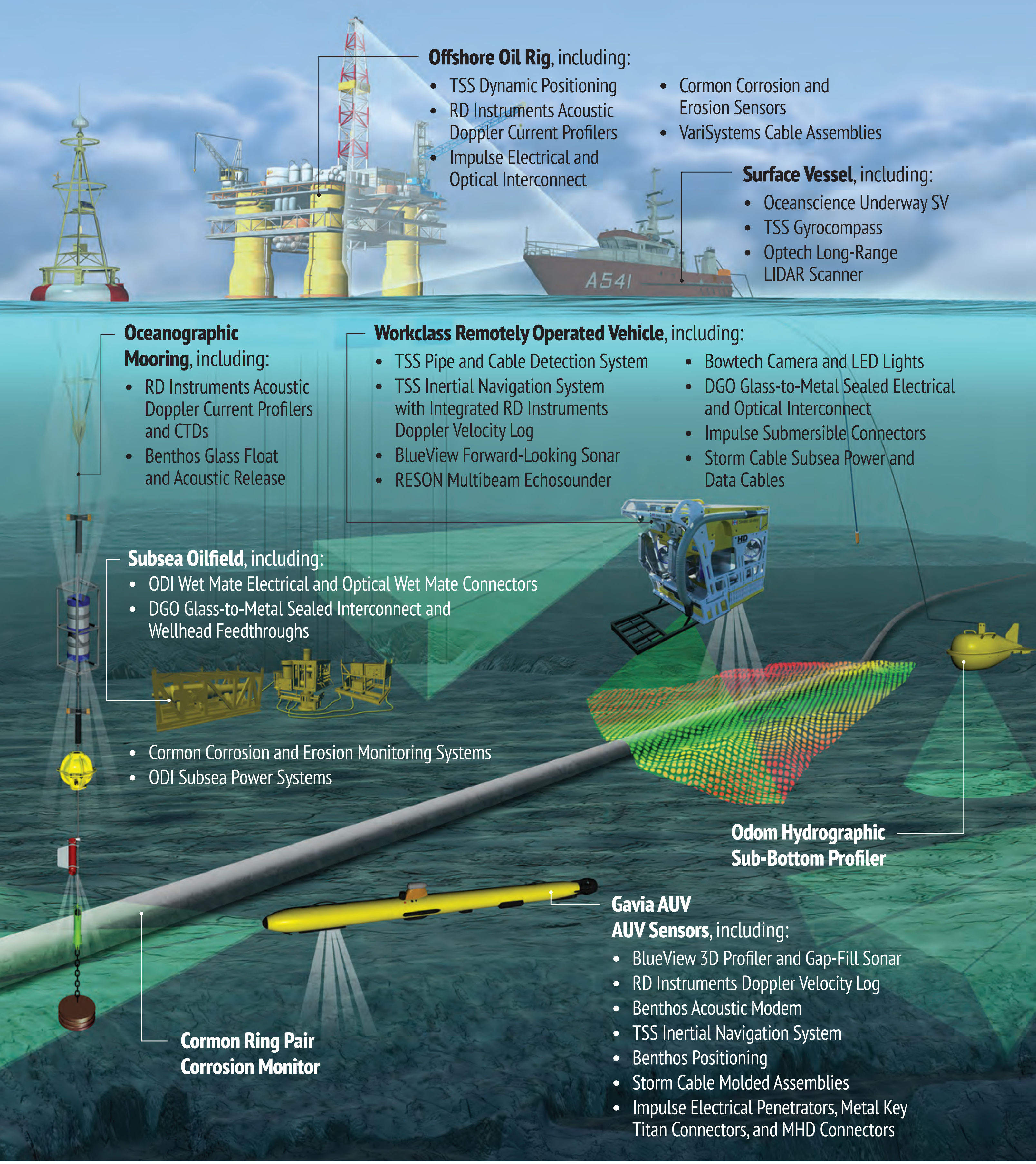
The dual head SeaBat 7125 multibeamechosounders are configured with an outward 50 degree tilt to maximize seabed coverage. There is a low frequency option (200kHz), from which a 1,000 meter swath may be achieved at 120 meters altitude, and a high frequency option (400kHz) which may be used to capture enhanced details over potential targets. Both systems utilize X-Range, a software and hardware feature that provides extended range performance using frequency modulated transmission. Teledyne PDS software was used to integrate sensor data, georeference soundings, and visualize the resulting seabed images.

Looking ahead

The companies of Teledyne Marine are hard at work to provide a new customer experience. Each can tap into Teledyne-wide resources. Thus, they can supply new tools and experience to help customers resolve complex challenges. Further, management foresees a coordinated approach to systems reliability. Test plans and results will show how an assemblage of Teledyne products operates as a system.

Customers will have a streamlined and simplified experience compared to working with multiple vendors. There will be a single focus for point of origin, terms and conditionsand warranty and the opportunity to manage a single purchase order across multiple brands. As another benefit, Teledyne Marine clients will see fewer compatibility issues. As experts in their core technologies, the individual field sales/business development teams and the technical fields reams are being trained to recognize applications where the expanded Teledyne Marine solutions set can add value to our customers for bundled and integrated solutions. These field teams can bring in subject matter experts as needed and will act as true consultative technical sales resources.In short, Teledyne Marine expects customers will see advantages in not only less time and cost of doing business but reduced risk – technical and performance.

Figure 8: TTV-200 Deep Tow vehicle



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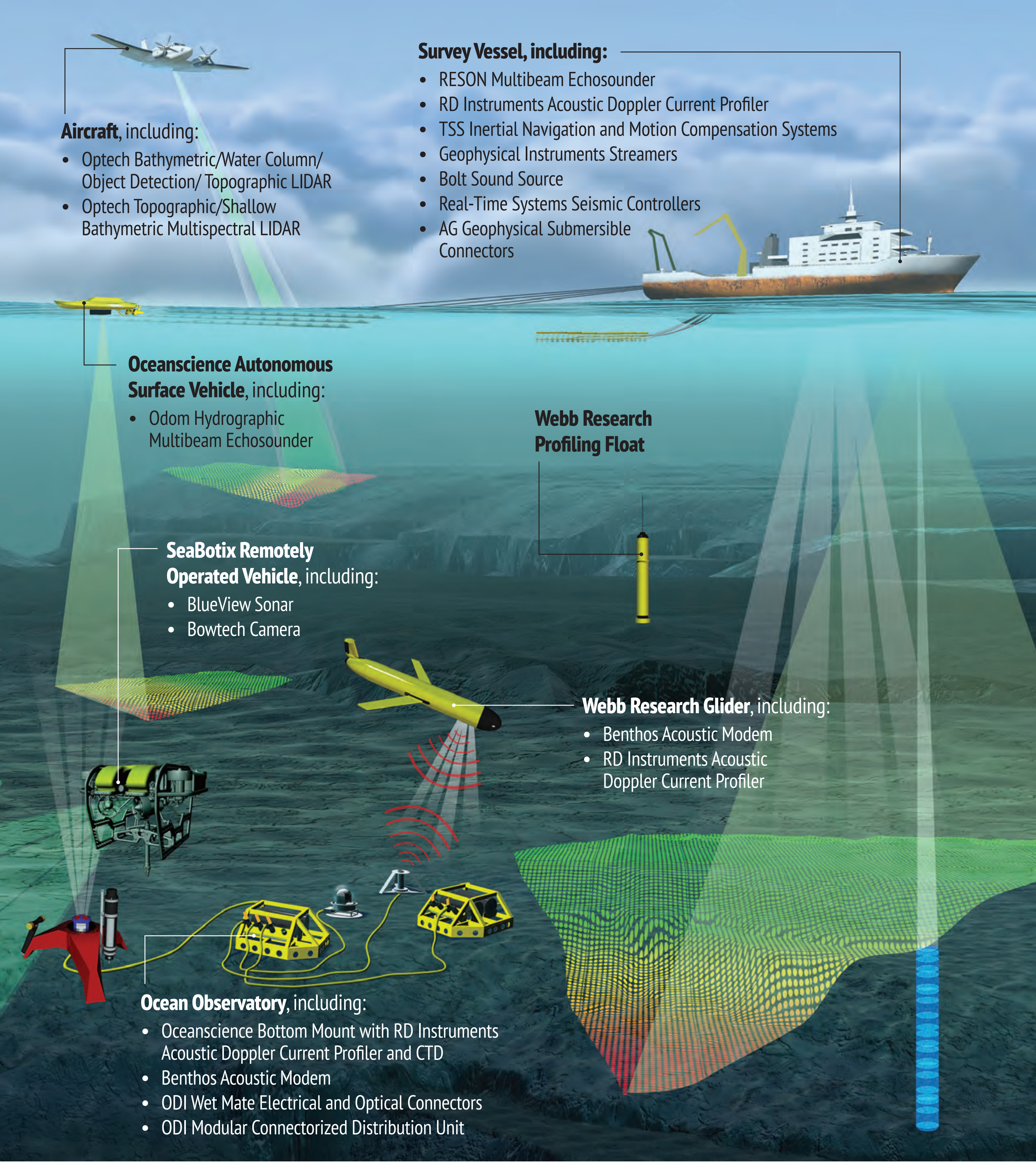


TELEDYNE MARINE
Everywhere**you**look™

QPS – Quality, Innovation & Revolution

Executive Summary:

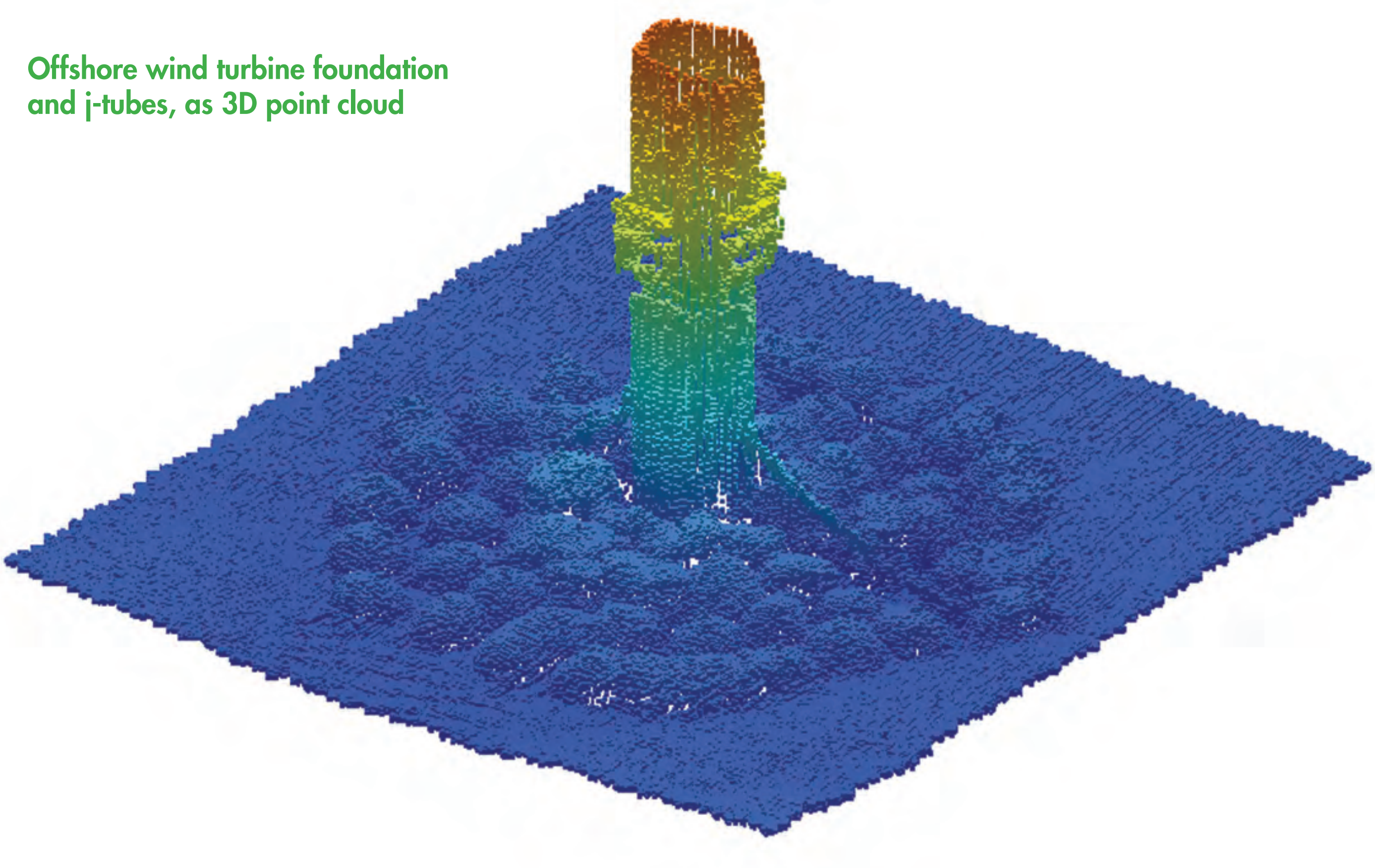
Established in 1997, Bibby HydroMap provide a range of hydrographic, geophysical, geotechnical and ROV survey services to clients mainly from the oil and gas, offshore renewables and subsea cables industries. Their fleet of dedicated survey vessels work throughout the UK and Northern Europe, are permanently mobilised with high-specification survey equipment from industry leading suppliers.

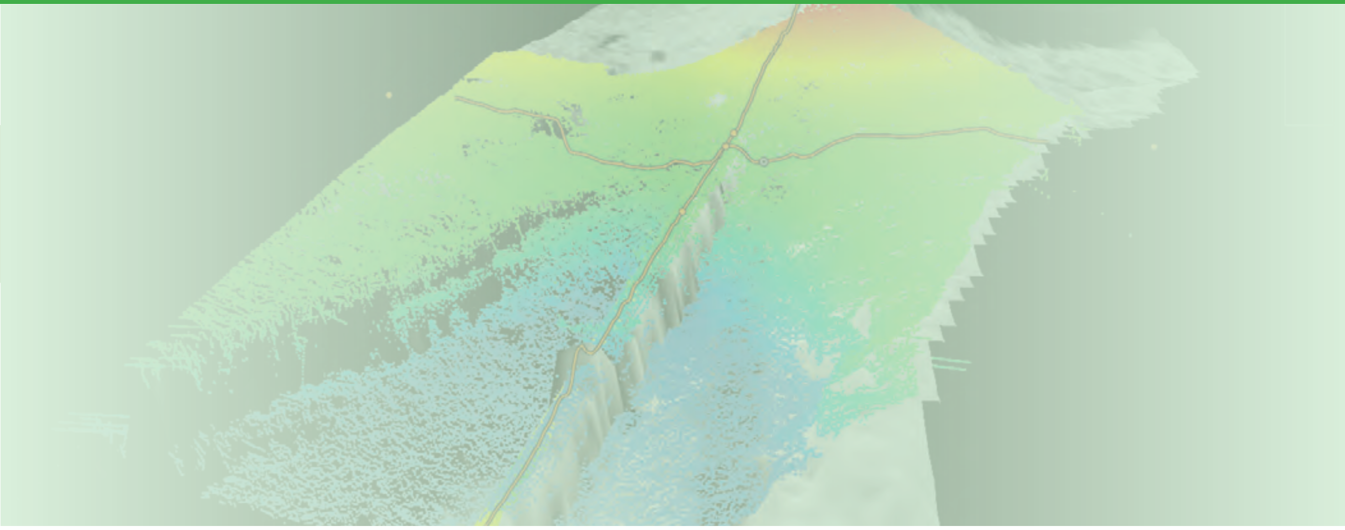
Introduction:

Bibby HydroMapis typically involved in most stages of a project lifecycle, from initial site suitability and investigation surveys, Unexploded Ordnance (UXO) survey, pre-construction survey, post-construction survey, monitoring and pre and post-decommissioning. The acquisition, processing and reporting of bathymetry data forms an integral element of these surveys and QPS products have for many years been a part of each stage at Bibby HydroMap.

QPS QINSy is the core software used by Bibby HydroMap for online data acquisition and integrates sensor data concisely from the onboard survey suite into one database file. There is also an extensive suite of options for creating user-defined files online and database templates can be easily be revised to adapt to client requirements.

Offshore wind turbine foundation and j-tubes, as 3D point cloud





Background:

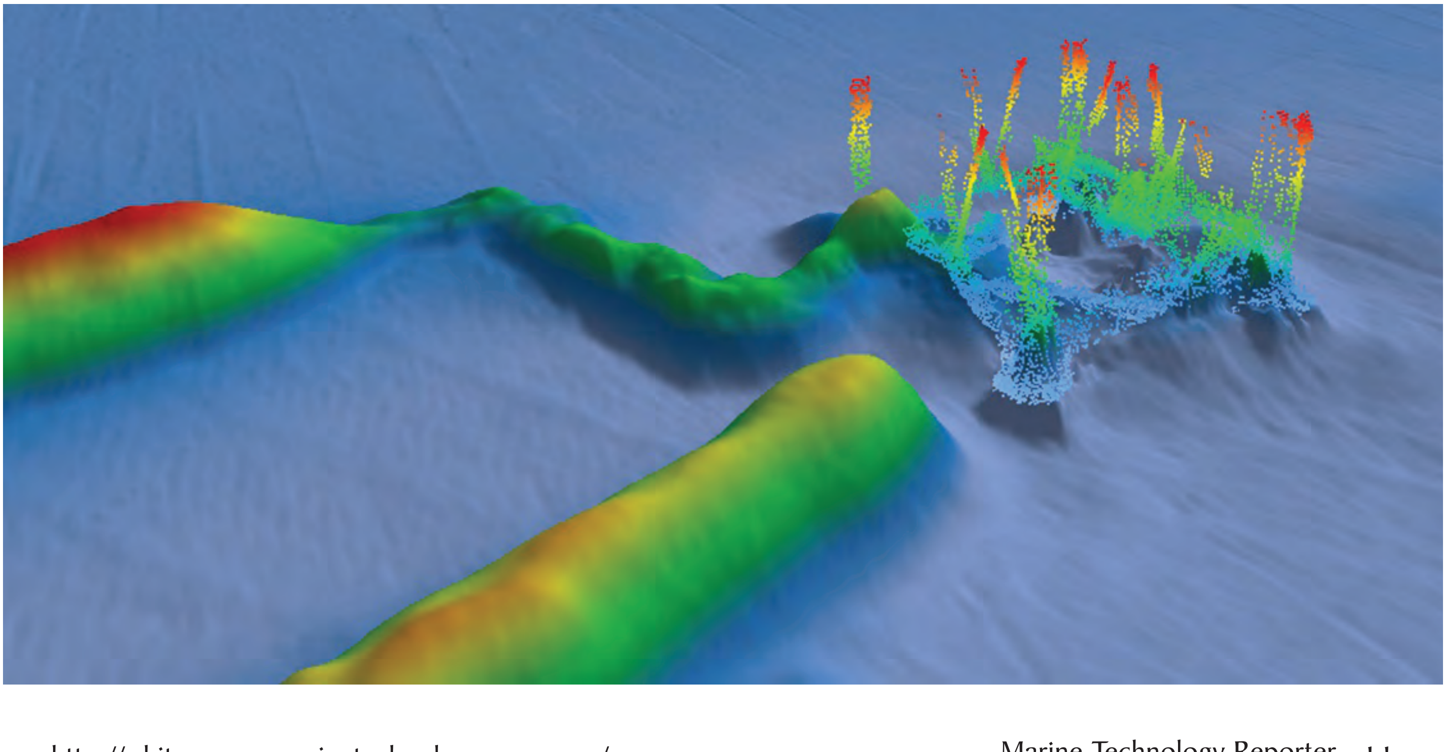
Recent significant technological developments combined with Bibby HydroMap's response and integration of such developments has seen the scale of projects increase significantly. Data quantities not only cover large spatial areas, but technological advances have influenced requirements for denser data coverage for enhanced seafloor ensonification and target detection. Consequently larger volumes of data are generated per square kilometre of seabed. This is particularly pertinent in relation to offshore renewables, as represented in the figure below.

Part of Bibby Line Group's and Bibby HydroMap's core values are to 'be better' and 'be innovative'. These principles drive workflows for handling and processing increasingly large data volumes, and for enhancing their final product deliverables. The company proudly became the first QPS customer to integrate QPS Qimera into their Management System.

Solution:

Tom Davenport (Principal Surveyor @ Bibby HydroMap) "QPS Qimera has delivered a significantly increased data processing efficiency.It's really user friendly and feature rich

Offshore sub station foundation, as 3D point cloud with seabed DTM

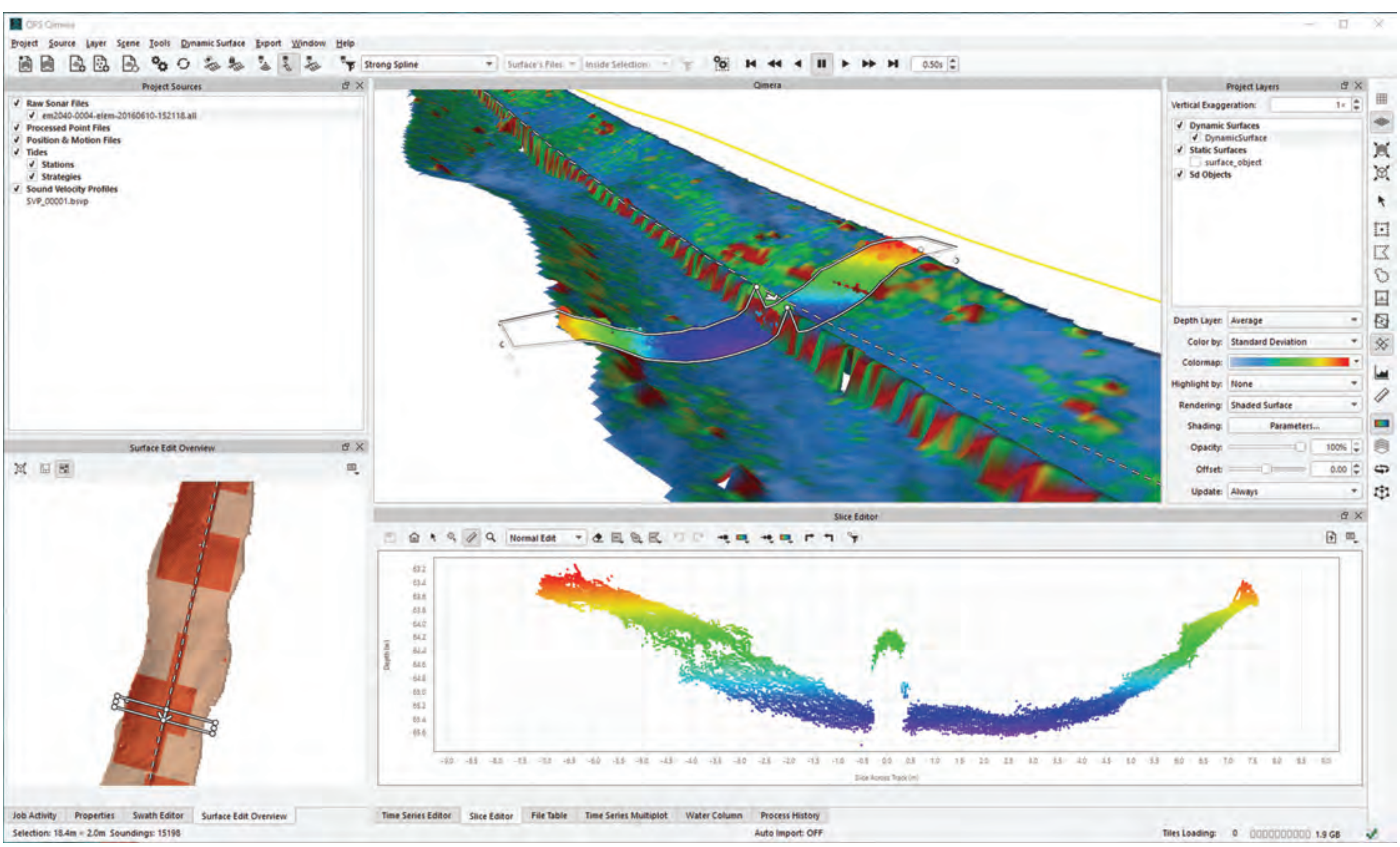


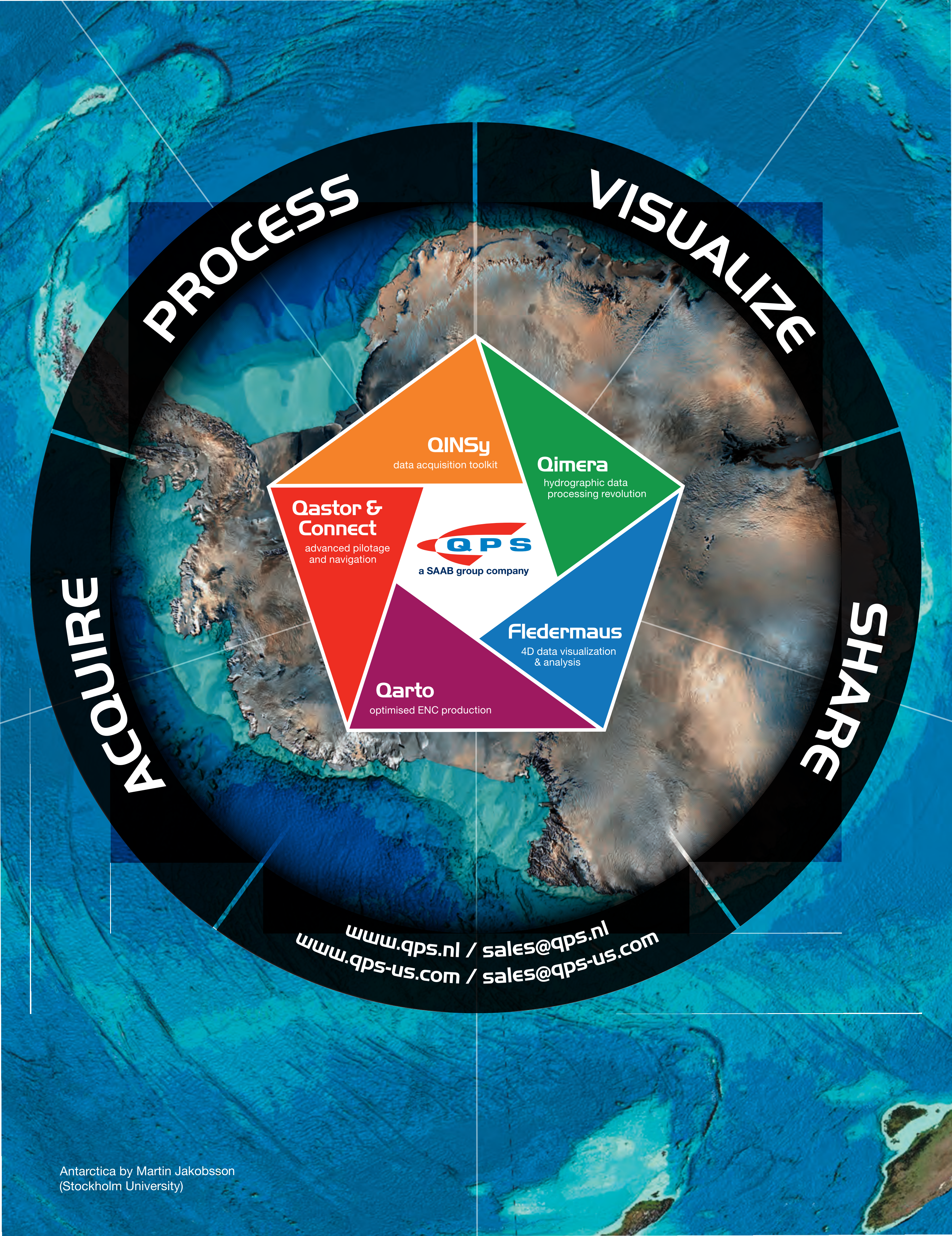
> *"QPS Qimera has delivered a significantly increased data processing efficiency. It's really user friendly and feature rich software."*

software, and gives us the full integration of 3D visualisation within the primary multibeam data processing suite. Qimera has successfully married the key processing tools from QINSy Processing Manager with the data quantity and visualisation capabilities of Fledermaus to form a powerful one-stop processing hub". The new utilities like the Wobble Analysis tool and the Time Series multi-plot have provided extra dimensions for data QC and allow operators to spatially review data and statistically analyse potential sources of error.

Bibby HydroMap now have Qimera licences to match all of their QINSy licenses, meaning that once recorded, online databases can be straightaway transferred to a Qimera project folder for the data QC and subsequent processing workflow stages.

Time after time we manage to impress our Clients with the imagery and fly-through 4D scenes of the data we produce with QPS Fledermaus, and we're already exploring the new features of QPS Fledermaus 7.6

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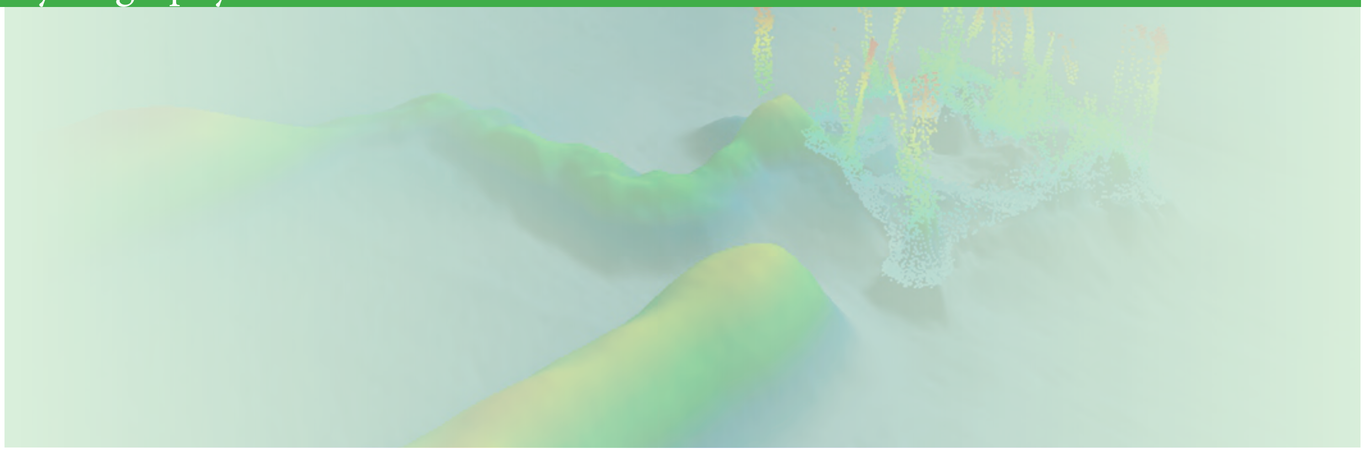

Looking ahead:

Bibby HydroMap is keen to further integration of the user-designed software tools within the QINSy - Qimera – Fledermaus suite. The close working relationship with QPS helps to ensure that the company continues to provide a unique and market-leading approach to coastal seabed survey.

About:

ACQUIRE – PROCESS – VISUALIZE – SHARE QPS has since 1986 been based in The Netherlands, now with subsidiary offices in USA, Canada and UK. In 2012 QPS became a member of the Saab (Sweden) group of companies. QPS makes industry leading software for collection, post processing and visualisation of navigation and survey data. Our products QPS QINSy, QPS Qimera, QPS Fledermaus and QPS Qarto aim to solve problems and gain efficiencies for maritime related geospatial business.

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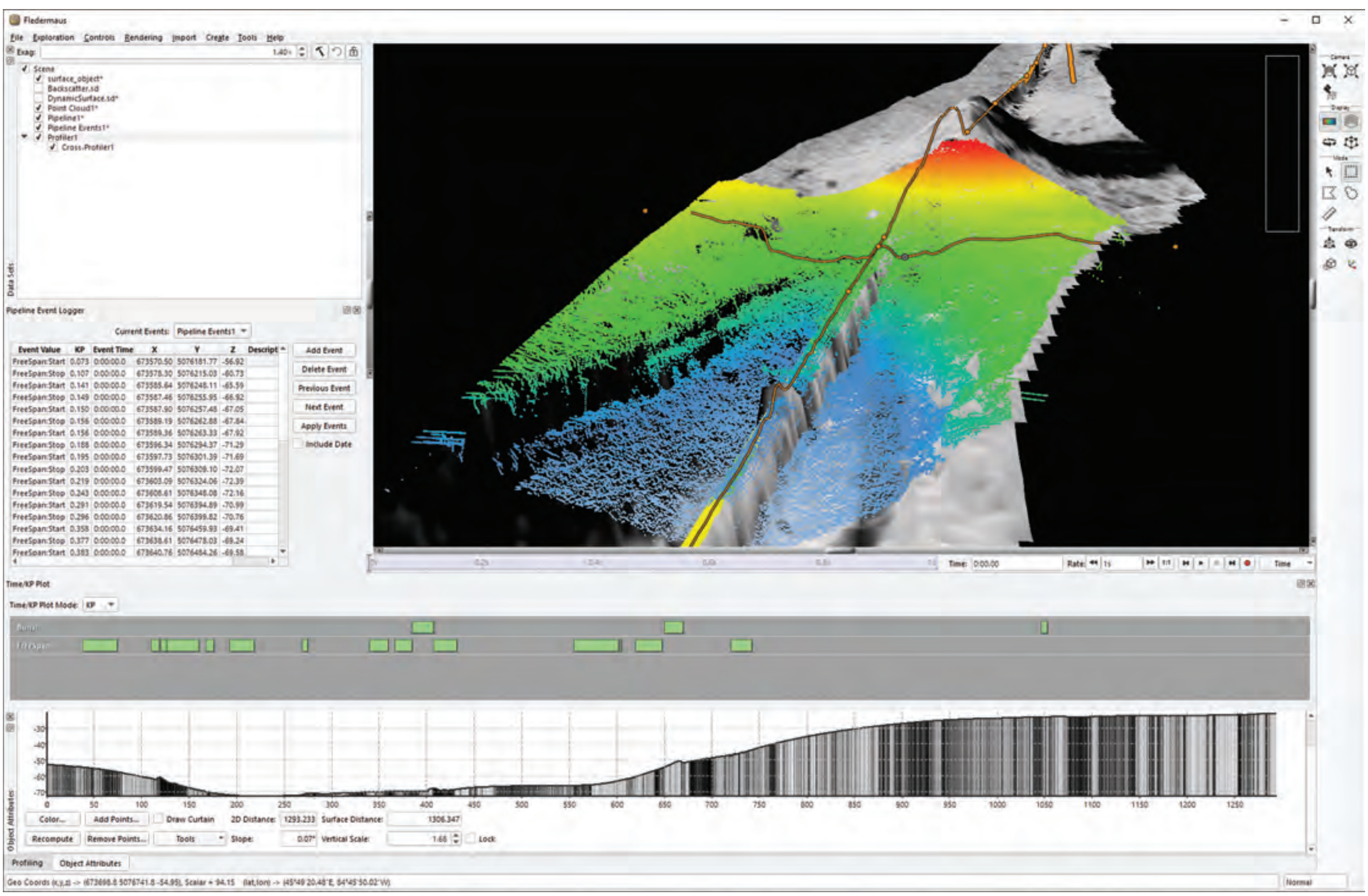

From surface to seafloor, Valeport innovative profilers are shaping the future of surveying

"TIME is money," said 18th Century scientist and inventor Benjamin Franklin, words that will strike a chord with anyone involved in underwater survey work.

With survey vessels costing up to £100,000 a day on the water, anything that reduces time surveying is going to save money.

Over the last decade there have been huge strides forward in positioning and motion referencing technology, reducing errors in multibeam date acquisition considerably. Performance of multibeam sonar systems has increased and processing power has resulted in greatly enhanced resolution, accuracy and detection capabilities.

Taking measurements can still be a time consuming and therefore costly business, which is where Valeport's new profilers are a major step forward.

Using the latest Bluetooth technology, state-of-the-art winches and new formulae developed by the British company, accuracy has been improved and downloading times reduced, eliminating the survey downtime normally associated with profile gathering.

Does More Really Mean Less?

Multibeam systems are improving all the time, but there remains the unknown of the environmental variability of the water column and the resultant sound speed field. This unknown factor can have a significant and measurable effect on data collected.

Significant errors in depth and positional accuracy of 'ping' locations will occur if an incorrect sound speed profile is applied to correct for refraction effects.

If more measurements are taken, is there a greater likelihood of reducing data inaccuracies?

Valeport examined that question during a series of tests in one of the most surveyed stretches of water in the world. The Barn Pool area of Plymouth Sound has arguably more pings per square metre than any other area of seabed.

Barn Pool was used as one of the data collection areas for the Shallow Survey 2015 Conference and, prior to that, the Shallow Survey 2005 Conference.

The University of Plymouth, the Royal Navy Survey School and commercial providers carry out hydrography training there. The popularity of the area can be attributed to the varied conditions found in a relatively small area.

Barn Pool sits at the mouth of the Hamoaze, the combined lower reaches of the Tamar and Lyner rivers on the border between Cornwall and Devon in the United Kingdom.

A flooded ria, the exchange between the Hamoaze and outer Plymouth Sound, occurs through the narrows between Devil's Point and Wilderness Point.

Tidal currents can reach up to three knots on the Spring ebb tide.

Trials Equipment

Over a week in November 2015 a joint exercise between Valeport, Teledyne OceanScience and the Fugro Academy used Barn Pool to train in the deployment of the recently launched rapidCAST winch using two Valeport profilers the SWiFT SVP and the rapidCTD. Fugro Academy provided the MV Bruyn and access to their waterside facilities in Plymouth Sound.

The rapidCAST winch was developed by Teledyne OceanScience as an evolution of the Underway SV system. Fully automated and able to gather vertical profiles down to 500 metres while surveying at speeds up to eight knots, the rapidCast winch uses an advanced, active line payout system with precise tension control. This configuration allows the effects of vessel speed and heave to be eliminated and allows the profiler to maintain a plus or minus five per cent depth accuracy.

The minimal deck footprint of the rapidCAST winch means it can be installed quickly and easily on most survey vessels. The mobilisation work on-board MV Bruyn took around three hours. A repeat installation would take approximately an hour.

MV Bruyn is usually used for training company staff in multibeam and underwater positioning. For the purpose of the Barn Pool trial the underwater positioning system was removed and the deployment mount repurposed to mount the rapidCAST winch. The existing multibeam system was retained alongside the rapidCAST.

Two Valeport profilers were used for the trials, both incorporating their world-leading sound velocity technology. A SWiFT SVP, the latest sound speed profiler from Valeport with built-in GPS, Bluetooth (comms) and a rechargeable battery. This measures sound speed, temperature and depth and calculates salinity and density using a new formula developed by Valeport. The second probe was a rapidCTD, which measures conductivity, temperature, and pressure to calculate salinity, density and sound speed.

Data Collection

While training on the rapidCAST winch, the Barn Pool area was used extensively as it offers one of the deepest areas in the Sound – up to 35 metres – along the flooded river channel.

The variation in sound speed in Barn Pool was both significant spatially across the pool but also had a distinct temporal variation, most likely due to tidal effects.

Two vertical transects through the Barn Pool Area are used as illustrations. Both were collected on the same day, approximately three hours apart. The first was collected at high tide with the rapidCTD as part of a longer transect from the breakwater to the upper reaches of the Tamar above the Tamar Bridge.

The second transect was collected on a dropping tide with the SWiFT SVP on the return leg. Tides were neap.

Figure four shows the locations where the profiles were taken with transect one (rapidCTD) in green and transect two (SWiFT SVP) in red. The positions recorded for transect one were extracted by matching the timestamp of the instrument with the GPS log from MV Bryn. The positions for transect two were recorded using integral GPS. Both transects took around 15 minutes to complete. As the first profile of transect one and the last profile of transect two were taken within five metres, data could be aligned for relatively easy comparison. All data processing was carried out with Python and the SciPy library.

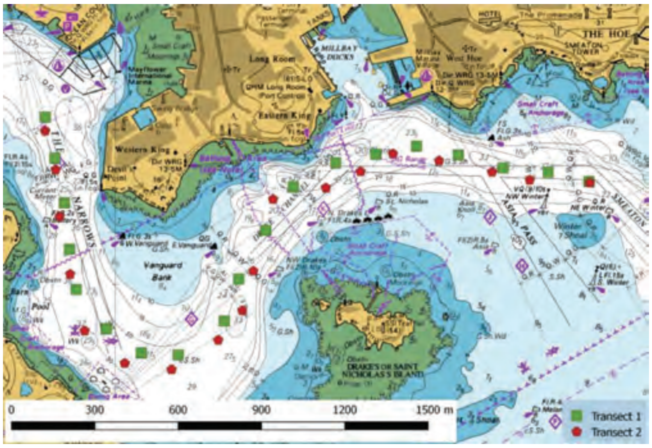

Figure 4: Transect and profile locations

The data presented a series of vertical transects showing contoured plots of salinity (fig 5), temperature (fig 6), sound speed (fig 7) and finally the difference between the sound speed and the two transects (fig 8). They are plotted with the western end of the transect on the left-hand end of the plot and the eastern end on the right.

Below 15 metres the salinity, temperature and sound speed can be seen to be relatively stable. In transect one a 5-10mm thick layer of colder and fresher water spreads across the transect towards the riverine end. In transect two, as the ebb tide is peaking, the fresher water has been displaced from the eastern end of the transect but the fresher water influence at the western end of the transect has intensified and deepened.

The effect this has on the sound speed field is dramatic (see fig 6-7) with a spatial variation in sound speed along transect in the order of 10-15 m/s, and a temporal variation between transects of ±7m/s.

The impact of this variability on the propagation of sound has not been assessed and will be the focus of the second paper by Valeport to be released shortly.

A Measure Of The Future

Marine instrumentation technology continues to advance and Valeport's newest profilers bring direct benefits of better, more accurate data and improved ship time utilization. New communications technologies and instrument automation offer exciting opportunities across a wide range of marine markets.

As Benjamin Franklin also said: 'an investment in knowledge pays the best interest' and customers can be confident

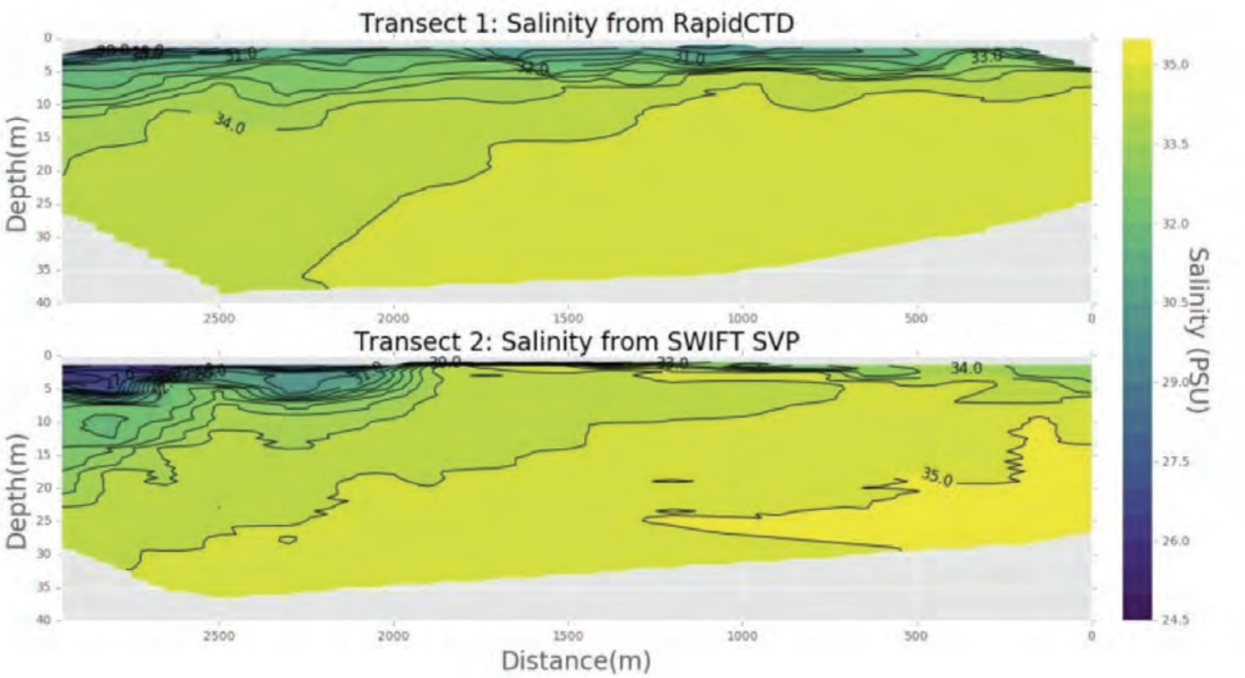

Figure 5: Salinity transects

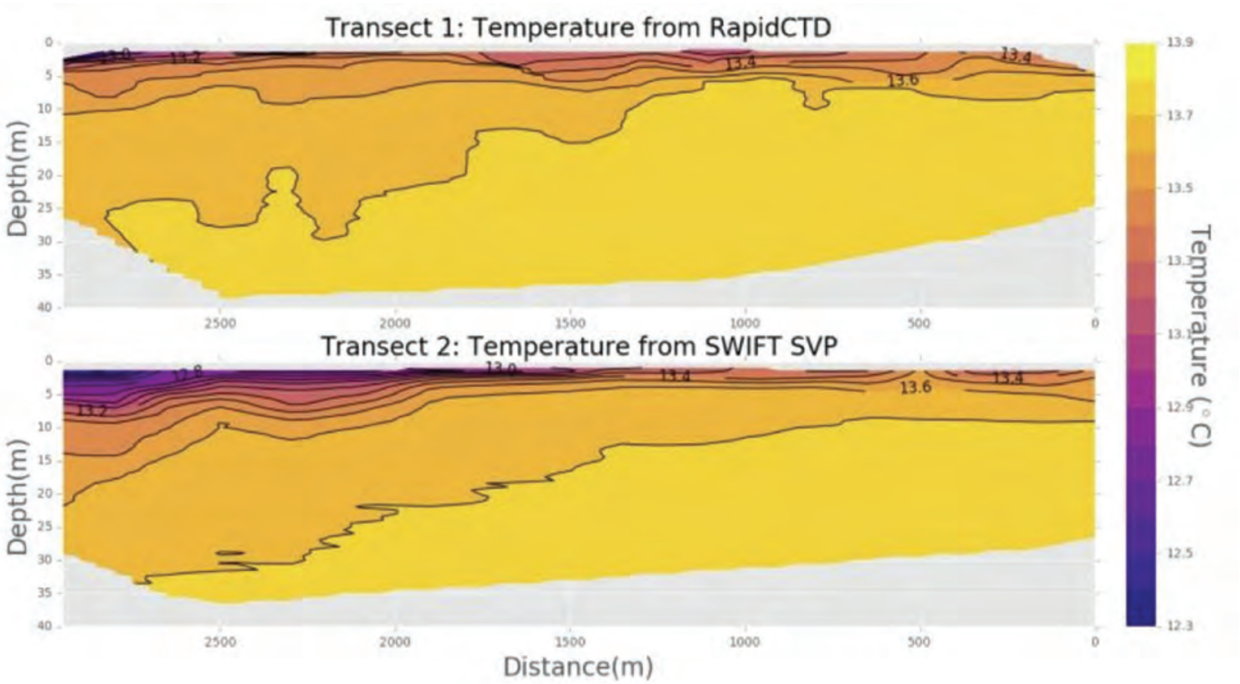

Figure 6: Temperature transects

Valeport is dedicated to pushing the boundaries of marine instrumentation to deliver the ultimate accuracy. Research and development coupled with collaborative partnerships will continue to lead Valeport's focus on growing its portfolio of innovative marine instrumentation and its role in supporting environmental measurement.

Valeport

- Valeport is the UK's leading manufacturer of oceanographic, hydrographic and hydrometric instrumentation.
- Valeport designs and manufactures instrumentation for the oceanographic, hydrographic and hydrometric communities with a worldwide customer base that includes:

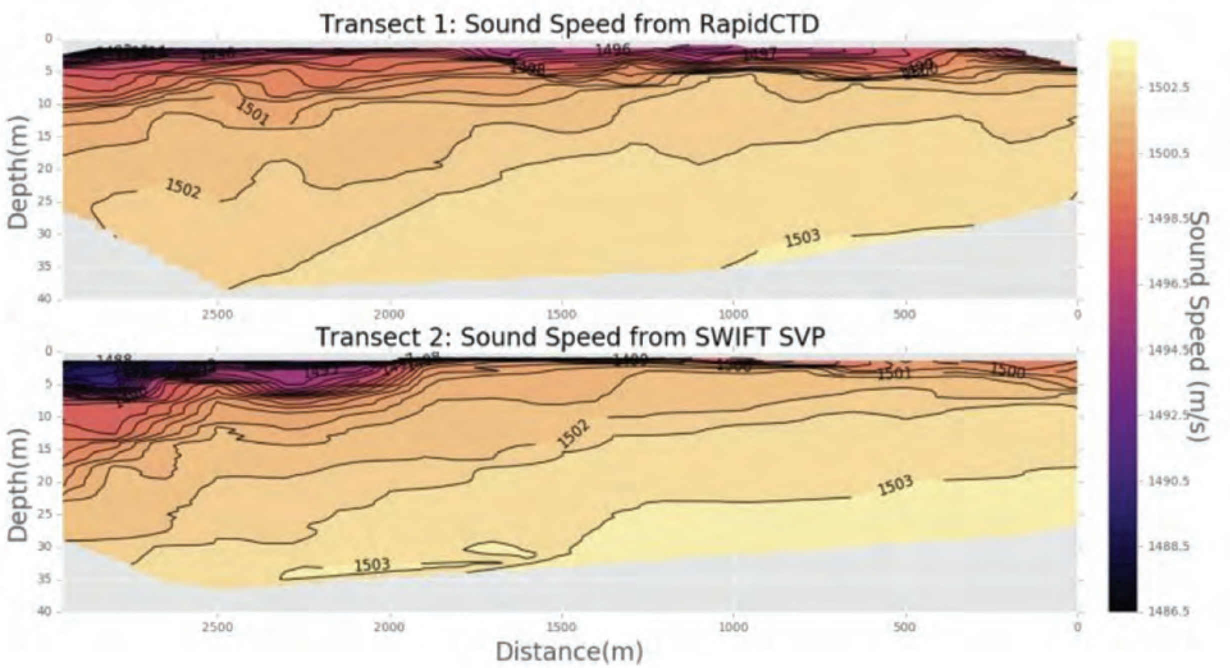

Figure 7: Sound speed transects

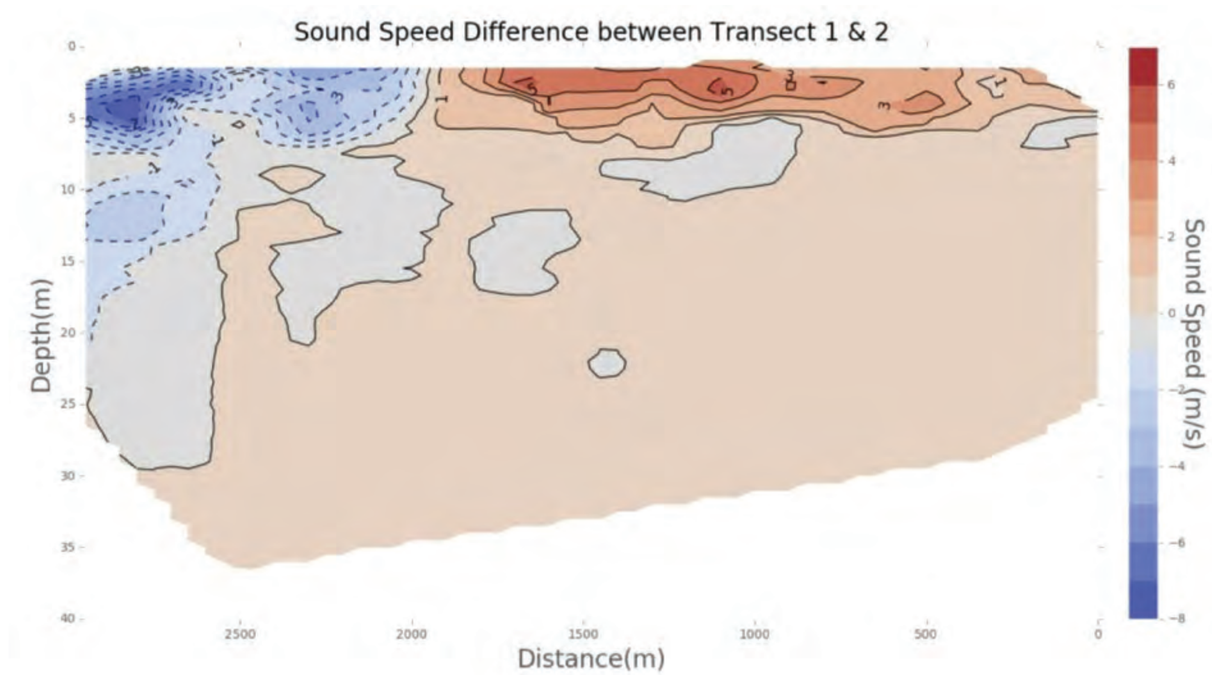

Figure 8: Sound speed difference transects

defence, environmental, oil and gas, renewable energy, construction, dredging and civil engineering sectors.

- Valeport has supplied to the subsea sector since it was established in 1969, now an independent, family owned business, Valeport employs more than 80 people from their base in Devon and works with a global network of agents to ensure a responsive and efficient worldwide service.

For further information: please contact

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Leveraging Near Real-Time Data Processing to Safely Increase Hydrographic Production

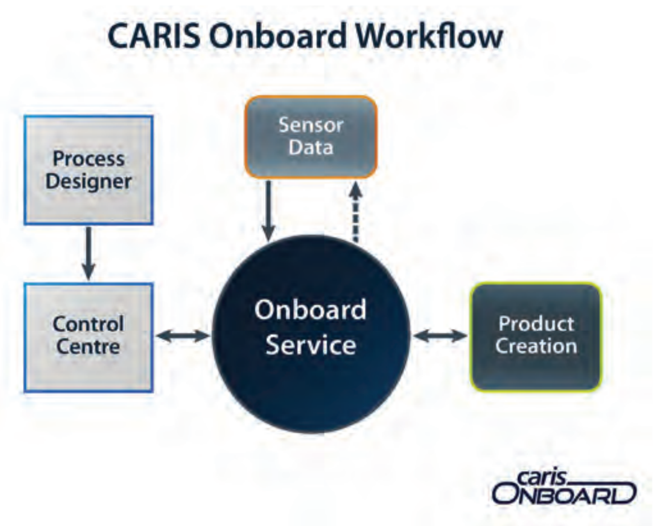
Kalman Czotter[1], Travis Hamilton[2], David Dodd[1]

1: Canadian Hydrographic Service

2: Teledyne CARIS Inc.

The Canadian Hydrographic Service (CHS) and Teledyne CARIS™ conducted two important sea trials in July and December of 2015. The July trial was to test the capabilities of CARIS Onboard™ for near real-time processing, while the December trial was focused on remote access to the products created through a remote survey operation.

CARIS Onboard is an automated service installed on the survey platform that monitors for raw data files from an acquisition system. As new data is detected, it is automatically processed using a customized workflow which can include converting the data to a HIPS™ project, applying tide and sound velocity corrections, and producing products such as surfaces and sonar image mosaics. Processing status and progress are monitored through the web application "Control Centre", while the products and quality information generated by the Onboard Service can be streamed to CARIS desktop applications. This enables the hydrographer to view the geo-referenced survey in near real-time from a remote location, for quality control and decision support, while the survey is still underway.



CARIS Onboard workflow diagram

CHS Atlantic -- July 2015

Teledyne CARIS and CHS organized a trial for CARIS Onboard during a survey of the Wood Island Ferry Route in July 2015. The survey consisted of EM2040 dual head data being collected from the CCGS FREDERICK G. CREED. The main goal was to test CARIS Onboard and ensure it produced the expected results.

During standard operations on the F.G. Creed, once the acquisition system has released a line the survey crew manually copies the file to a separate drive. When the data processor sees the new line appear they manually run it through the following sequence of processes.

1. Convert Kongsberg raw data files into a HIPS™ project
2. Load a predicted tide
3. Merge
4. Compute TPU
5. Add the data to a CUBE surface

The initial workflow allows quality control on the data to occur during operations, allowing problems in acquisition to be identified and corrected before the survey is completed. To test CARIS Onboard, the software was installed on an independent computer, to not interfere with normal operations, and the same initial workflow was applied. However, CARIS Onboard was able to directly monitor the acquisition computer for the raw files.

Once each file was finished, the software automatically imported the raw data into a HIPS project and applied all the processing steps which are required for the initial quality control to occur. Not only did the software ensure the data was available for quality control in the fastest possible time, but it also freed up time for both the acquisition and processing teams, allowing them to focus more on mission critical tasks.

As CARIS Onboard is automated, it reliably applies the same pre-configured workflow to each file as per operational procedures, removing the possibility of human blunders. The software freed the processing team from having to spend their time on mundane tasks, and allowed them to focus their time on processing the navigation data, reviewing the survey quality, and moving the processed data further along in the work-

View of CARIS Onboard running on the F.G. Creed. Left on the screen is Control Centre, used for monitoring the processing progress. Right on the screen is CARIS Easy View™ connected to the live updating CUBE surface.

flow. Ultimately, CARIS Onboard minimized the remaining processing backlog for when the project finished.

The acquisition team was no longer distracted by copying each file as it finished, allowing their focus to be on running the survey equipment. By having real-time access to the CUBE surface on the bridge, the surface could be quickly reviewed for systematic errors that had adverse effects on the data quality. Or by using the standard deviation, Total Propagated Uncertainty (TPU) and data density layers they could easily note when the line spacing required adjustment or, a section had to be re-surveyed. Ultimately the survey quality feedback loop became much smaller than the traditional method of waiting on the manual processing.

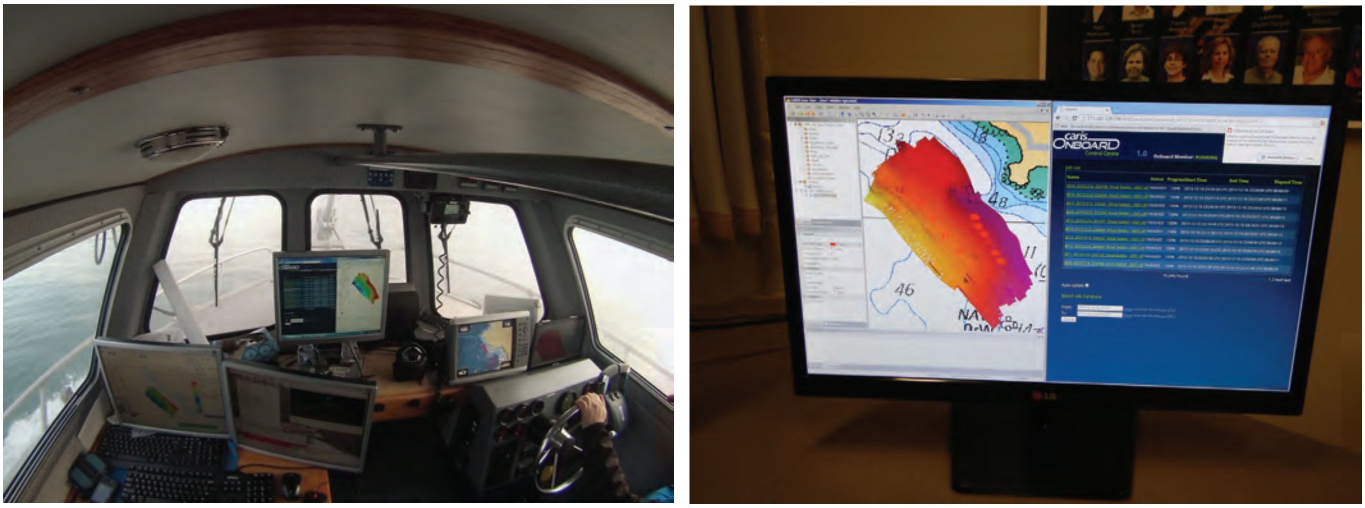
To validate that CARIS Onboard was producing the same results as the manual processing, a three dimensional comparison of processed depths for individual soundings was performed. After all processes have been applied, the processed depths consist of the latitude, longitude and depth value for each sounding. The comparison showed that all soundings matched to the full stored precision, which is 1mm for depths and 1/10000th of an arc second for latitude and longitude.

A comparison of the generated surfaces was also performed using the difference surface function in HIPS and SIPS™. As the CUBE function is dependent on the order that the lines are added to the surface, care was taken to ensure that only a single line was added at a time, in the order they were acquired. The difference surface produced from this test showed a min and max value of 0.000m, confirming that the two workflows produced identical surfaces.

CHS Pacific -- December 2015

Teledyne CARIS and CHS organized a joint trial focused on the remote access capabilities of CARIS Onboard. This would demonstrate that the software would be a viable solution for allowing the quality of data collected, without a hydrographer onboard, to be reviewed remotely. The survey consisted

CSL Shoal Seeker. Equipped with an R2Sonic 2022, Applainix POS MV and AML Oceanographic Minos X (SVP); the vessel provided an ideal platform for testing CARIS Onboard.



Simultaneous viewing of the processed survey data, both on the vessel (left) and in the CHS Pacific offices (right).

of R2Sonic 2022 data being collected from the CSL Shoal Seeker.

The December trials had two main goals. First was proving that CARIS Onboard could supply reliable access to the CUBE surface over a 3G connection. Second was validating the performance of the overall survey system, which included real-time Global Navigation Satellite System (GNSS), using a previous in-time sound velocity correction, and CARIS Onboard.

The CSL Shoal Seeker was mobilized with two computers. The first computer was interfaced with the survey equipment and was used to run the acquisition software, while the second computer was setup as the processing box, and was connected to the acquisition computer through a local workgroup. To provide remote access a Telus 3G wireless mobile internet device was connected to the processing computer. CARIS Onboard was installed on the processing computer, and was able to monitor the raw data directory on the acquisition computer. As each line was released by acquisition, CARIS Onboard detected that the line was complete and submit it through the following workflow:

1. Convert XTF raw data files into a HIPS project
2. Load predicted tide
3. Sound Velocity Correct using a previous in time algorithm
4. Merge
5. Compute TPU
6. Add the data to a CUBE surface

By using the Telus 3G connection to serve the CUBE surface over the internet, it was available for use on the survey vessel as well as being available for review from within the CHS Pacific offices while the survey was ongoing. As the entire CUBE surface was made available for a remote connection, the hydrographer in the CHS Pacific office was able to connect to the surface using CARIS Easy View, while loading in background information to give the survey context. The hydrographer was also able to query the various surface layers, such as density and standard deviation to quantitatively and qualitatively review the survey results.

While the survey was ongoing, the hydrographer was able to extract from the remote connection that the vessel speed was too fast. He immediately made contact with the vessel crew, requesting they reduce the vessel speed to improve the along track sounding density. The unintended event actually turned out to be exactly the results that the CHS was hoping to see,

Target #	Target Size (m)	Horizontal Diff. (m)	THU (m)	Vertical Diff. (m)	TVU (m)
1	0.5	0.106	2.000	-0.096	0.280
2	1.0	0.459	2.000	0.134	0.291
3	0.5	0.352	2.000	0.114	0.289
4	1.0	0.575	2.000	-0.002	0.293
5	0.5	0.495	2.000	0.098	0.291
6	0.5	0.432	2.000	0.072	0.287
7	1.0	0.454	2.000	0.016	0.364
8	1.0	0.158	2.000	0.174	0.372
9	1.0	0.398	2.000	0.114	0.374
10	1.0	0.502	2.000	0.134	0.371

Comparison of known target coordinates to the detected coordinates.

caris ONBOARD

FOCUS ON THE TOUGH STUFF

CARIS Onboard™ automates many of the standard processing steps required in a modern hydrographic survey that not only reduces subjectivity but allows your skilled staff to work on the most important tasks. With the ever expanding volume of data being collected at higher resolutions CARIS Onboard will reduce your data Ping-to-Chart™ timeline.

Built on decades of hydrographic data processing expertise and supported by the highly scalable CSAR framework, CARIS Onboard enables users to process data in near real-time resulting in minimized data conversion and processing times. Designed with autonomous operations in mind, CARIS Onboard will save valuable time so you can focus on the tough stuff.

Contact us about deploying CARIS Onboard on your survey platform.

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TELEDYNE CARIS
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as it proved that CARIS Onboard allowed a remote hydrographer to review survey quality and initiate changes in how the data was being acquired, while the survey operations were still underway.

To validate the performance of the overall survey system, including CARIS Onboard, the trial survey was carried out over the test bed in Patricia Bay, which includes a series of 10 concrete blocks ranging in size from 0.5m to 1.0m. The blocks were placed in water depths ranging from 16.6m to 37.2m in 2011 as part of a collaboration between CHS and The Naval Oceanographic Office (NAVOCEANO) [Hare et. al., 2012]. Over the course of several surveys the position of the blocks has become well established, so for the purpose of validating the real-time system the positions are considered to be known. The detected position of the targets in the real-time surface produced by CARIS Onboard were compared to the known positions, determining whether or not the system could detect and position the target within IHO special order

Given that the results are produced in near real-time, using sound velocity with a previous in time algorithm and real-time GNSS, the comparison provides a reasonable representation of the level of uncertainty that could be expected. Although this method doesn't directly demonstrate the TPU for the system, the positioning of all 10 targets within IHO S-44 special order standards is a good indication that hazards to navigation can be reliably identified and reported through a Notice to Shipping or Notice to Mariners, based purely on a remote connection to the real-time surface being produced by CARIS Onboard.

Conclusion

Remote access and the use of autonomous survey platforms, are outside the normal scope of current CHS operations. Without a means to process the data on the platforms during, or immediately following acquisition, these types of operations will begin to form a processing backlog, creating several negative effects. It could cause detected hazards to remain unidentified for several months. Not having a feedback loop could have serious implications on the quality and quantity of the survey production.

Also, if the delay between acquisition and production becomes too long, it could discourage the essential cooperation by the crew aboard a survey launch or vessel. By automatically processing the raw data on the survey platform in near real-time and making the surfaces available over a remote connection, the concerns related to the lack of feedback loop and ever increasing processing backlog, diminish.

Through the use of software such as CARIS Onboard, the platforms will return from their surveys with datasets that are partially to fully processed, depending on the overall workflow. Additionally by making use of the remote connection, the data can be reviewed while operations are underway maintaining a feedback loop, even without a hydrographer, on the vessel.

References

Hare, R., et. al. (2012). "Establishing a multibeam sonar evaluation test bed near Sidney, British Columbia". *Proceedings of the Canadian Hydrographic Conference 2012, Niagara Falls, Canada.*

Acknowledgements

The authors would like to thank CHS Pacific for assistance with Shoal Seeker mobilization and data collection and CHS Atlantic for assistance with F.G. Creed mobilization and data collection.

Author Biographies

Travis Hamilton has been the Product Manager for CARIS Onboard since 2015. Before working with CARIS he spent several years working in research and industry gaining experience with the operation of, and processing data from, AUVs, subsea positioning systems and swath sonar systems.

Kalman Czotter is currently the Engineering Project Supervisor with the Canadian Hydrographic Service. He has worked as a Field Hydrographer with CHS since 1974. He obtained his Canada Lands Surveyor's commission in 1993. He has authored numerous articles, reports on various hydrographic systems, served as member on the Association of Canada Lands Surveyors – Offshore Committee and represented CHS-Pacific on the CHS National Technical Support Working Group, CHS Standards and Procedures Working Group. His passion lies in developing and field implementing hardware/software solutions for hydrographic acquisition and data preparation tools.

David Dodd PhD P.Eng CLS, joined IIC Technologies in April 2016. His previous positions included a three-year industry exchange with the Canadian Hydrographic Service (CHS Pacific region) and a three-year research and lecturer position at the University of Southern Mississippi's (USM) Hydrographic Science Research Center. Dr. Dodd spent eight years as the director of the USM Master's in hydrographic science program before moving to the research center. He has a B.Sc. and M.Sc. in Surveying Engineering from the University of New Brunswick and a PhD in Marine Science from the University of Southern Mississippi. In his 20 years in the hydrographic community he has worked in academia, government and the private sector. In the private sector he was involved with multibeam surveys, bridge construction, cable lay operations, software development and training, and hydrographic data quality control. He has worked as an adult educator in academia both at the community college and university levels, and he has conducted research in the fields of high-precision GNSS, ellipsoidally referenced surveying, bathymetric LiDAR, MSDI and phase differencing multibeam.

Hélène Leplomb, Marketing and Communication Manager, SBG SYSTEMS

Technology is moving fast with always the "more accurate, cheaper, smaller" dictate. Three years ago, SBG Systems has been able to integrate all those wishes into a single unit: the Ekinox Inertial Navigation System (INS). In 2015, SBG Systems took another step forward with the release of the Apogee, the most accurate inertial navigation system based on the robust and cost-effective MEMS technology. Without export restriction, the Apogee stands as a game changer on the hydrographic market. It provides an unmatched Performance-Price-Size ratio and sets up new standard in the industry.

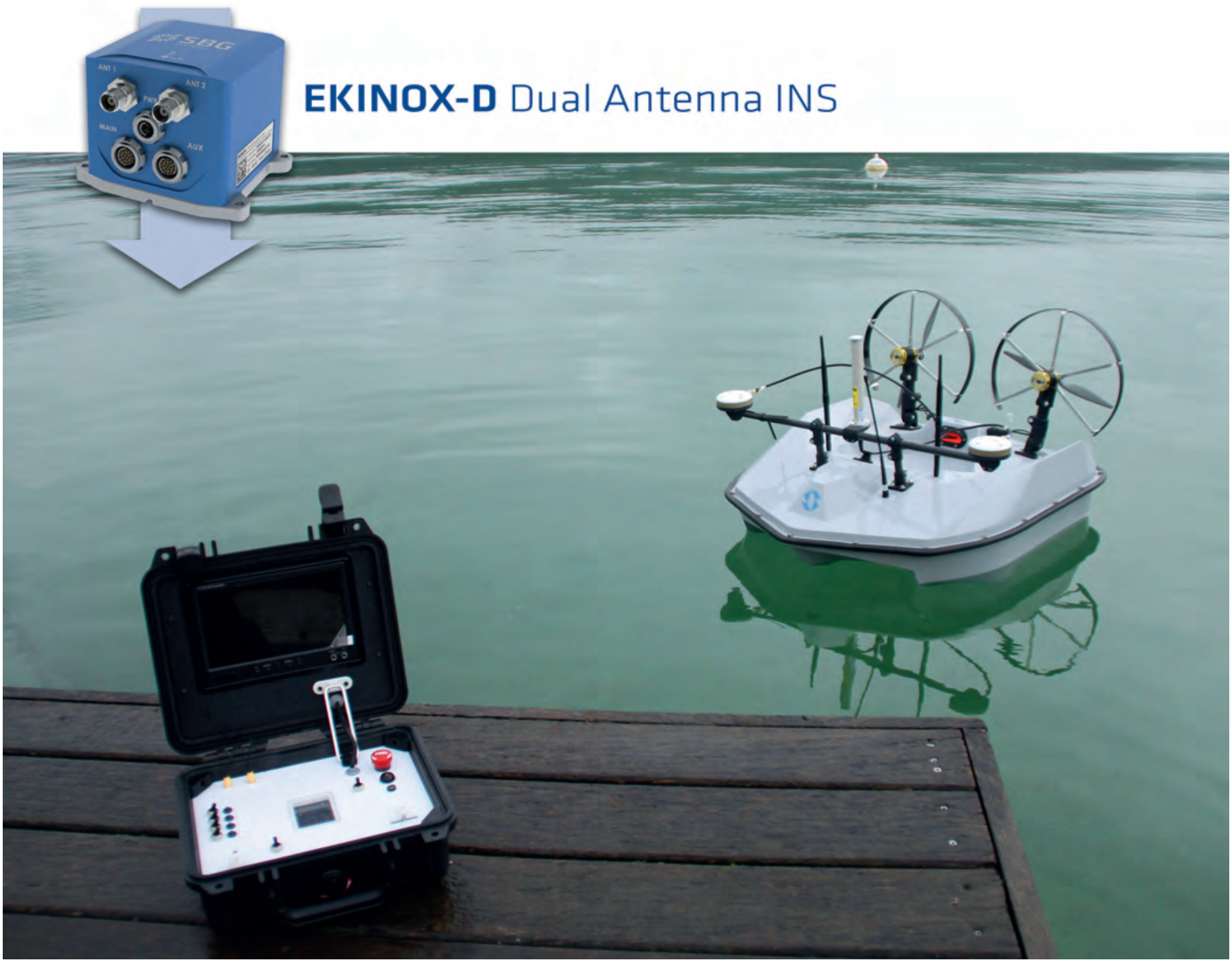
Let's see how MEMS-based inertial sensors can be used in some of the latest technical solutions dedicated to hydrographic surveyors.

UNMANNED SURFACE VEHICLES FOR SHALLOW WATER SURVEYS

USVs allow cost-effective surveys in area where ships could not have been able to collect data, without interrupting traffic for example, or keeping people safe from hazardous areas.

Like most of unmanned systems, USVs have space and power constraints. Ekinox-D is the best INS to be integrated into this type of vehicle. Weighting less than 600 grams and low power (<7W), the Ekinox-D INS integrates an RTK dual antenna GNSS receiver for a centimeter-level position. It provides a 0.05° attitude while delivering a 5 cm real-time heave that automatically adjusts to the wave period.

SPYBOAT® Swan, equipped with a swath bathymetry sonar aided by the Ekinox-D INS



Let's see two examples of integration:

- SPYBOAT® Swan, a USV equipped with a swath bathymetry sonar aided by the Ekinox-D INS

SPYBOAT® Swan is an Unmanned Surface Vessel (USV) fully equipped for hydrographic operations in shallow waters. It is remotely controlled by an operator staying on shore, up to one kilometer away from the USV. Swan conducts bathymetric surveys in areas where vessels cannot navigate such as riverbed, lake, reservoir, dam or harbor. Swan is equipped with a swath bathymetry sonar; requiring motion compensation, true heading, and accurate position data. "We were looking for a compact, precise and cost-effective inertial navigation system. The Ekinox-D was the perfect match", states David Maillotte, CEO of ITER Systems, in charge of the Swan instrumentation. Equipped with a Bathyswath 2, a swath bathymetry sonar; and aided by an Ekinox-D dual antenna GNSS inertial navigation system, the USV provides bathymetric and navigation information in real-time to the operator's tablet PC. Swan is compatible with all hydrographic software.

- Z-boat, a USV equipped with a multibeam sonar aided by the Ekinox-D INS

The Oceanscience Z-Boat is designed with the surveyor in mind. The hull shape, propulsion, radio communication, and on demand sonar instrumentation combine to offer an easy to use and powerful option for the hydrographic surveyor or land surveyor wishing to complete inshore hydrographic work.

The custom integration for the University of Washington Tacoma delivered in May, 2016 included the Rugged Z-Boat 1800RP, SBG Systems' Ekinox-D Inertial Navigation System, Teledyne Odom Hydrographic MB2 Multibeam, Teledyne RD Instruments RiverPro ADCP, a camera and onboard computer. This integration is another proof of the Ekinox-D perfect fit to Survey-based USV operating in shallow waters.

Ekinox-D is the best partner to USV for autonomous navigation, motion compensation and data georeferencing.With an embedded data logger, raw inertial measurements can be stored in the unit and post processed after acquisition to increase the accuracy.

INNOVATIVE SOLUTIONS FOR BATHYMETRIC DATA COLLECTION

Technology is also moving fast on the bathymetric, let's see two examples of innovative bathymetric systems integrating SBG INS:

Oceanscience Z-Boat integrates Ekinox-D INS for the University of Washington Tacoma

- Economic Swath Sonar aided by Ekinox-E

Bathyswath 2 is a swath bathymetry sonar; it measures the depth of the bottom either side of a vessel, which adds up to a "swath" of depth measurements as the boat moves forwards. It also records the strength of the echo, which is used to create a monochrome picture of the bottom, called "sidescan".

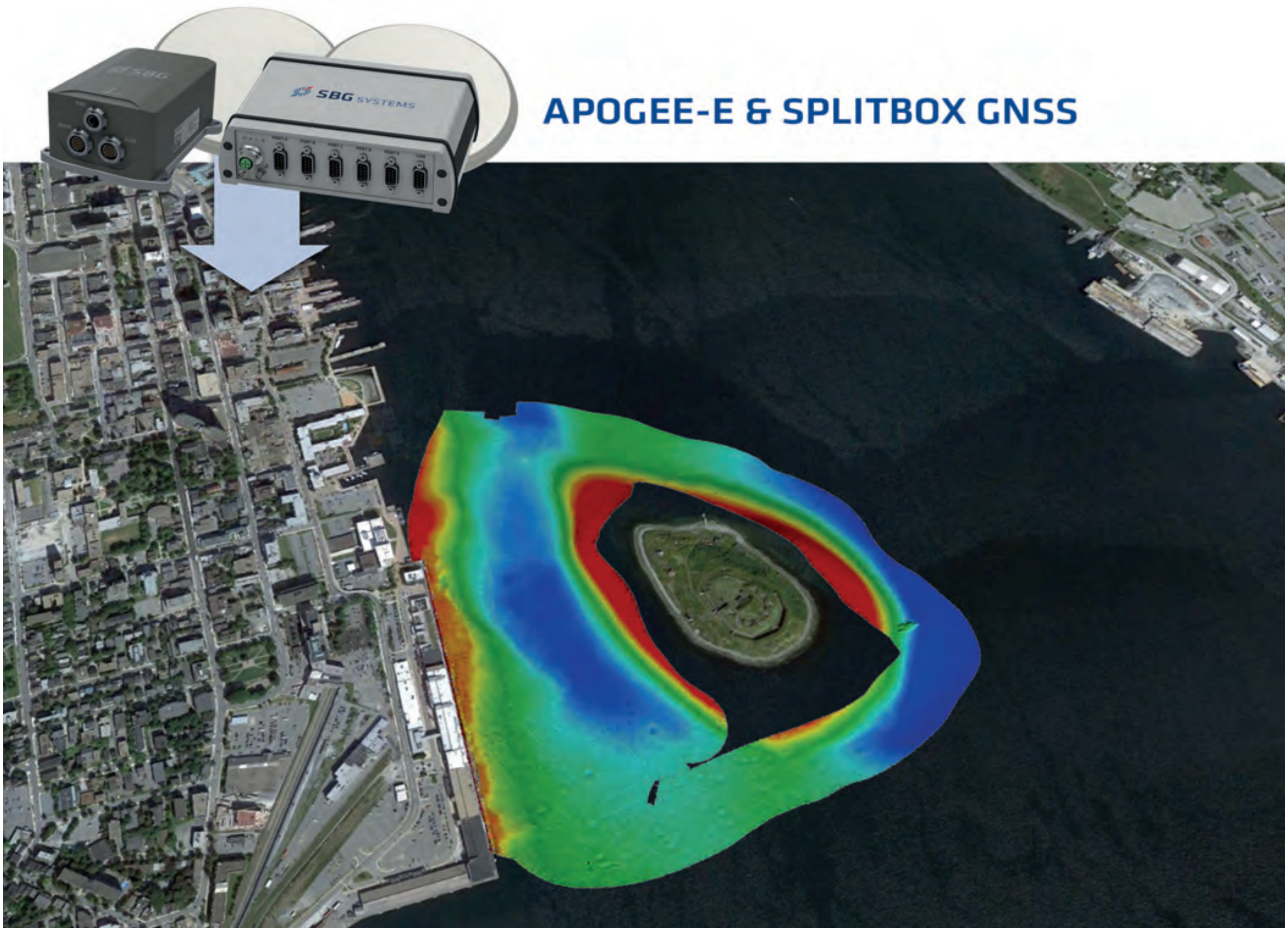
Bathyswath measures depths over a very wide angle, which makes it ideal for use in shallow water, less than 30 meters; typical for rivers and coasts. That gives wider swaths, which means that a survey area is covered in a shorter time. The sidescan images allow small objects on the bottom to be located and identified, and help with assessing what the bottom is made of and what is living there. ITER Systems provides systems that meet international survey specification requirements at a very competitive price. That makes them affordable for smaller organizations and in developing countries, and is important for all in these times of restricted budgets. All swath bathymetry sonars need attitude and GNSS position information, to relate the measurements of the sonar to geographic locations. "SBG Systems INS products are the perfect match; they do a great job at a price that the customer can afford, with a full set of features that make them easy to interface to, set up and use. The algorithms and data timing are better than many more expensive products. The Ekinox product range gives the right mix of price and performance"states Matt Geen, Technical Director at ITER Systems.

- Innovative Edgetech 6205 aided by the Apogee INS

The EdgeTech 6205 SwathBathymetric and Simultaneous Dual Frequency Side Scan Sonar System (EdgeTech 6205) is a combined, fully integrated system that produces real-time high resolution 3D maps of the seafloor while providing co-registered simultaneous dual frequency side scan and bathymetric data. The high number of channels employed by the system enables enhanced rejection of multi-path effects as well as reverberation and acoustic noise.

Traditionally, survey efforts involving the acquisition of both side scan imagery and seafloor bathymetry require the deployment of two sensors. Using a combined system significantly reduces the time to complete surveys that require both data sets. Since the side scan is directly co-registered with the bathymetric point data, there is no down time trying to render the two sets together.

Data set collected with an EdgeTech 6205 aided by an Apogee-E and SplitBox GNSS during the CHC demonstration



In May 2016, Echo81 representing EdgeTech for North America has used the Apogee-E Inertial Navigation System during the Canadian Hydrographic Conference in Halifax, Canada. "I was really impressed by the quality of the data and the ease-of-use of the Apogee solution", declares Damon Wolfe, CEO of ECHO81.

Apogee-E INS achieves 0.008° in roll and pitch in real-time, and reaches 0.005° in post-processing. Like the Ekinox, it comes with a unique delayed heave feature with no additional software or user action. This specific algorithm allows a more extensive calculation, resulting in a heave accurate to 2 cm displayed in real-time with a little delay.

For this demonstration, Apogee-E is coupled with the SplitBox GNSS. Especially designed for hydrographic applications, the SplitBox GNSS is a simplified interface for easy connection and synchronization with external equipment such as echo sounder, computers, etc. It integrates the latest generation of tri-frequency GNSS receiver to deliver navigation data with a large choice of positioning services (Marinestar, TerraStar, RTK, etc.). Sharing the same protocol than the Ekinox, Apogee is compatible with the main hydrographic software such as QINSy, Hypack, Teledyne PDS2000, or SonarWiz (software used during this demonstration).

INNOVATIVE HUMAN TO MACHINE INTERFACE

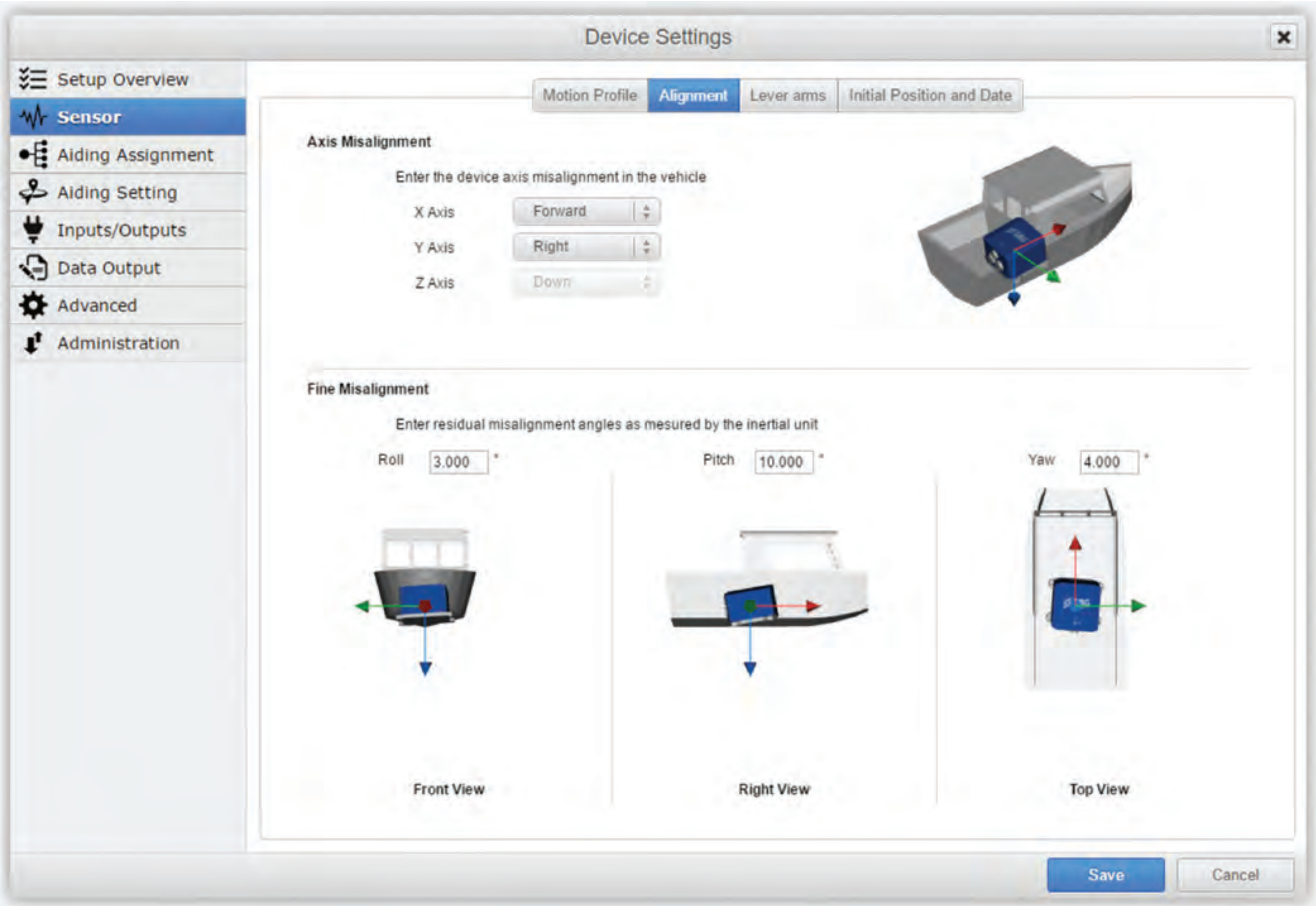
On the field of hydrography, innovation can also be found in the software design. By listening closely to hydrographic surveyors, the SBG R&D team has been able to customize the web interface. This interface facilitates configuration and mounting by giving a step-by-step process. The 3D visualization check is especially useful for sensor position, alignments, and lever arms. The fastest is the mount, the fastest the job can begin; and accurate mounting and alignment settings provide more accurate data.

Thank you to ITER Systems, CT2MC, ECHO81, and Ocean Sciences for their kind participation.

More information:

SBG Systems **www.sbg-systems.com**
ITER Systems **http://bathyswath.com**
CT2MC **http://www.spyboat-technologies.com**
ECHO81 **https://www.echo81.com**
Ocean Sciences **http://oceanscience.com**

Ekinox and Apogee shared web interface



EDITORIAL CALENDAR

Month/Edition	Features		Bonus Distribution
January/February Underwater Vehicle Annual: ROV, AUV & UUVs Ad Close: 01/21	Market: Technical: Product: Special Report:	HD Cameras and Sonar for Vehicles Underwater Navigation Scientific Deck Machinery US Navy	
MTR Special Reports: Oceanographic February 2016 Bonus Electronic Edition			Publication Date: February 27, 2016
March Oceanographic Instrumentation: Measurement, Process & Analysis Ad Close: 02/22	Market: Technical: Product:	Subsea Engineering: Complexity of Subsea Field Architecture Oceanology International 2016 Technology Spotlight Sonar Systems & Seafloor Mapping	Oceanology International March 15-17, London Subsea Tieback March 22-24, San Antonio
April Offshore Energy Annual Ad Close: 03/21	Market: Technical: Product:	Seismic Vessels: Streamers & Magnetometers Deepwater Positioning, Mooring & Anchoring Subsea Vehicles and Systems for Pipeline Survey & Inspection	AUVSI May 2-5, Arlington OTC May 2-5, Houston
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June Hydrographic Survey Ad Close: 05/20	Market: Technical: Product:	Comms, Telemetry & Data Processing GPS, Gyro Compasses & MEMS Motion Tracking Interconnect: Underwater Cables & Connectors	
MTR Special Reports: Hydrographic July 2016 Bonus Electronic Edition			Publication Date: July 15, 2016
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October AUV Operations Ad Close: 09/21	Market: Technical: Product:	Harsh Environment Systems for Arctic Ops ROV Technology: Workclass to Micro Systems Underwater Tools & Manipulators	Arctic Technology Conference October 24-26, St. John's
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MTR Special Reports: Unmanned Marine & Subsea Vehicles November 2016 Bonus Electronic Edition
Publication Date: November 7, 2016

Survey Solutions For Challenging Waters: Combining High-Resolution Multibeam Sonar with an ASV

By Josh Grava and Cody Carlson June 4, 2016

A submerged dock lays off the Fort McHenry National Monument, in the Patapsco River, Baltimore MD—and a well-known marked hazard zone. The depth surrounding the object is navigable at depths greater than 30 feet. Just over the hazard, depths are only 5-8 feet, making it impossible for a traditional survey vessel to navigate. We chose this particular location to demonstrate how an ultra-high resolution multibeam sonar can be used in conjunction with a small autonomous surface vehicle (ASV) to obtain a more complete survey of a complex and challenging area.

Figure 1 Hazard area of the submerged dock

The Multibeam

To collect high-resolution bathymetry around the dock, we employed the **Teledyne RESON SeaBat T50-P™ Multibeam Sonar** side-mounted on the US Army Corps of Engineers Baltimore District's survey vessel. An **Applanix POS MV** was used for position, motion, and heading compensation. Data was collected in **HYPACK/HYSWEEP Multibeam data Acquisition Software**.

The SeaBat T50-P, with its extremely high resolution performance, high sounding density, unique adaptive gates, and other performance enhancing tools made it an excellent choice to survey the complicated structure and produce an extremely clean and detailed data set with minimal editing.

The SeaBat T50 was able to operate in the site's water depths with a 150-degree usable swath, translating to 7x water depth swath coverage; all data well within USACE's most stringent requirements when statistically analyzing confidence vs. beam angle limits.

We knew getting soundings on the middle of the submerged dock was going to be a challenge. We employed the SeaBat T50's electronic swath steering and sailed the boat as close to the dock as possible, but we still could not obtain soundings in the middle of the dock. The result was gaps in the data on the target area.

Using point cloud renderings, the following images show different angles and views of the complete MBES data set.

The Remotely Controlled Singlebeam Platform

After completing the multibeam data collection effort, we launched our compact portable **HyDrone™ Catamaran Survey Platform**, integrated with the **HydroLite-TM™ Singlebeam Echosounder Pole Kit**, a **Trimble SPS985 GNSS Smart Antenna** for positioning, along with Seafloor's **Radio Telemetry kit** to send both GPS and sounding data back, in real time, to a

Figure 2 USACE-Baltimore District survey vessel with RESON SeaBat T50-P and portable HyDrone-RCV

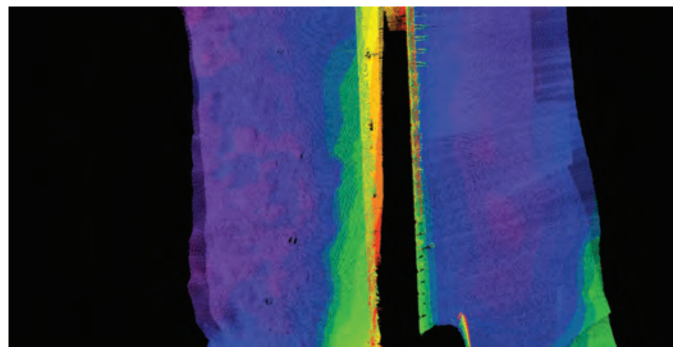

Figure 3 Multibeam image showing missing data in the shallowest sections of the submerged dock

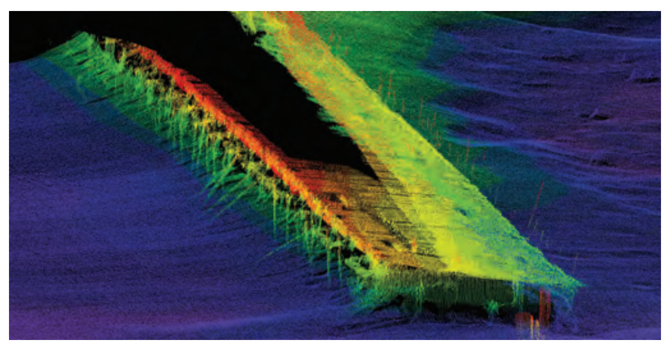

Figure 4 Multibeam image: side view of dock, no singlebeam. Dock is broken away from pilings on the right, and slanting down. Pilings on the right still present, some penetrate above the water surface. Most pilings on the right are submerged and not visible.

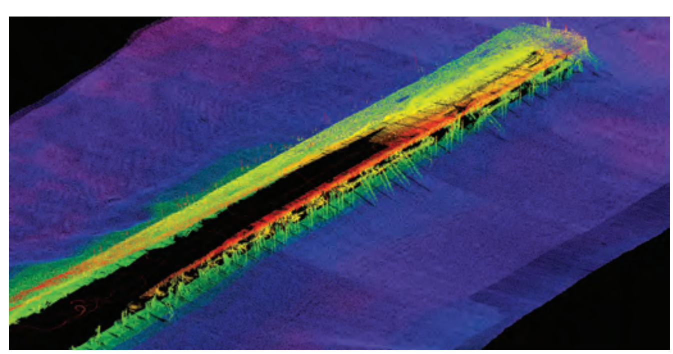

Figure 5 Multibeam image: side view of dock

laptop running **HYPACK** on the USACE vessel.

The **HyDrone vehicle** is designed and manufactured by Seafloor Systems as a survey platform to integrate our small **HydroLite DFX Echosounder Pole Kit**. This unique system offers the surveyor an ideal tool to access remote bodies of water, rivers with difficult access, or extremely shallow areas where launching standard survey boats or dinghies are not possible.

The HyDrone is ideal to map areas as shallow as 1-2' depth via remote control, or fully autonomously. Seafloor Systems offers these vehicles with our AutoNav™ auto pilot module and Mission Planner Software,which allows the surveyor to pre-program the survey lines and customize waypoint routes that will be executed and surveyed autonomously.

Seafloor Systems also manufactures a larger ASV, the **EchoBoat**, designed to handle a higher payload including a wider variety of sensors, larger dual frequency echosounders, small multibeam and sidescan sonars, as well as acoustic Doppler current profilers (ADCP) or imaging sonars. For this project, we determined the HyDrone-RCV was the better choice due to the shallow depths over the hazard.

The Results

To obtain the missing data over the center of the dock, we operated the HyDrone in remote control mode, successfully navigating free-form contour lines and a center line-pass between the visible pilings and hazard marks.

Despite utilizing an advanced, ultra-high performance multibeam sonar system, employing all its unique features and tool sets, the multibeam was not the complete solution to obtain the full picture of this hazard area. For this situation, we required the assistance of the HyDrone to fill in the gaps and complete the intended survey mission.

Figure 6 Seafloor Systems HyDrone-RCV integrated with HydroLite-TM, Trimble SPS985 GNSS Smart Antenna, and Seafloor Radio Telemetry System

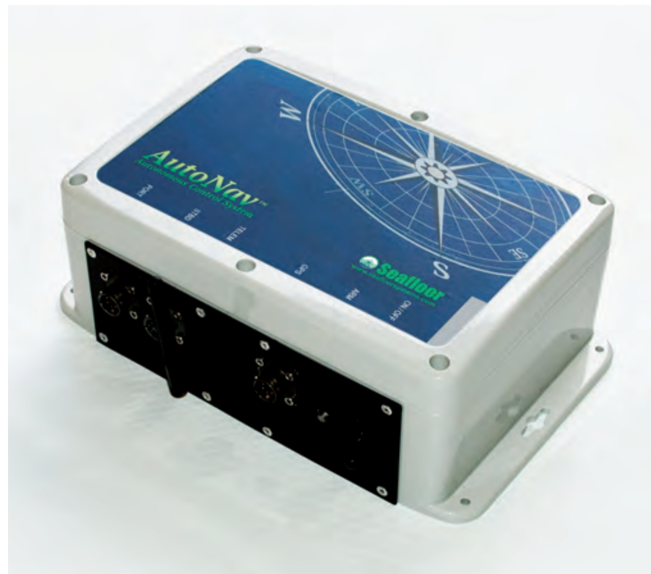

Figure 7 Seafloor's AutoNav™ auto pilot control system integrated on EchoBoat and HyDrone

Figure 8 EchoBoat-ASV™ equipped with a SonarMite DFX™ Echosounder, Trimble GA830 GNSS Antenna, and Seafloor AutoNav™

Creative Problem Solving
Utilizing the most appropriate combination of survey methods to fill in the gaps.
▪ Multibeam
▪ Singlebeam
▪ ASVs / RCVs
▪ Sales & Rentals
Image: Hydrographic survey of a submerged dock located in Patapsco River, Baltimore, Maryland
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For maximum detail, we ran a total of five lines with the multibeam: two parallel lines along each side of the dock in opposite directions (giving the port and starboard beams the same view), and one parallel line to the end of the dock (creating a "U" shape). The **HyDrone** ran a few free-form single beam survey lines in and around the pilings, which can be seen from red dots in the screen shot.

We merged the singlebeam data set with the multibeam data sets into single point cloud, using **HYPACK** software, to obtain a full picture, revealing the submerged dock. The image below represents the TIN model generated based off of 1-foot cell spacing.

Figure 9 Remote controlunit for the HyDrone-RCV

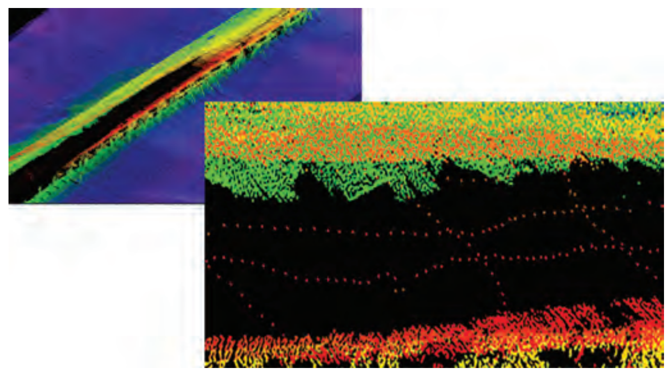
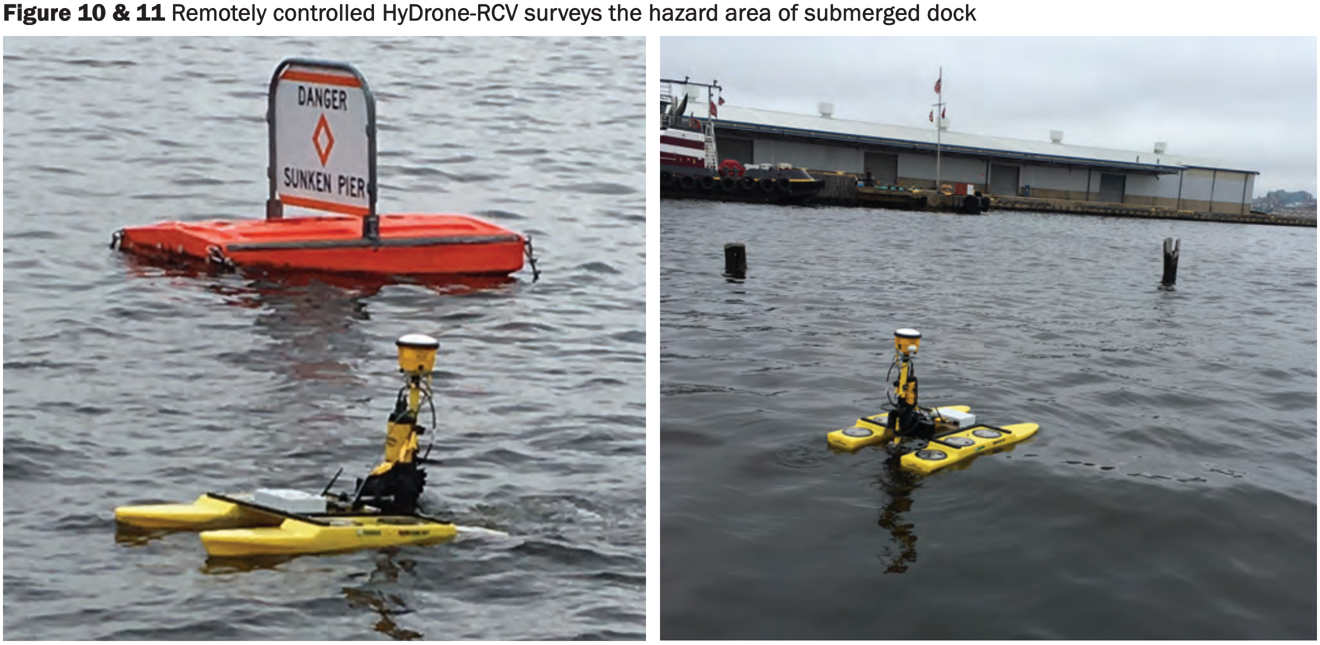


Figure 12 View of dock and close-up view of singlebeam survey lines (red dots) used to fill in the gap of data from multibeam survey

Figure 10 & 11 Remotely controlled HyDrone-RCV surveys the hazard area of submerged dock



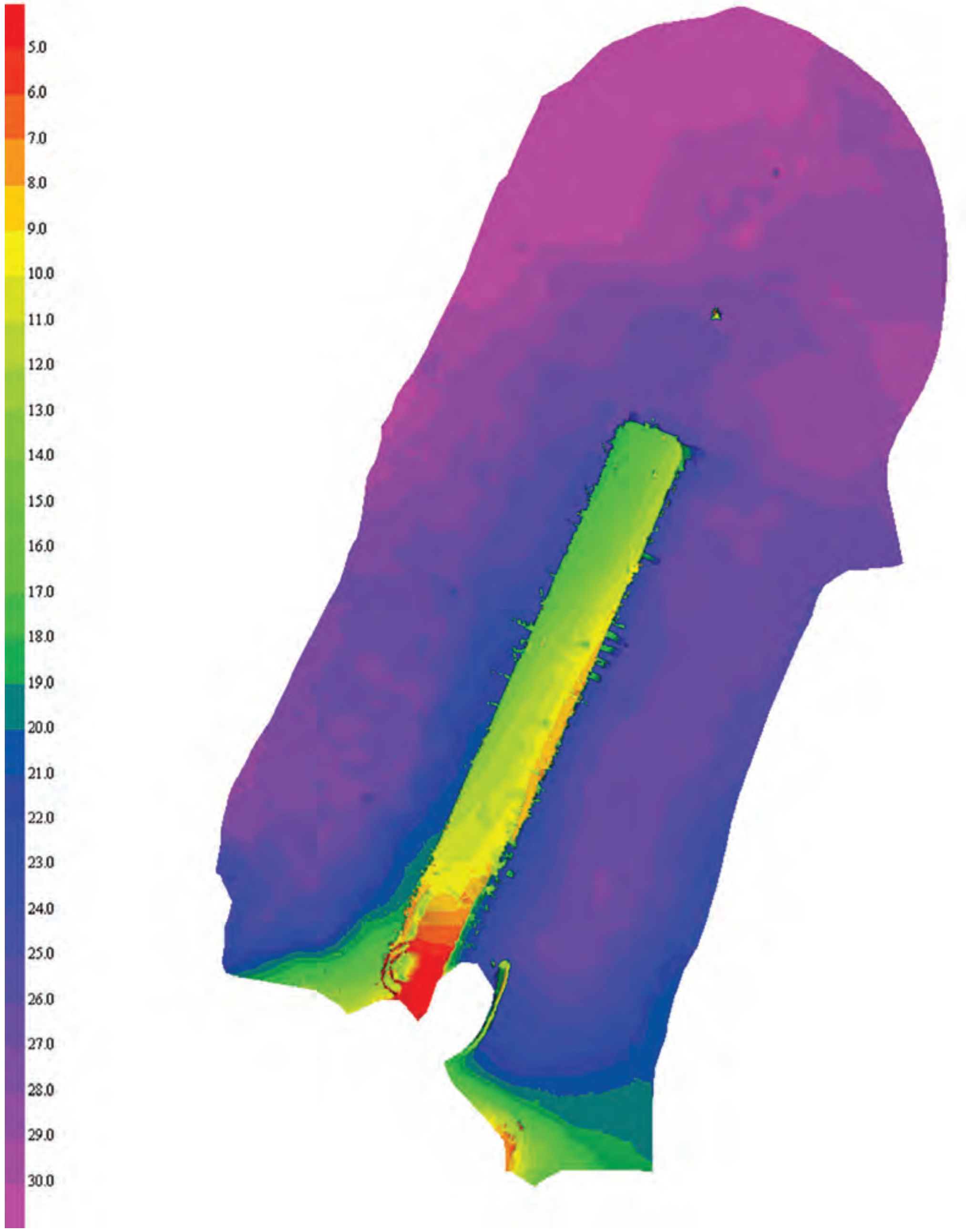


Figure 13 Combined survey lines from multibeam and singlebeam echosounders.

About the Authors

Josh Grava joined **Seafloor Systems** in 2016 as Vice President Sales. He began his career at **RESON** in 1997, directly out ofthe University of California Santa Barbara, as sales and marketing assistant. Within a year, he created a sales manager position for himself with RESON's Transducer and Hydrophone product line, and through dedicated business development, steadily built the program from $10,000/year business to over $1MIL/year. In 2004, he expanded his sales reach within RESON to include the SeaBat Multibeam systems. During the past 12 years with RESON (two years with Teledyne Marine), Josh has managed and grown SeaBat customer accounts in North America, and established solid customer relations within the Multibeam community.

Cody Carlson, Hydrographer, has been with **Seafloor Systems** since 2009, specializing in training and support, integration, calibration, and installation for complete solutions. Cody supports customers worldwide for singlebeam echosounders, multibeam and sidescan sonars, data acquisition/processing, as well as other hydrographic equipment.

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