

Hydro

INTERNATIONAL

THE GLOBAL MAGAZINE FOR HYDROGRAPHY

WWW.HYDRO-INTERNATIONAL.COM



VOLUME 25 | ISSUE 2 | 2021

**Robotics and Automation
Advance the Offshore
Wind Industry**

**Towards a Coastline Base
Map in Indonesia**

**Cable Inspections the
Uncrewed Way**

Creating a 3D Dataset from a USV and UAV Survey

Greener, Faster, Safer.

DriX is a force-multiplier USV able to conduct remote-controlled and supervised autonomous operations. It offers outstanding seakeeping and speed capabilities for high quality data acquisition and subsea positioning in both shallow and deep waters.



iXblue

Hydro INTERNATIONAL

Hydro International is an independent international magazine published six times a year by Geomares. The magazine and related e-newsletter inform worldwide professional, industrial and governmental readers of the latest news and developments in the hydrographic, surveying, marine cartographic and geomatics world. Hydro International encompasses all aspects, activities and equipment related to the acquisition, processing, presentation, control and management of hydrographic and surveying-related activities.



Geomares
P.O. Box 112, 8530 AC Lemmer, The Netherlands
Phone: +31 (0) 514 56 18 54
E-mail: info@geomares.nl
Website: www.geomares-marketing.com

No material may be reproduced in whole or in part without written permission from Geomares. Copyright © 2021, Geomares, The Netherlands
All rights reserved. ISSN 1385-4569

Director Strategy & Business Development: Durk Haarsma
Financial Director: Meine van der Bijl
Editorial Board: Huibert-Jan Lekkerkerk, Mark Pronk, BSc, Marek Smit, Auke van der Werf
Content Manager: Wim van Wegen
Copy Editors: Serena Lyon and Claire Koers
Marketing Advisor: Feline van Hettema
Circulation Manager: Adrian Holland
Design: ZeeDesign, Wilmarsum, www.zeedesign.nl

Advertisements
Information about advertising and deadlines are available in the Media Planner. For more information please contact our marketing advisor (feline.van.hettema@geomares.nl) or go to www.geomares-marketing.com.

Subscription
Hydro International is available bi-monthly on a subscription basis. You can subscribe at any time via <https://www.hydro-international.com/subscribe>. Subscriptions will be automatically renewed upon expiry, unless Geomares receives written notification of cancellation at least 60 days before the expiry date.

Editorial Contributions
All material submitted to the publisher (Geomares) and relating to *Hydro International* will be treated as unconditionally assigned for publication under copyright subject to the Editor's unrestricted right to edit and offer editorial comment. Geomares assumes no responsibility for unsolicited material or for the accuracy of information thus received. In addition, Geomares assumes no obligation for return postage of material if not explicitly requested. Contributions must be sent to the content manager wim.van.wegen@geomares.nl.

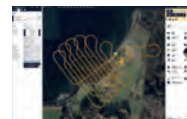
P. 12 Portable ASV for Extremely Shallow Waters

SWAMP (Shallow Water Autonomous Multipurpose Platform) is a new autonomous surface vehicle (ASV) whose design and development forms the foundation for an innovative class of highly modular and reconfigurable lightweight ASVs, expressly intended for operation in remote areas and extremely shallow waters.



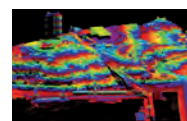
P. 16 Cable Inspections the Uncrewed Way

XOCEAN recently completed 35 cable inspection surveys between the Scottish mainland and Western Isles using a combination of USVs and UAVs. There was a large geographical spread to the project, with operations taking place between 55°N and 58°N and on 25 different islands. Flying the UAVs at low water and sailing the USVs at high water produced a seamless land/sea 3D dataset at the highest resolution that products can produce.



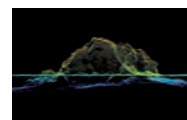
P. 21 Towards a Coastline Base Map in Indonesia

The accuracy of coastline data in Indonesia could be much improved by making use of Lidar bathymetry technology. In this article, the authors describe how Lidar bathymetry survey techniques were applied to a section of coastline in the Sunda Strait.



P. 24 Airborne Lidar Bathymetry in Close Up

RIEGL tested the performance of its topo-bathymetric airborne laser scanning system in a transition zone context along the French Mediterranean coast. Initially planned as a UAV survey, tests were conducted using a fixed-wing aircraft due to the restrictions placed on operations by the ongoing coronavirus pandemic.



P. 32 Robotics and Automation Advance the Offshore Wind Industry

During the life cycle of offshore wind farms (OWFs), operators must maximize the uptime of wind turbines to generate as much energy as possible. As OWFs are constructed further from the coast, maintenance and inspection with crewed vessels becomes increasingly risky, time-consuming and expensive. To overcome this challenge, the industry is turning to remote and autonomous technological solutions that can support OWFs far out at sea.



P. 39 How Early Engagement Can Cut Costs and Enhance Project Outcomes

Acteon, a leading provider of services to the offshore wind industry, is growing, along with the rapidly expanding offshore wind market. The company believes it is important to listen and respond to customers and to get in early on projects to deliver benefits such as new survey methods that increase safety and reduce costs.



P. 5 Editorial

P. 6 Headlines

P. 11 IHO

P. 42 History

Cover Story

The front cover shows the X-04 USV surveying the coastal waters of Scotland. XOCEAN recently completed a campaign of cable inspection surveys between the Scottish mainland and Western Isles. The use of unmanned vessels in marine surveys is increasing rapidly. As well as ROVs and AUVs, which have been in use underwater for some time, we are now seeing a proliferation of vehicles that operate on the surface of the water without a crew.





KONGSBERG

SUS TAIN ABLE OCE ANS

**Kongsberg Maritime is leading the way in
technology for sustainable oceans;**

With the widest range of products in the maritime industry and our world
class 24/7 support, we provide you with the tools needed to operate
responsibly whilst maximizing performance at sea.

kongsberg.com/maritime

Space Exploration Beats Ocean, or Not?

The first news item that I read on Monday morning in the week that this issue of *Hydro International* goes to print was about the stunning performance of an unmanned spacecraft deep in our solar system. The OSIRIS-REx – which stands for Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer – is a NASA spacecraft that, as I read, has just begun its two-year return trip home to Earth. The OSIRIS-REx has left the space rock Bennu, where it had been collecting material from the asteroid.

The unmanned spacecraft has a long flight ahead of it: it is not expected to land on Earth until September 2023, when scientists will start to study the roughly 60 grams of pebbles and dust that the OSIRIS-REx sucked up from the asteroid Bennu in October. This all happened at a distance of nearly 333 million kilometres from Earth, and the asteroid samples were collected in a tray onboard the space probe.

I find this kind of news absolutely exciting as it intrigues me as to how we are able to send a space probe to an asteroid with a mean diameter of only 490m, and even manage to touch down on its surface and collect a sample using an extendable arm. This is the first time that the Americans have collected material from an asteroid; Japan led the way in 2005 with the missions Hayabusa and Hayabusa2.

It seems that our own solar system feels more like home than the deep waters of our own planet. It is often said that we know more about space than our own seas. At first sight, especially for people who are not involved in hydrography or oceanography, we earthlings may seem like fish out of water when it comes to exploring our oceans. However, if we look a bit further below the surface, we see some promising projects that are determined to turn the tide, of which the Seabed 2030 initiative probably stands out the most. This collaborative project between the Nippon Foundation of Japan and the General Bathymetric Chart of the Oceans (GEBCO) aims to gather all available bathymetric data to produce the definitive map of the world's ocean floor by 2030.

The first time in my childhood that my interest was triggered in the underwater world was when I and my brothers explored the ditches around our house, and in particular the species that lived there. We discovered the great diving beetle, the water scorpion, dragonfly larvae

and, of course, we were fascinated by the tadpoles that swarmed in large numbers through the shallow water. Nature documentaries on TV brought the underwater world very close, but just like space it keeps on sparking the imagination, as there is still so much unknown about so many parts of the world's seas. I have always been hugely intrigued by space, but I must say that our oceans pose an endless captivation as well. When I was a school pupil, geography – together with history – was my favourite subject. I have never lost my interest in maps. Maps of the Earth's surface are overwhelmingly detailed, but maps of the bottom of the ocean have some serious catching up to do. Hydrography and all its encompassing technologies are set to make this possible.



▲ Wim van Wegen.

The use of existing and emerging technologies will play a central role in making the Seabed 2030 project a success. Multiple vessels will be equipped with multibeam echosounders, while the rapid developments in remote technology combined with uncrewed vehicles make it possible to map the seafloor thousands of metres below the surface. Modern hydrography will be able to unveil many of the mysteries that today are still hidden deep in our oceans.

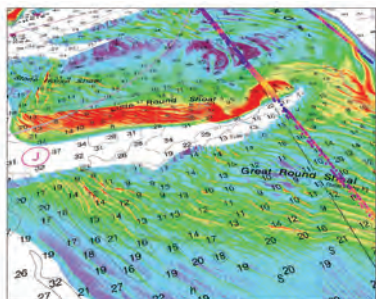
If all goes according to plan, the OSIRIS-REx capsule will land in the U.S. state of Utah on 24 September 2023. Let's see if we have made any progress with mapping the bottom of our oceans by then. I sometimes get the feeling that we will discover extraterrestrial life before we have a good overview of all that is hidden in the depths of our seas; however, the Seabed 2030 initiative will at least provide us with a detailed map of the surface of the underwater part of our world – as 71% of the Earth's surface is water-covered, this would be a milestone and make us feel less like fish out of water.

wim van wegen, content manager
✉ wim.van.wegen@geomares.nl

ADVERTISERS

Saab Seaeye	7	IIC Technologies	34	SBG	20
MacArtney	43	iXblue	2, 29	Sea Machines	10
Blueprint Subsea	9	Klein Marine	28	Teledyne CARIS	8
Seafloor Systems	36	Kongsberg	4	SeaTrac Systems	38
EvoLogics	44	Hypack	28	Valeport	20

TCarta Delivers Bathymetry for U.S. Coastal Mapping Pilot



▲ 2m SDB in Nantucket Sound, MA, produced using WorldView satellite imagery with ICESat-2 tracks overlaid.

TCarta Marine, a global provider of marine geospatial products, has supplied the National Oceanic and Atmospheric Administration (NOAA) with satellite-derived bathymetry (SDB) validated by green laser altimeter data from the NASA ICESat-2 satellite for two U.S. shallow-water coastal areas. TCarta was the subcontractor on the prime contract awarded to Woolpert, an international geospatial firm

headquartered in Dayton, Ohio. The NOAA pilot focused on two shallow-water regions that were 3,000 square kilometres in total area – one in the Green Bay area of western Lake Michigan and the other around Cape Cod and Nantucket Sound. Both areas experience natural forces that alter the underwater terrain faster than traditional bathymetric surveys can be completed.

► <https://bit.ly/2QSAOQH>

Woolpert Selected for Topo-bathy Lidar Collection

The Department of Fisheries and Oceans Canada (DFO) has contracted Woolpert to collect aerial topographic and bathymetric Lidar data and high-resolution, four-band imagery at select sites along the southwest coast of British Columbia. This data, collected with accompanying oceanographic and ground survey information, will support the missions of the Canadian Hydrographic Service (CHS). The data will be used to update nautical charts and provide vital information for marine research and to support indigenous communities. Woolpert is flying this project with its dual port Cessna 404 with the firm's Leica Hawkeye 4X Lidar sensor, navigating water clarity, tide levels and weather conditions. Data are scheduled to be delivered to DFO by the end of June.

► <https://bit.ly/3urWoKn>



▲ Woolpert is flying this project with its dual port Cessna 404 with the firm's Leica Hawkeye 4X Lidar sensor.

Satellite Imagery Reveals Three Decades of Coastal Change



▲ The interactive DEA Maps platform. (Courtesy: Geoscience Australia)

The evolution of Australia's coastlines can now be seen in unprecedented scale and detail, using a new tool developed by Geoscience Australia's Digital Earth Australia (DEA) programme. Using satellite imagery collected since

1988, DEA Coastlines maps annual changes to Australia's coastlines to highlight long-term trends in coastal erosion and growth. The free online tool also illustrates how natural coastal features such as sandbanks or river mouths shift and change over time. Geoscience Australia's National Earth and Marine Observations Branch Head Maree Wilson said DEA Coastlines provides scientists, managers and policymakers with new information to maintain and protect Australia's iconic shores for future generations.

► <https://bit.ly/3h5b91K>

New Survey Company Nicola Offshore Opens for Business

Nicola Offshore, a new company specializing in turnkey services for the most challenging marine survey campaigns and on-demand missions in and around Europe, started operations from its headquarters in Hamburg this month. Working from an agile logistics and technology platform, Nicola Offshore was established to service the more complex and specialist aspects of marine surveying, including underwater object detection, unexploded ordnance (UXO) and subsea cable investigations, as well as pre- and post-dredging reports. The company is a joint venture between Nicola Engineering, a German marine survey provider with over 40 years of experience, and ProMarine, a well-known and highly regarded Dutch workboat manufacturer.

► <https://bit.ly/2PZswG8>

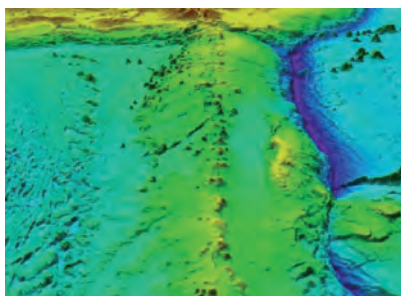


▲ Nicola Offshore's Nautical Explorer.

BIMCO Supports Global Seabed Mapping Initiative

Knowing the depth and shape of the seafloor (bathymetry) is fundamental to our understanding of ocean circulation, tides, sediment transport and environmental change. Currently, and despite many years of effort, less than 20% of the ocean seafloor has been mapped. Therefore, BIMCO supports the Seabed 2030 initiative and encourages the industry to contribute with input to the project via an online survey. In addition to the importance of fundamental knowledge of the seafloor, seabed mapping is equally important from an industry point of view for infrastructure construction and maintenance, cable and pipeline routing and – of course – navigating our ships. A coordinated international effort is needed to bring together all existing datasets and to identify areas for future surveys – in other words, to ‘map the gaps’.

► <https://bit.ly/3nWim5z>



▲ *The Seabed 2030 project is set to bring together all available bathymetric data.*

Hydro 21 Conference and Exhibition



▲ *Cork City Hall. (Photo: Shutterstock)*

The Hydrographic Society UK (THS UK) will be hosting the Hydro 21 conference from 16 to 18 November 2021 at Cork City Hall, Cork City, Ireland. Hydro 21 is the latest in the International Federation of Hydrographic Societies' world-renowned series of hydrographic symposia which date back to 1976. Hydro 21 will incorporate the THS UK postponed Remote Hydrography conference but will be further expanded in terms of papers, an exhibition and aligned events, and will retain the theme of 'remote hydrography'. The speakers that were originally selected have been invited to refresh or

revise their papers, and it is likely that a further call for papers will be issued. THS UK chief executive David Parker said: "Whilst we were very disappointed to have postponed our Remote Hydrography conference twice in 2020, we are now looking forward to delivering an even better event in 2021. Hydro 21 will be a fantastic event that provides the hydrographic community with the opportunity for education and networking."

► <https://bit.ly/2Rz8hiM>

Bedrock Emerges with US\$8M Seed

Bedrock, whose mission is to accelerate our understanding of the ocean, has raised a US\$8M seed round from Eniac Ventures, Primary Venture Partners, Quiet Capital and R7. The new funding will help Bedrock to scale their robotics and cloud software to map the ocean floor in a way that aims to remove the inefficiencies of people and ship-centric acquisition operations. Their goal is to ultimately provide centralized access to the first complete map and database of our oceans at the highest possible resolution. "For over three years, we explored ocean tech as a category of interest. We believe that it is a deeply underinvested sector and that it is ripe for opportunity, given the vast amount of data. When we met Anthony DiMare and Charles Chiau, we knew that we had found the right team. They bridge a necessary technology gap in a way that the industry desperately needs. We are excited to partner with Bedrock to build the category-defining company in ocean mapping and exploration – an enormous market, with few technology players," said Vic Singh, general partner at Eniac Ventures.

► <https://bit.ly/3ep7gms>



▲ *Bedrock Ocean Exploration AUV.*

EMPOWERING

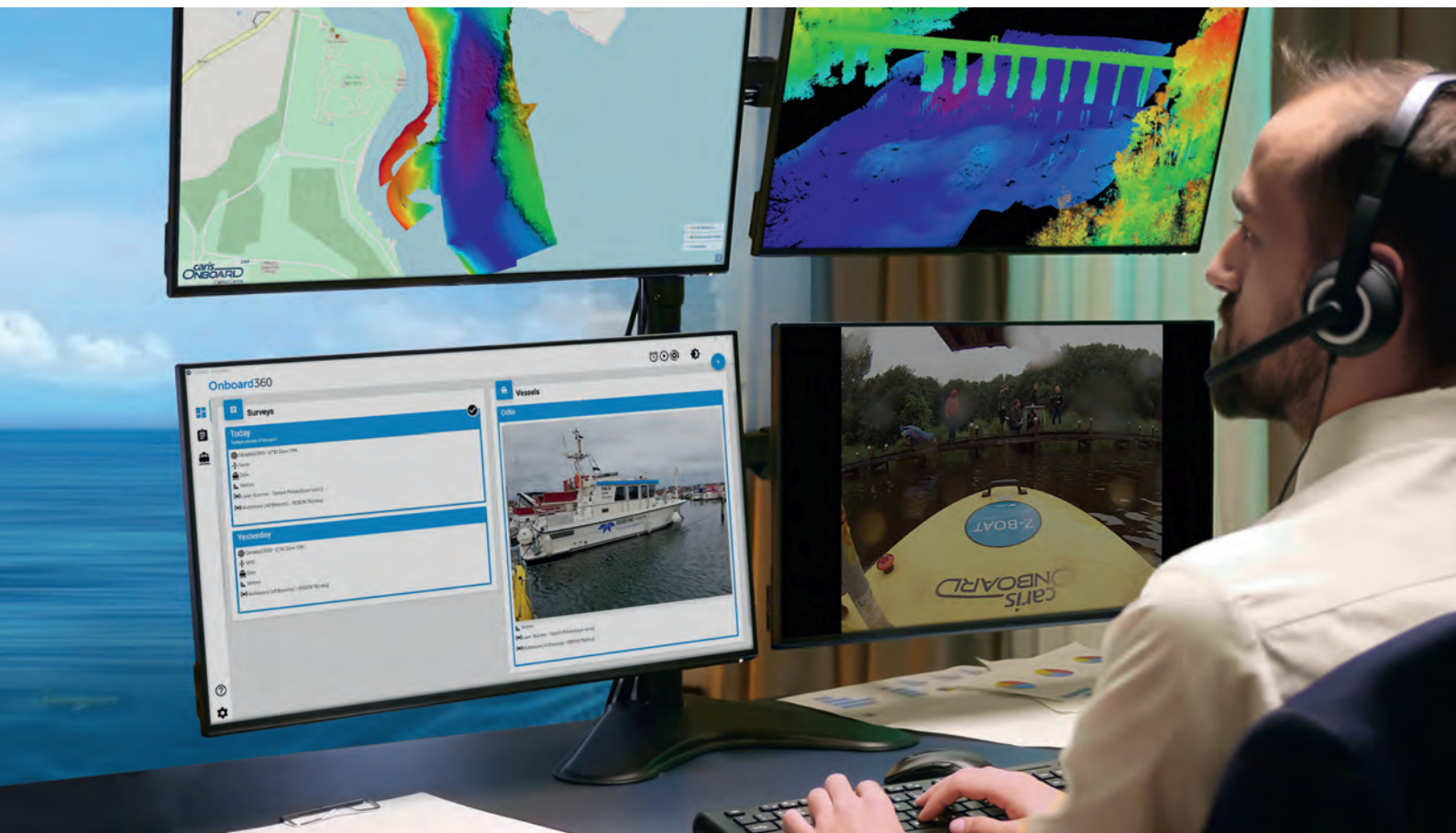
world leader in electric underwater robotics

SAAB SEA EYE



SAAB

COLLECT WITH CONFIDENCE



The evolution of CARIS Onboard has arrived.

Onboard360

Featuring:

- CARIS Collect module for sonar & lidar acquisition
- CARIS Process module for automated processing & QC
- Seamless integration into survey operations
- Complete Ping-to-Chart workflow solution

Available as a perpetual or SaaS annual license

Onboard360 brings the most cost-effective acquisition and automated processing software package to the market.

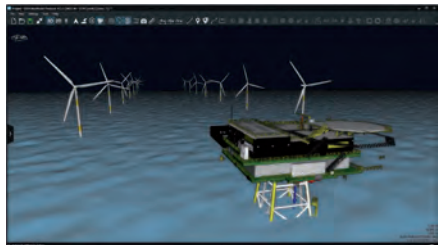


Discover more at
www.teledynecaris.com/onboard360



TELEDYNE CARIS
Everywhere you look™

EIVA Releases Survey Data Software Upgrade



▲ *NaviModel 4.5 supports faster 3D object rendering.*

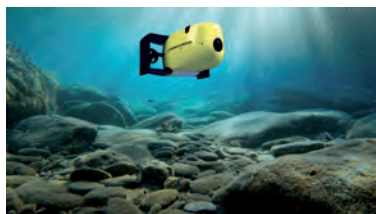
EIVA's software combination, NaviEdit and NaviModel, has undergone a significant upgrade. NaviEdit is the company's software tool for editing survey data, while NaviModel enables the creation of high-performance digital terrain models in 2D and 3D. These two tools go hand in hand, working together across the various NaviSuite software bundles, such as NaviSuite Kuda for hydrographic surveys and NaviSuite Nardoa for pipeline inspections. In these recent updates, EIVA has made a variety of improvements based on the experiences of users of previous versions. The following sections (see URL below) discuss some of the handy new software features, including faster 3D object rendering, new data cleaning and modelling tools, running on cloud services and supporting bin grid data.

► <https://bit.ly/3nXCkNy>

ARL Receives Grant to Develop Seismic Sensor

Autonomous Robotics Ltd (ARL) has been awarded a grant-funded project from OGTC and two European energy companies who have a proven track record using ocean bottom seismic and are keen supporters of technology development. The project is to develop a bespoke seismic sensor to fit in the company's autonomous underwater vehicle solution, Flying Node, and is expected to last 15 months. The grant was awarded as part of OGTC's strategy to work with partners as they transition to a net zero objective and their Offshore Energy 4.0 programme is focused on enabling remotely controlled operations, empowered by data, robotics and autonomous systems.

► <https://bit.ly/3vP4Wep>



▲ *Flying Node AUV.*

New Research Vessel for Schmidt Ocean Institute



▲ *Side-by-side comparison of the Falkor and Falkor (too) research vessels.*

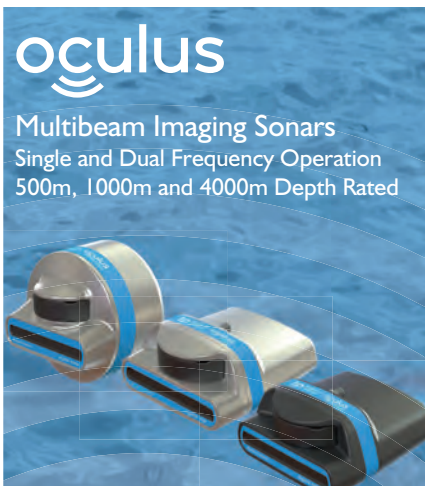
Schmidt Ocean Institute has acquired a new research vessel that will expand the organization's philanthropic science programme and capability to explore the ocean. The new ship is significantly larger and can travel further than Schmidt Ocean Institute's existing research vessel, *Falkor*, which has been operating since 2012 and was the world's first year-round philanthropic research vessel made available for free to scientists. The new vessel was purchased from GC Rieber Shipping ASA as the *Polar Queen* and was built in 2011 as an offshore industry vessel, used most recently to construct offshore wind farms in Europe. The new ship – re-named *Falkor (too)* – is 110m in length, compared to the 83-metre *Falkor*, built in 1980. The new vessel is also ice-rated and can cover more of the globe, extending Schmidt Ocean Institute's reach.

► <https://bit.ly/33pQM7f>



www.blueprintsubsea.com

sound by design



find out more

www.blueprintsubsea.com



“

OPERATE YOUR VESSEL
FROM WHATEVER
LOCATION PROVIDES
THE BEST VANTAGE POINT.

SHANE FAUCHEUX

President, Rio Controls & Hydraulics



Rio has successfully installed multiple Sea Machines systems on US Flag vessels with a growing backlog in 2021.

See how autonomous technology is bringing change to your sector at **Sea-Machines.com**.

International Cooperation as Basis for Suitable Provision of Hydrographic Services

Mankind's written history is full of stories about our coasts and seas. Homer's Iliad, for example, contains reports on the dangers and challenges of a ship's voyage, while Christopher Columbus not only shared his impressions of the New World with his contemporaries, but provided many details on how to get there. The cartographers of the Renaissance, sitting in their scholarly cabins, created a new image of the world that was largely based on reports received from the great explorers. James Cook surveyed water depths with accuracy, described spots to anchor safely, and noted bearings to landmarks for the convenience and safety of those who would visit those places after him. But were these examples of international cooperation in hydrography? Certainly not, as in those times a seaman's geographic knowledge (no one called it 'hydrography') represented power and advantage for those in the know, so knowledge was generally not shared.

It was in the beginning of the last century that the call of maritime nations to better share information, agree on preventive measures and introduce technical standardization led to focused attention on the need for international cooperation in the delivery of hydrographic services – and in particular the improvement and standardization of nautical charts.

On 21 June, it will be exactly 100 years ago that representatives of 19 nations on 4 continents established a new organization that focused on promoting hydrography. A particular aim for the new-founded International Hydrographic Bureau (IHB), later the International Hydrographic Organization (IHO), was to achieve global uniformity in nautical charting. This eventually resulted in the adoption of metric units, standardized symbols and colours, and coordination in scales and paper sizes. Matters such as precise position fixing and the provision of nautical information such as sailing directions were also on the agenda.

In 1921, there was no such organization as the International Maritime Organization, so the IHB also took on the task of establishing recommended routes, and there was no World Meteorological Organization, so the IHB compiled and promulgated lists of stations that provided storm warning signals and undertook detailed studies of the various descriptions of the wind force at sea, leading to the adoption of the standardization known as the Beaufort scale. There was also no Intergovernmental Oceanographic Commission, so any coordination on measuring tidal streams or ocean currents was done by the IHB. However, as these bodies came into existence, the IHB relinquished the roles and tasks that were then logically part of the new organizations. This formed the foundation for long-standing and successful cooperative relationships with these organizations.

The world fleet of commercial vessels has continued to grow inexorably. To satisfy this growth in international shipping, the IHO has continuously moved to improve hydrographic services to facilitate better coverage, higher accuracy and up-to-date nautical charts. In that regard, by the early 1980s it had become obvious that paper-based media might no longer be the best way to satisfy these requirements.

The need for uniform global coverage of what are now 'electronic' charts initiated a paradigm shift whereby each coastal state was called upon to accept responsibility for the systematic survey and charting of the waters under its jurisdiction. Meeting the charting needs of international shipping has been one central focus of the IHO since its beginning; however, the constant increase in requests for customized hydrographic products from a growing community of stakeholders is now leading hydrographic offices to move towards becoming data-centric service providers rather



▲ *Mathias Jonas.*

than just nautical chart publishers. Moreover, the focus of the United Nations on global geospatial information management as a means of supporting sustainable development and environmental protection has only increased the need for IHO Member States to adapt.

Over the last 100 years, international cooperation in hydrography has matured organizationally and technologically. While many of today's arrangements have been subject to lengthy discussion over the years, they are now taken for granted. The IHO has provided the forum, the protocols and the standards for achieving effective and beneficial international collaboration. As a result, hydrography is one of the very few technical disciplines in which standards and the levels of international and intergovernmental cooperation are truly and consistently implemented at the global level.

There is a well-known truism that the seas and oceans know no boundaries. The IHO has worked and will continue to work in accordance with that axiom as it moves forward into its second century of activity. ◀

A Modular and Lightweight Solution for Multipurpose Surveys

Introducing a Portable ASV for Extremely Shallow Waters

SWAMP (Shallow Water Autonomous Multipurpose Platform) is a new autonomous surface vehicle (ASV) whose design and development forms the foundation for an innovative class of highly modular and reconfigurable lightweight ASVs, expressly intended for operation in remote areas and extremely shallow waters. Its design is based on a holistic approach involving different aspects of robotics: the use of innovative and soft materials to protect the propulsion system, electronics and sensors; the design of pump jet propulsion modules contained within the hull; and a modular hardware/software architecture for a multi-agent distributed guidance, navigation and control (GNC) system.

Coastal waters, swamps, lakes and rivers with their mouths and deltas and tidal freshwaters, generally known as wetlands, are considered to be an important natural resource that require continuous protection and monitoring. Various national and international directives, laws and conventions focus on wetland protection, monitoring and maintenance. Regional administrations are often obliged to perform environmental monitoring in these areas, and the acquisition of data to map wetland ecosystems and to assess their change over time represents a key step in their environmental protection. Nevertheless, the number, quality and spatial resolution of surveys

in these environments are limited by a lack of suitable tools. In this framework, the use of robotic-aided solutions can increase the precision and the quality of the surveys and enable the performance of tasks in areas where access is dangerous or difficult. Because water sampling, limnological surveys, bathymetric analysis and water quality monitoring are complicated by difficulties in accessing extremely shallow waters, the use of traditional ASVs results in approximate and inefficient surveys. Most research results point to the lack of hydrographic vessels capable of carrying out measurements in shallow waters at depths of less than one metre.

A SOLUTION FOR EXTREMELY SHALLOW WATERS

SWAMP arises from the idea of creating a portable robotic tool for carrying out operations in wetlands. The first prototype was designed and built in the framework of a cooperation between the Institute of Marine Engineering of the Italian National Research Council (CNR-INM) and the Electrical, Electronics and Telecommunication Engineering and Naval Architecture Department of the University of Genoa (DITEN-UNIGE), to find a solution for the problem of extending operations into extremely shallow waters.

REQUIREMENTS

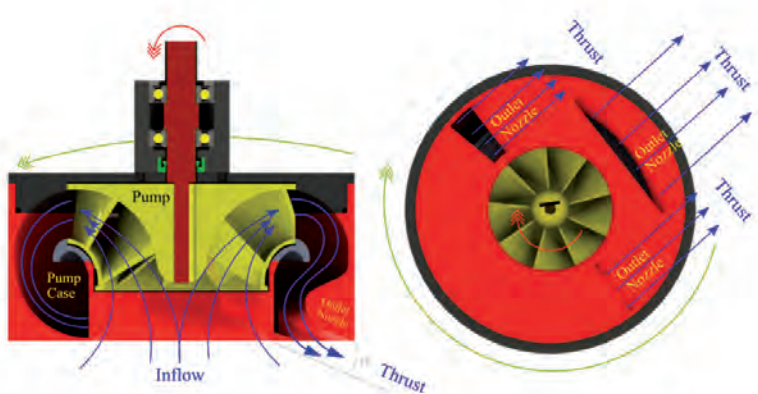
The SWAMP design arose from the idea that a vehicle for extremely shallow waters should meet a number of requirements, in addition to standard ASV requirements. In particular, the vehicle needed to be modular so that it could be used for multipurpose surveys. To achieve this, it needed to have an open hardware and software architecture, to make it possible to easily mount different payloads in different working configurations. A catamaran-like structure with a high payload area was therefore thought to be a good idea. Furthermore, as access to some wetland areas is only possible by foot or with a small car, or by boat or helicopter, the vehicle needed to be compact and easily transportable by hand. Moreover, it needed to be able to access restricted spaces



▲ The SWAMP vehicle in operation in extremely shallow water with a single beam sonar payload.



▲ The SWAMP propulsion system layout.



▲ Working principle of the pump jet.

with good controllability and to carry out sampling in the presence of external disturbances (current and wind) and for at least two to four hours. The propulsion units also needed to be able to operate in very shallow waters without the risk of damage, for example from grounding, vegetation or ice. In many cases, it is the adoption of inadequate propulsion units that reduces the operative area of vehicles ("I won't go there because I don't

between 0.7m and 1.25m. The hull height is 0.4m and the vehicle including structure and antennas is 1.1m high. SWAMP is lightweight at 38kg and has a draft of 0.1m. The standard maximum payload is 20kg with a maximum design draft of 0.14m, but the reserve of buoyancy allows SWAMP to take on up to 60kg with a draft of 0.22m. The small dimensions of the vehicle comply with the idea of a reduced logistics. The hull shape is inspired by the

allows the vehicle to survive in the case of impact and protects sensors and tools present inside the hull. Moreover, the closed-cell foam gives a high reserve of buoyancy.

The propulsion choice fell on a modular propulsion unit based on pump jets that can be easily installed on the vehicle and that contain all of the electronic control boards. Such a solution also allows the removal, if necessary, of some of the thrusters and/or their substitution with sensors, tools or even other thrust units. Using four azimuth thrusters gives SWAMP the controllability that is required for high-quality surveys. The vehicle also has path-following and dynamic positioning capabilities.

The pump jet operates on the principle of a vertical axis pump and produces thrust through a nozzle contained in the silhouette of the hull. Compared with classical water jet propulsion, the pump jet is characterized by lower operative speeds, higher structural integrity due to the total integration in the hull, and higher manoeuvrability thanks to 360° steering ability. The main advantage of using pump jets is the maximum thrust at minimum draft, and the fact that they can be used as a main thruster and manoeuvring thruster.

One of the main characteristics of SWAMP is that each hull is conceived to be a single vehicle with its own propulsion, GNC unit and power system from a Li-ion battery. Each monohull results in an ASV in itself and, thanks to the azimuth thrusters, is also highly controllable. Moreover, the intelligent core of each vehicle controls the monohull but is able to take over the control of the entire vehicle in the event of failure of the other core. This possibility is guaranteed by the existence of a

SWAMP was developed in response to a perceived lack of a light and portable robotic vehicle able to easily access extremely shallow waters

want to lose the vehicle"). In addition, since the vehicle might be deployed in harsh environments, the hull structure, the system of propulsion and the sensor supports were designed and built taking into account the possible impact of the vehicle with stones, shores, roots or other objects that can damage a fragile structure, with consequent loss of the vehicle or damage to the sensors. Finally, the vehicle itself had to have a minimum impact on the surveyed environment, requiring the use of inert materials, electrical power and reduced noise levels.

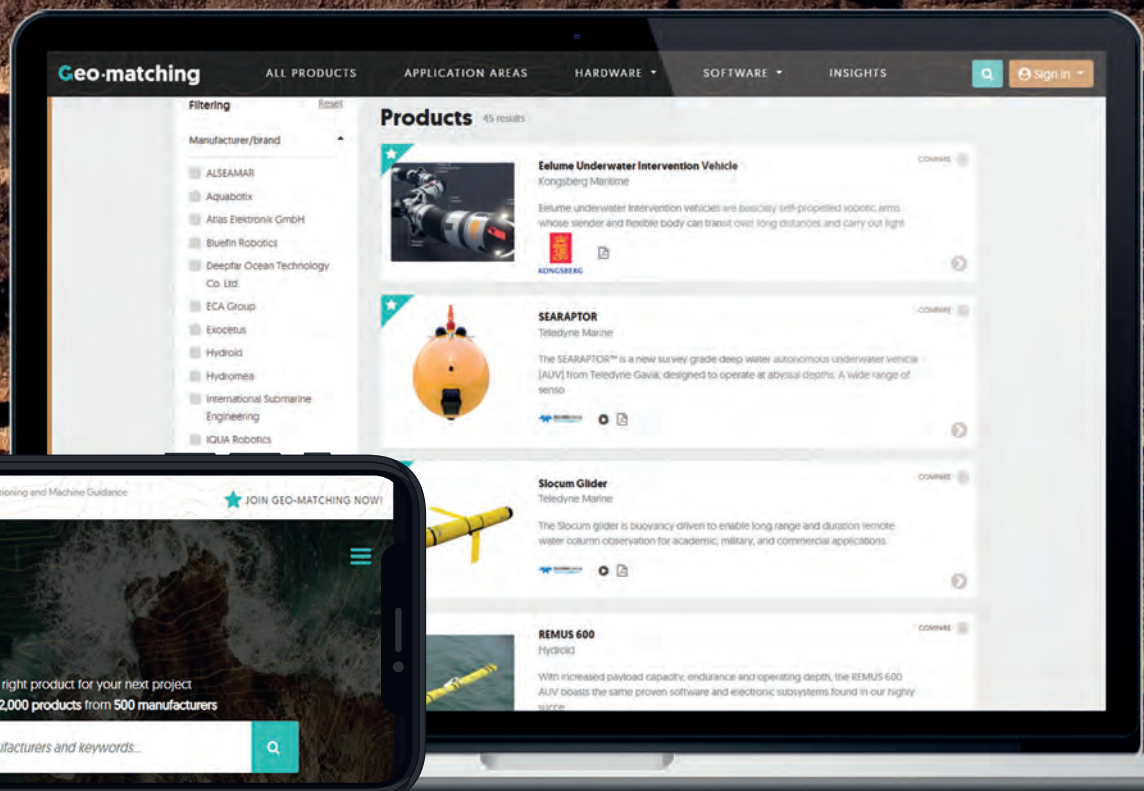
VEHICLE DESCRIPTION

The SWAMP vehicle was designed to find a good balance between all of the requirements. SWAMP is a fully electric catamaran, 1.23m long with a design breadth of 1.1m that, by adopting a sliding structure, can be varied

double-ended Wigley series but with a flat bottom. The double-ended hull form and propulsion system is characterized by equally efficient sailing ahead and astern, with the possibility of manoeuvring in narrow spaces. The hull configuration shape was chosen both for hosting four pump jet type 360° azimuth thrusters expressly designed and studied for this project, and to create an innovative structure. Indeed, one of the main characteristic aspects of SWAMP is its light, soft and impact-survival flexible structure made with a sandwich of soft closed-cell HDPE foam, HDPE plates and pultruded bars. With this design, SWAMP is a completely modular vehicle that can be dismantled and transported to be remounted in various possible configurations. This design allows it to host various types of tools, thrusters, control systems, samplers and sensors. The soft hull

Geo-matching

Your Product Platform for Surveying, Positioning and Machine Guidance



Search and compare

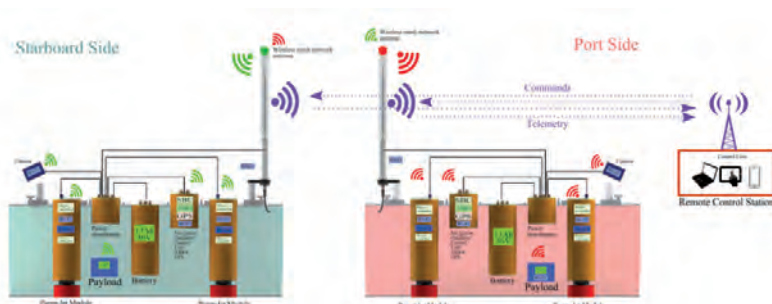


Get insights



Connect

www.geo-matching.com



▲ The hardware control system and the architectural scheme of SWAMP.

distributed, Wi-Fi-based communication architecture.

The SWAMP hulls were tested, also in shallow water, in the DITEN-UNIGE towing tank at various depths, payloads and breadths. The maximum speed of SWAMP at maximum payload in deep water is 1.6m/s, while the speed in extremely shallow waters down to 200mm (i.e. 60mm of under-keel water) is reduced to 1m/s due to the change in hydrodynamic characteristics in shallow waters.

The software architecture of SWAMP is based on COTS (commercial off-the-shelf)

requirements were listed in the initial stage of design with a 'requirement-based' project, and in the end all of these requirements were met. The vehicle and its control unit are portable, its dimensions comply with small size and shallow water, and the vehicle is easily deployable. Its structure can withstand external loads and impacts and the propulsion system is suitable for working in extremely shallow water. Moreover, the vehicle is modular and reconfigurable, also in its hardware and software architecture. This concept is important, not only to comply with the various tasks that it may carry out, but also for satisfying the different requirements coming from the same mission.

The SWAMP vehicle can work autonomously with the help of the GPS, IMU and other sensors mounted onboard

components. One of the main hardware innovations introduced in SWAMP is the elimination of most of the required wiring by reducing the number of wires to just the ones used for power connections. The basic GNC package of each hull is composed of an IMU and a GPS. Communication is guaranteed by one communication module present in each hull that provides a communication framework for both its own hull and for the other hull modules when required.

The SWAMP vehicle can be remotely controlled and can work autonomously with the help of the GPS, IMU and other sensors mounted onboard.

CONCLUSION

SWAMP was developed in response to a perceived lack, identified through interactions with stakeholders, of a light and portable robotic vehicle able to easily and efficiently access extremely shallow waters. The operational

The vehicle is also fully controllable thanks to its four azimuth thrusters.

As a collateral result, although the vehicle was studied to solve the problem of monitoring wetlands, the SWAMP class of ASVs will be able to support, as a test bed, research in various aspects of marine engineering and robotics, such as propulsion systems, mechanical structures, artificial intelligence, cooperative distributed controls, GNC systems and innovative technological solutions in terms of communications, materials, sensors and actuators.

ACKNOWLEDGEMENTS

Special thanks go to Marco Altosole, Marco Bibuli, Giorgio Bruzzone, Roberta Ferretti, Mauro Giacomelli, Edoardo Spirandelli, Michele Viviani and Enrica Zereik, who played an important role in the design, development and field testing of the SWAMP vehicle. ◀

References

- A. Odetti, G. Bruzzone, M. Altosole, M. Viviani, and M. Caccia. Swamp, an autonomous surface vehicle expressly designed for extremely shallow waters. *Ocean Engineering*, 216: 108205, 2020. ISSN 0029-8018. doi:<https://doi.org/10.1016/j.oceaneng.2020>
- A. Odetti, M. Altosole, M. Bibuli, G. Bruzzone, M. Caccia, and M. Viviani. Advance speed-hull-pump-jet interactions in small ASV. In *Proceedings of 12th Symposium on High Speed Marine Vehicle (HSMV) Conference*, Naples, Italy, Volume 1. IOS Press, 2020
- A. Odetti, M. Altosole, G. Bruzzone, M. Caccia, and M. Viviani. Design and construction of a modular pump-jet thruster for autonomous surface vehicle operations in extremely shallow water. *Journal of Marine Science and Engineering*, 7(7):222, 2019

Videos:

- Roja River (Italy) survey with SWAMP:
<https://youtu.be/cedv-E-M79U>
- BTS sea trials:
<https://youtu.be/ccKQ4c03ylo>
- Towing tank trials on SWAMP hull:
<https://youtu.be/DHTdHpaEtKM>
- Citizen engagement in science and engineering experiment:
<https://youtu.be/nozHpp1TneQ>



Angelo Odetti, PhD, Marine Engineer and Naval Architect

With experience in air cushion technology, Angelo Odetti joined CNR-INM in 2013. His research is

based on the development of new concept vehicles for access in remote areas. He is the designer of the hybrid (ROV-AUV) e-URoPe, P2ROV and PROTEUS vehicles, and the ASV SWAMP and samplers, tools and actuators.



Gabriele Bruzzone, Senior Researcher

Gabriele Bruzzone received a degree with distinction in Electronic Engineering from the University of Genoa in 1993. Since 1996, he has

been working as a researcher at CNR-INM, and as a senior researcher since 2010. In 2015, he became head of the Marine Robotics research group.



Massimo Caccia, Senior Researcher

Massimo Caccia's research focuses on the design, development and application of cooperative unmanned marine vehicles. He is currently prime

investigator in the EMFF-EASME Blue RoSES, Interreg Maritime Italy-France MATRAC-ACP and PON ARES projects.

Creating a 3D Dataset from a USV and UAV Survey

Cable Inspections the Uncrewed Way

XOCEAN recently completed 35 cable inspection surveys between the Scottish mainland and Western Isles using a combination of Uncrewed Surface Vessels (USV) and Uncrewed Aerial Vehicles (UAV). There was a large geographical spread to the project, with operations taking place between 55°N and 58°N and on 25 different islands. Flying the UAVs at low water and sailing the USVs at high water produced a seamless land/sea 3D dataset at the highest resolution that products can produce. The project was completed within a six-week time frame.

EQUIPMENT

Two USVs were used to complete the survey campaign: X-04, an XO-450 class USV, and USV Harry. X-04 is a 4.5m catamaran vessel powered by a 5MaH battery that is kept topped up by a small diesel generator that uses only 9 litres of diesel per day. USV Harry is a 2.5m USV that is powered by a total of 3MaH batteries only. X-04 was used to survey the more exposed and longer

cables, while USV Harry surveyed the very shallow and the easier-to-access cables.

X-04 was equipped with a new Norbit Winghead i77h 0.5-degree multibeam echosounder complete with an Applanix POS MV IMU. USV Harry was equipped with an R2Sonic 2020 multibeam echosounder and again with an Applanix POS MV IMU. Valeport Swifts were

used on both USV winches for sound velocity casts. Both USVs used QPS QINSy to acquire the data and to provide information to the USVs' autopilot to steer them along the survey lines. Bathymetry, backscatter and sidescan were acquired from each multibeam system.

Two senseFly eBee X UAVs, one equipped with a S.O.D.A. 3D camera and one with an AeriaX



▲ X-04 surveying near the Isle of Arran.

camera, were used to acquire the topographic data. Bathymetry was also extracted from the UAV dataset in the very shallow water, using the QPS Qimera SfM refraction algorithm to enable it to match the USV bathymetry. Both cameras are designed purely for UAV use and have 20 MPs and 24 MPs respectively. The datasets from the UAVs use PPK positioned imagery, which is then processed using Pix4D Mapper.

METHODOLOGY

The USVs were transported by trailer, which meant that it was very quick to move from island to island and, most importantly, that they weren't affected by weather in the way that a traditional survey vessel would be. This was also achieved using very little fuel (just 4x4 vehicles). The USVs could be deployed on cables that were sheltered, which meant that the project was affected by very little weather downtime, especially given that it was performed in winter.

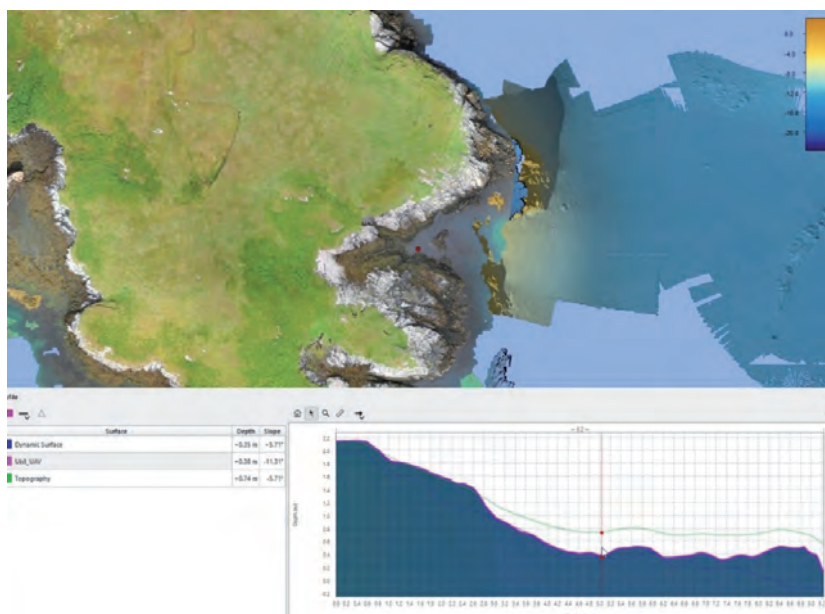
If time and conditions allowed, the UAV was flown before the USV sailed. The UAV data was rapidly processed to produce an orthophoto and LAS files to show the extent of the UAV data coverage but also, and more importantly, to show where the dangerously shallow areas were for the USV to avoid during its survey. The UAV was flown at two altitudes in one flight: 119m and 75m. The two imagery datasets were combined to give the highest possible resolution, with the higher flight used to provide longitudinal overlap to ensure enough key point matches could be identified by the software. The eBee X UAV with the new endurance batteries allowed the UAV to fly for approximately 1 hr 15 mins in good conditions and 40 mins in 12m/s wind speed (the maximum in which it can fly). If in mobile phone range, RTK corrections were streamed to the UAV in real time. This allowed for accurate rapid processing but also seemed to allow the eBee X to land much more easily, especially on undulating terrain or if landing from offshore onto land over a cliff.

Once the UAV data had been collected, it was put through a three-stage post-processing workflow.

1. The raw GNSS and IMU data was post processed in senseFly's eMotion software package.
2. The geo-tagged imagery was loaded into a new Pix4D project.
3. The LAS files were loaded into QPS Qimera for seamless matching with the USV multibeam data.



▲ senseFly eBee X in-flight view.



▲ QPS Qimera showing line correction.

If the cable was buried on land, a radio detection unit was used to ascertain where the cable was and how deep it was buried. Many of the power cables were laid over 30 years ago, so

The USVs were operated with depth stop alarms enabled, which means that if the depth becomes too shallow, the USV will stop, reverse back to a safe depth and wait for the onshore

The USVs could be deployed on cables that were sheltered, which meant that the project was affected by very little weather downtime

the as-given location was often incorrect. Using this information and the UAV data, the surveyors had a better idea of where the cable was underwater.

USV pilot to instruct it on what to do next. This feature was not actioned during the survey as the shallowest sections were run parallel to shore and always within the previous swath

Surveying in all waters

Stay informed with *Hydro International*

The worldwide information source with insights and developments on hydrographic and oceanographic surveying in the industry.



Sign up for your free subscription to the online magazine and weekly newsletter today!

Hydro
INTERNATIONAL

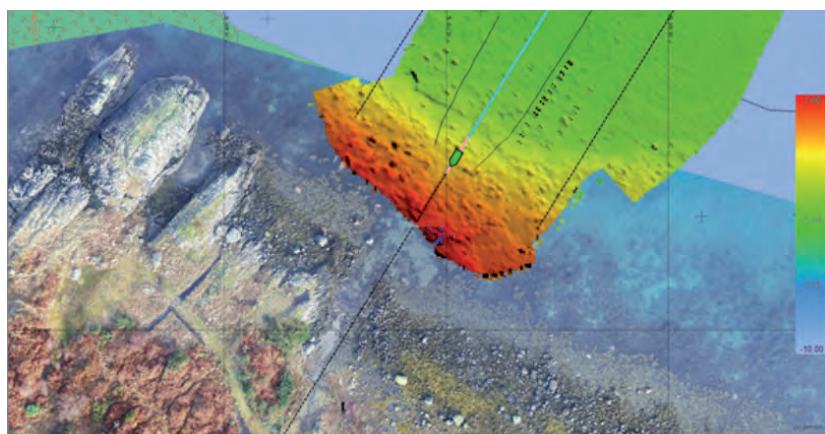


www.hydro-international.com

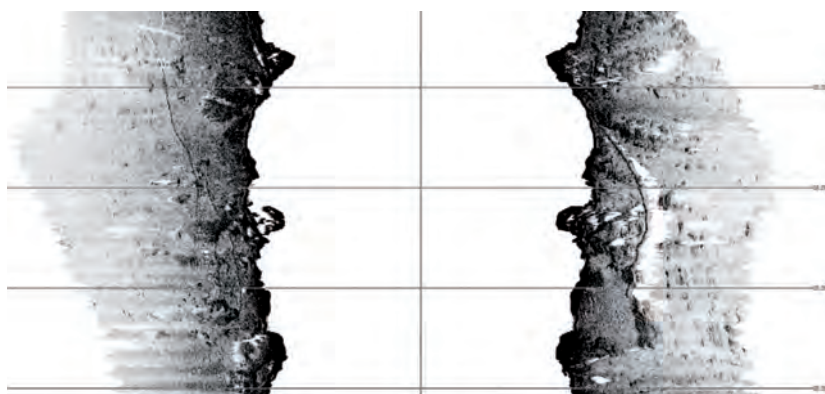
coverage, which ensured the safest operations as well as very high-quality data. The USV pilots also had access to real-time 360-degree vision from the cameras on the USVs, and AIS was integrated into each USV's QINSy Navigation Display and the XO-450 Cyberdeck.

The cable RPL was used as the initial survey line for the USV to follow. This also output a bearing and cross course to the USV's autopilot. The USV pilot adjusted the speed of the USV and kept a lookout while the USV was guided by the survey computer along the line. After completing the RPL and at least two wing lines, the USV ran parallel lines to the shore. When running parallel lines, the QPS QINSy AutoSwath function drew a line based on the previous multibeam swath extents using a 110% overlap to ensure that the USV was always over previously surveyed data. The online surveyor monitored all the time and the real-time DTM colour map was coloured in such a way that when it reached a particular value it turned blue. The blue colour was essentially a safety contour for the USV, enabling safe but efficient data collection.

Looking just at the bathymetry, detection of the cable in real time was challenging as the terrain was inherently rocky and there was also a great deal of kelp (sea grass) in the shallower areas. However, using the sidescan output from both the Norbit and R2Sonic multibeam systems proved to be very effective and, where the cable was found to be a long way from the as-given location, the USV was piloted along the cable by looking at the sidescan display.



▲ USV approaching the shoreline using the UAV imagery.



▲ R2Sonic Truepix imagery showing two cables.

making it easy to see what was rock and what was noise in these splash zone areas.

From the final cleaned data, the as-found cable was digitized, and any boulders or seabed features close to or on the cable were found and

suited to this type of survey XOCEAN's uncrewed technology is. It also proved that, in shallow water, the sidescan output from the multibeam systems is as good as a hull-mounted traditional sidescan, without the inconvenience and safety issues of running a towed sidescan in these water depths, currents and kelp. ◀

Looking just at the bathymetry, detection of the cable in real time was challenging as the terrain was inherently rocky

The multibeam data from the USVs was brought into the same QPS Qimera project and processed independently. Sound velocity data was loaded into the acquisition software.

A dynamic DTM surface was created using both the cleaned multibeam data and the UAV files. During data cleaning, it was possible to view the two datasets together either coloured by file or, preferably, coloured by RGB. This gave a photorealistic point cloud of the UAV data with the USV multibeam data coloured white,

reported. A full report was written for each cable, complete with GIS, charts and final RPL and event listings.

CONCLUSIONS

Conducting this survey campaign with USVs and UAVs not only enabled the collection of the highest possible resolution data, but ensured that the survey was safe, carbon-neutral and logistically efficient. The 70 UAV flights and 35 USV surveys were an exceptional achievement in the 6-week time frame and proved how well



Duncan Mallace is the Chief Strategy Officer of XOCEAN. He has about 30 years of experience in the collection, processing and analysis of ocean data. A highly skilled hydrographic surveyor, Mallace was a pioneer and early adopter of high-resolution multibeam technology in the early 1990s and helped push the boundaries of multibeam technology from its infancy to the de facto tool for seabed mapping that it is today.

Making Hydrographers' Tasks Easier



Navsight Marine Solution

State-of-the-art Motion
& Navigation Solution



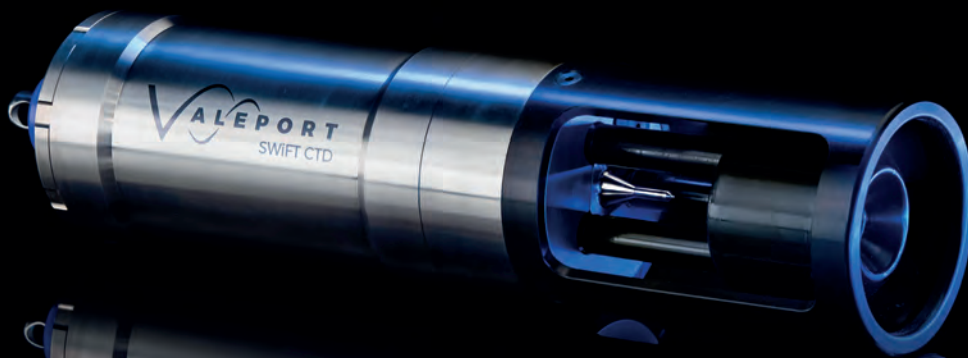
Qinertia

The Next Generation INS/GNSS
Post-processing Software

www.sbg-systems.com



VALEPORT SWiFT CTD



Measured CTD, with all the benefits of the SWiFT

CTD & Environmental • Current • Echosounders & Bathymetry • Sound Velocity • Tide and Wave

AUV • ROV & ASV • HYDROGRAPHY • HYDROMETRY • METROLOGY & POSITIONING
OCEANOGRAPHY • PORTS, HARBOURS & DREDGING • RENEWABLE ENERGY

Visit valeport.co.uk to find out more

+44 (0) 1803 869292 \ sales@valeport.co.uk

Seashore Large-scale Mapping Acceleration Using Lidar Bathymetry

Towards a Coastline Base Map in Indonesia

The accuracy of coastline data in Indonesia could be much improved by making use of Lidar bathymetry technology. In this article, the authors describe how Lidar bathymetry survey techniques were applied to a section of coastline in the Sunda Strait.

The determination of a sea or coastal area depends on the availability of coastline data, as it is based on the coastline reference (see Figure 1). The definition of the area of Indonesia's sovereignty could be improved if it were based on accurate coastline data. Unfortunately, a coastline base map at a scale of 10,000 was only available for about 8% of the total of 108,000km of coastline in Indonesia in 2019. Shoreline data was therefore generated by integrating elevation data (Digital Elevation Model; DEM) for land and sea that was obtained by topographic and bathymetric surveys. However, the topographical conditions in Indonesia are unique, with shallow water characteristics. Furthermore, some of the coastal areas are inland seas that are difficult to access using technologies such as sounding sensors. An alternative method is therefore needed to accelerate the availability of coastline data in Indonesia that utilizes Lidar technology for bathymetry survey activities. Improving the availability of coastline data on a large scale is expected to benefit the national economy, in particular the maritime sector.

AIRBORNE LIDAR BATHYMETRY

Lidar (Light Detection and Ranging) is part of a remote sensing system that uses active sensors and that works by comparing the characteristics of the transmission signal with its reflection; namely, the differences in pulse propagation time, wavelength and angle of reflection. In the Lidar bathymetry application, the laser used is a green light that can penetrate to the bottom of the water. When the laser hits the surface of the water, part of the laser wave is reflected and refracted in all directions and another part

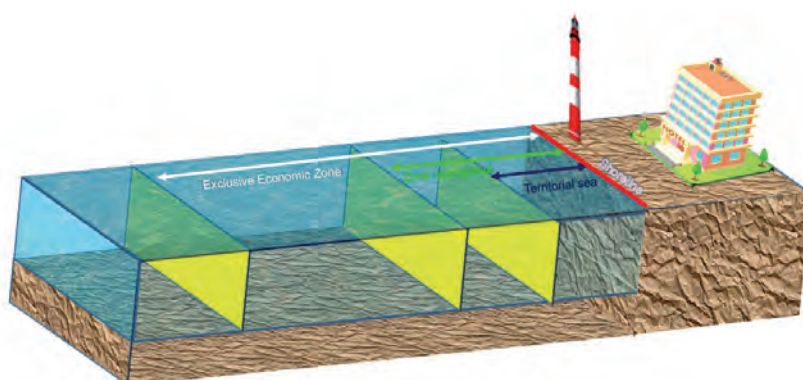
penetrates the water. The basic principles of Lidar bathymetry are shown in Figure 2.

ACQUISITION OF LIDAR BATHYMETRY IN INDONESIA

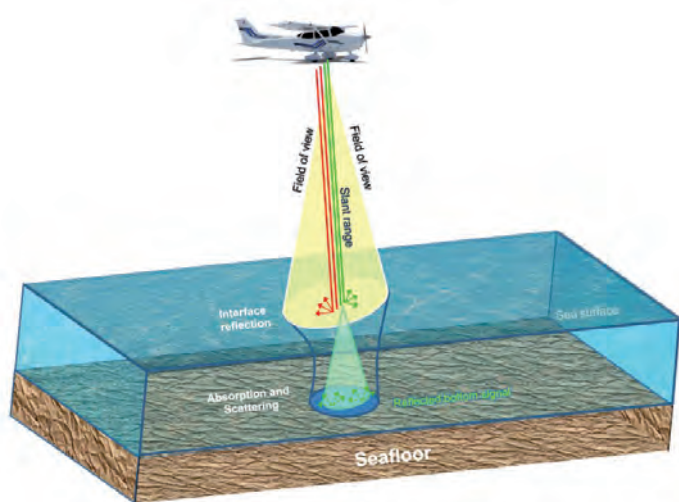
To accelerate the availability of national coastline data, airborne Lidar bathymetry was conducted in 2020 around the Sunda Strait. A differential positioning method was used to provide an aircraft position with an accuracy of 10cm. All resulting positions were referenced to the geodetic datum in Indonesia, SRGI2013. The altitude used was about 600m, and the distance between flight lines was 280m. A higher altitude can effectively increase the coverage area while maintaining the density of the point clouds, and Lidar acquisition can be carried out over a large area in a single flight. The capacity of the Lidar bathymetry acquisition was around 145km per day, with a total mapped coastline of 1,000km. Acquisition of Lidar bathymetry in the Sunda Strait reached a depth of up to 5m, because the measurement location was not fully in clear

water. In this case, the Lidar bathymetry acquisition took just two months to complete the entire Area of Interest (AoI). Based on this capacity, the Indonesian archipelago could be mapped quickly; however, the biggest difficulty during data acquisition was the rainy season in the area around the Sunda Strait.

There are other difficulties in southern Java, as the region is dominated by high waves (high wave regime domination). In bathymetry surveys, the surface of the water is considered to be a horizontal plane of reflection where the laser beam refracts into the water based on the off-nadir beam angle. If the surface ripples, the laser will be refracted in all directions, changing the angle of incidence of the laser beam. This makes it difficult for laser to penetrate to the bottom of the water in such areas. The geometry of the beam path refracted from the laser under water therefore depends on the conditions of the water surface plane above it. An illustration of the DEM data extracted from the Lidar bathymetry measurement results can be seen in



▲ Figure 1: Determination of Indonesia's sovereign territory based on coastline references.



▲ Figure 2: Basic principles of Lidar bathymetry.

Figure 3. As this shows, objects around the coast can be mapped in detail, including the water area.

LEVEL OF DETAIL OF AIRBORNE LIDAR BATHYMETRY

Lidar bathymetry uses infrared to produce land topography and green lasers to obtain the seabed. Therefore, Lidar bathymetry can produce a single seamless land and sea DEM, which greatly facilitates the data integration process as the resulting DEM is based on the same reference system. In addition, Lidar bathymetry can be conducted in areas such as shallow waters or coral reefs, which are difficult

to survey using acoustic sensors, as can be seen in Figure 4. Figure 4 also shows that shallow water areas with corals are depicted

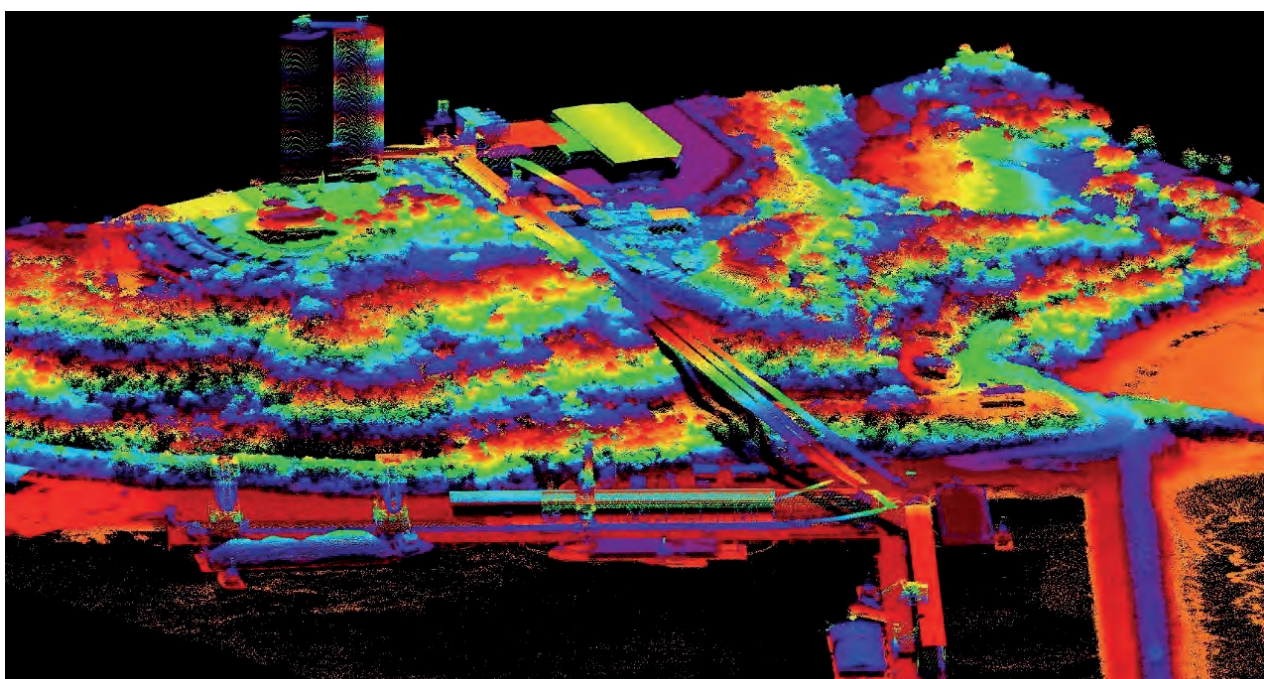
Lidar bathymetry for hydrographic survey activities provides many benefits, especially in terms of data acquisition cost efficiency

very clearly using Lidar bathymetry, in contrast to multibeam which results in less detailed seabed mapping. Lidar bathymetry therefore

produces high-resolution DEM data, making the extraction process of the shoreline easier.

EFFECTIVENESS OF AIRBORNE LIDAR BATHYMETRY

Sounding technology has a capacity of about 50 line km per day when acquiring marine DEM data. Furthermore, the integration of marine and land DEM requires a time-consuming topographic measurement, and problems arise during the DEM integration process between land and sea due to the use of different technologies and different measurement conditions when collecting the data. In addition, there are problems due to the differences in the references used, so that the DEM elevation values are not the same. Although the depth results using a sounding sensor are very accurate, the sounding sensor cannot be used in shallow waters and inaccessible areas. Lidar bathymetry can, however, acquire data over a large area in a single flight, making it



▲ Figure 3: Extraction of DEM data from the results of Lidar bathymetry measurements.

highly efficient in terms of time. Its capacity for mapping coastlines is up to about 145 line km per day. For this reason, Lidar bathymetry is

able to almost halve the survey time compared with the technology currently used. With such a capacity, the use of Lidar bathymetry for hydrographic survey activities provides many benefits, especially in terms of data acquisition cost efficiency. Therefore, Lidar bathymetry technology is very much worth considering as a method for accelerating the availability of a large-scale coastline map in Indonesia.

ACCURACY ASSESSMENT OF LIDAR BATHYMETRY

An evaluation of accuracy was carried out to compare the accuracy of the DEM with the Lidar bathymetry measurement results. Furthermore, the z coordinates (both on land and part of the coast) were compared with field measurements using precise GNSS tools. The accuracy test was therefore carried out around

the coast and in water areas that can be accessed using GNSS geodetic devices. The results of the accuracy evaluation show that the accuracy of the Lidar bathymetry measurement is 0.3m with a 90% confidence level. These

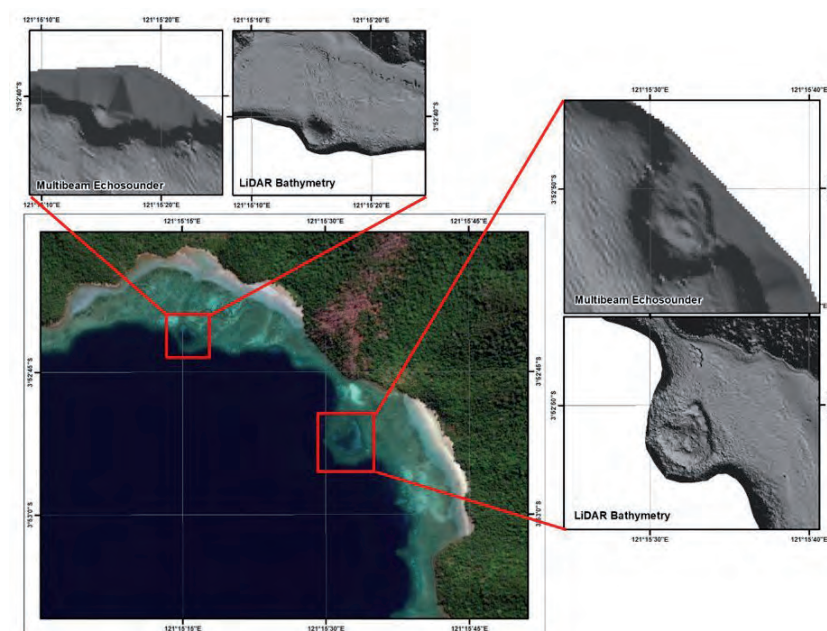
Lidar bathymetry surveys are very effective in shallow water locations and inaccessible areas, such as in archipelagic areas in Indonesia

results are in accordance with vertical accuracy standards in Indonesia. Lidar bathymetry results can therefore be used to produce maps at a scale of 1:5,000.

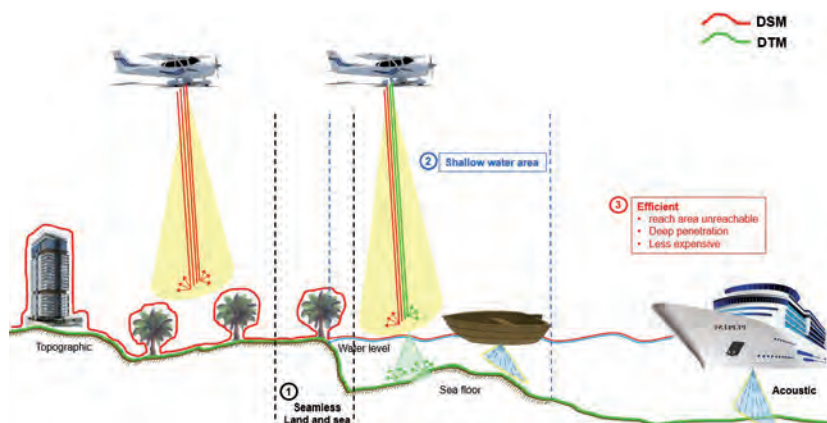
CONCLUSION

Lidar bathymetry surveys are very effective in shallow water locations and inaccessible areas, such as in archipelagic areas in Indonesia. Another advantage is that Lidar bathymetry

produces seamless DEM, making it easy to integrate land data with marine data. In addition, the high altitude flight range of the aircraft means that the Lidar bathymetry survey has a large coverage area in a single flight. These advantages can help to accelerate the availability of a coastline base map in Indonesia. It should be noted that the success of a bathymetry Lidar survey is highly dependent on the ability of the green laser to penetrate the water column. For this reason, bathymetric Lidar surveys depend on environmental conditions such as water turbidity, the water surface plane and weather conditions. Lidar bathymetry is therefore highly suitable for use in areas of Indonesia with clear and calm waters that are influenced by non-dominant sediment processes. However, the penetration ability of the Lidar bathymetry system to the bottom of the water column decreases in coastal areas with poor water quality, so that data collection needs to be done using sounding sensors and terrestrial methods. This combination of technologies obtains maximum results. ◀



▲ Figure 4: The level of detail of Lidar bathymetry measurements compared with multibeam echosounder data (acquisition area Kolaka, South Sulawesi). Lidar bathymetry data acquisition courtesy of PT Map Tiga Internasional.



▲ Figure 5: The advantages of Lidar bathymetry technology.



Agung Syetiawan is a researcher in the Geospatial Information Agency of Indonesia. He received his Master's degree in Geodesy and Geomatics Engineering from Bandung Institute of Technology, Indonesia. His research activities include oceanography, UAV and GNSS processing.
✉ agung.syetiawan@big.go.id



Herjuno Gularso is a mapping surveyor at the Center for Marine and Coastal Environment Mapping at the Geospatial Information Agency. He received a Bachelor's degree in Geodesy Engineering from Diponegoro University. His research activities include UAV, photogrammetry and shoreline extraction.

Low-altitude Surveying on the French Mediterranean Coast

Airborne Lidar Bathymetry in Close Up

RIEGL tested the performance of its topo-bathymetric airborne laser scanning system in a transition zone context along the French Mediterranean coast. Initially planned as a UAV survey, tests were conducted using a fixed-wing aircraft due to the restrictions placed on operations by the ongoing coronavirus pandemic. The results are encouraging, and the next step will be drone operations in more challenging sea conditions.

Topo-bathymetric airborne laser scanning (a field of airborne laser bathymetry, or ALB) is known for its efficiency in seamlessly surveying hybrid landscapes. It is therefore used in hydrography and the maritime cartography of shallow water areas, with the advantage of capturing topographic and bathymetric data in one single mission. These transition zones, which are difficult to cover by shipborne means or by land-based acquisition only, typically accommodate a large diversity of natural habitats and artificial structures, settlements or infrastructure. Consequently, they carry a high inherent risk due to terrain change, both offshore and onshore. These changes have to be monitored rigorously. The survey tasks are

manifold, and include habitat preservation and protection, for example in areas that are exposed to flooding, land shrinkage or coastal erosion. Surveys are also used for infrastructure maintenance and to ensure coastal navigation safety. As a non-intrusive surveying method, ALB supports all of these tasks without impacting the environment and without putting surveyors at risk.

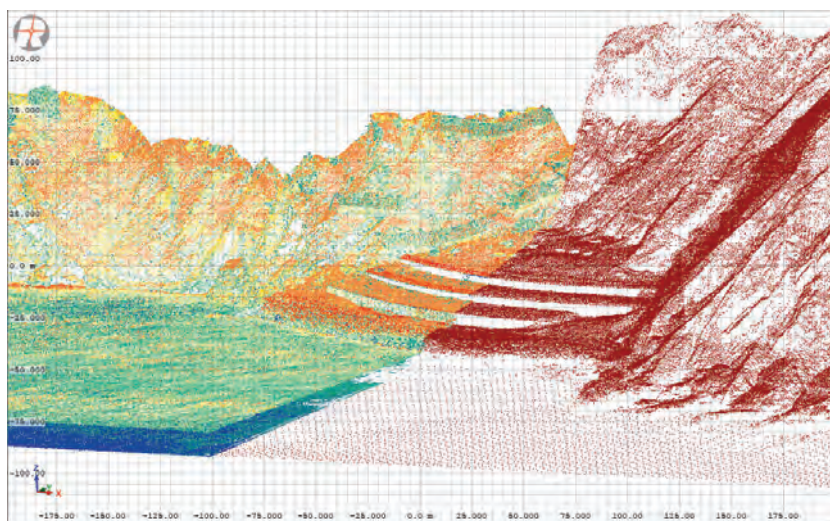
LIDAR IN BATHYMETRY

The specific requirements and limitations of Lidar in the context of bathymetry have to be taken into account. After all, it involves light and water, and for all the beauty that these two evoke when they mingle, it means a meticulous

balancing of the gain-and-loss ratio in Lidar technology. ALB systems are usually employed from manned aircraft at an operating altitude of > 1500ft (457m) AGL. They utilize green wavelength lasers, typically with a beam divergence of > 1mrad for reasons of eye safety, which is broader than that of the near infrared (IR) lasers used in purely topographic Lidar systems. The resulting laser footprint diameter on the ground surface is around 50cm. As a consequence, the planimetric resolution of the data is limited.

Turbidity further limits the usability of ALB. A coarse measure for the turbidity is the Secchi depth, which refers to the depth that a white or black and white disc can be lowered into the water before it disappears to an observer on the surface. By using powerful lasers as well as large and sensitive receivers, it is possible to acquire data in multitudes of the Secchi depth. However, in turbid waters this can still mean quite poor penetration.

When the laser beam interacts with the water, it is not only scattered and attenuated due to absorption but its direction and velocity of propagation also change at the air/water interface due to refraction. Correcting for the effects of refraction requires accurate knowledge about the location where the laser beam hits the water, which can be determined by classifying the water surface points and generating a water surface model. These additional processing steps can be time-consuming and require experience on the part of the processing team.



▲ Comparison of point density: red points (right picture half) are LIT03D data on land and on the seafloor (no water surface data shown), multicolour points are data acquired with RIEGL VQ-840-G (water surface and seafloor).

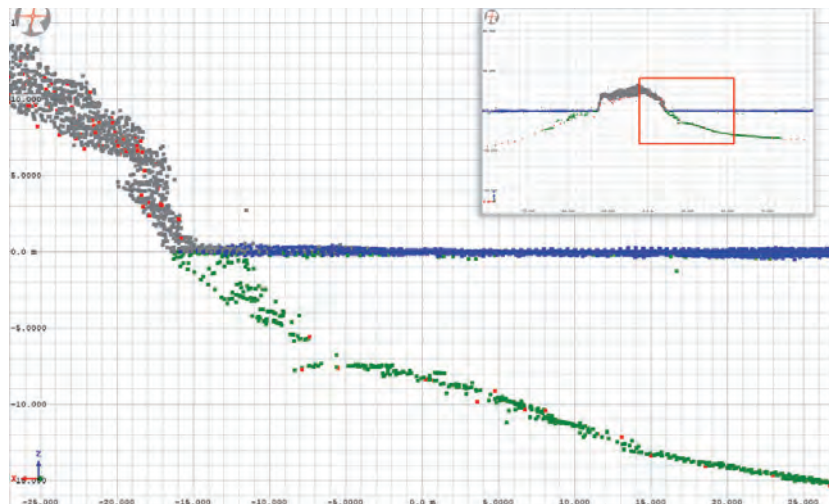
TOPO-BATHYMETRIC LIDAR AT LOW FLYING ALTITUDES

Over the last decade, the use of unmanned aircrafts (miniature or midsized) as carrier platform for cameras and all kinds of surveying equipment has been well established and has revolutionized the surveying sector. The availability of both UAS (unmanned aerial systems) and high-quality miniaturized sensors has enabled a new survey dimension in terms of perspective, flexibility and degree of detail.

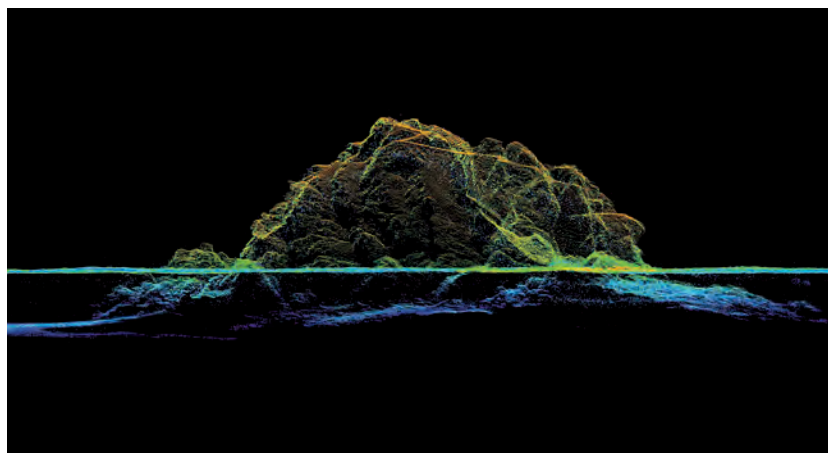
Based on this experience, recent research and industrial development have begun to focus on equally adapted sensor systems for hydrography.

While it is undisputed that bringing Lidar closer to the water surface restrains the swath width, and that the limited airspeed further reduces overall efficiency with respect to area coverage, this downscaling leads to a considerable gain in data quality concerning spatial resolution and potential depth performance. Expectations were especially high for complex, small area applications or the detailed mapping of riverine landscapes, which are underserved by high-altitude ALB.

RIEGL presented a first bathymetric Lidar profiler for UAS integration in 2016, followed by a first commercially available small-sized topo-bathymetric scanning system, the RIEGL VQ-840-G, in 2018. The core part of this system is a fully integrated compact airborne laser scanner for combined topographic and bathymetric surveying. The instrument can be equipped with an integrated and factory-calibrated IMU/GNSS system and with an integrated industrial camera. Compact and lightweight, at just 12 kg, it can be installed on various platforms, including UASs. The laser scanner comprises a frequency-doubled IR laser, emitting pulses with a roughly 1.5ns pulse duration at a wavelength of 532nm and at a PRR (pulse repetition rate) of 50–200kHz. At the receiver side, the incoming optical echo signals are converted into an electrical signal, amplified and digitized at a digitization rate of close to 2G samples/s. The VQ-840-G comes with special parametrization features allowing adaptation to the survey situation at hand. One option is to select the beam divergence between 1mrad and 6mrad to maintain a constant energy density on the ground and therefore balance eye-safe operation with spatial resolution. Also, the receiver's iFOV (instantaneous field of view) can be chosen



▲ Profile of superposed Lidar data from LITTO3D (red points) and VQ-840-G (grey for topography, blue for water surface, green for seafloor). The two point clouds match perfectly. Differences (in the steep slope) might indicate a change in terrain or vegetation between the two acquisition campaigns. Wide-area Lidar (LITTO3D) outperforms in coverage and depth penetration capacity, near-surface Lidar (VQ-840-G) excels in complexity and detail.



▲ VQ-840-G high-resolution point cloud: view of Les Deux Frères rock formation and seafloor terrain, maximum depths achieved 17.5m.

between 3mrad and 18mrad. For topographic measurements and very clear or shallow water, a lower setting is suitable, while for turbid water it is better to increase the receiver's iFOV in order to collect a larger amount of light scattered by the water body.

The VQ-840-G employs a Palmer scanner generating an elliptical scan pattern on the ground. The laser beam consequently hits the water surface at an incidence angle with low variation. The onboard distance measurement is based on time-of-flight measurement through online waveform processing of the digitized echo signal. A real-time detection algorithm identifies potential targets within the stream of the digitized waveform and feeds the corresponding sampling values to the signal

processing unit, which is capable of performing system response fitting (SRF) in real time at a rate of up to 2.5 million targets per second. These targets are represented by the basic attributes of range, amplitude, reflectance and pulse shape deviation and are saved to the storage device. Besides being fed to target detection and online waveform processing, the digitized echo waveforms can also be stored for subsequent offline full waveform analysis.

TESTING THE SYSTEM ON THE FRENCH MEDITERRANEAN COAST

After a series of successful test projects on various inland water bodies, with the VQ-840-G integrated both on manned helicopters and on two different models of electrical multirotor UAVs, an experiment by means of a manned

fixed-wing aircraft was carried out in March 2021 on the French Mediterranean coast. The choice of carrier platform was due to the current pandemic situation. Initially, the project had been planned as a UAV survey, but this had to be postponed throughout 2020. As travel and dispatch of personnel continue to be subject to restrictions, the crew was better off in the air. And after all, it was a good occasion to evaluate the performance of the system operated from a manned aircraft. A Cessna T206H, OE-KRI, was used for the mission, at a mission flight altitude of 150m AGL and flying at 110kts, resulting in a point density of about 6-8 points/m² at the measurement rate of 50kHz that was used for maximum performance. Of course, the flight dynamic of a manned fixed-wing aircraft is very different from the manoeuvring agility of a drone. And certainly, compared to typical drone flight parameters (e.g. 75m altitude; 20–30kts speed), the point density and performance was reduced, but this was offset by the flexibility and the possibility to cover a lot of ground in a short trip.

On 2 March 2021, the morning air was cool and calm as the Cessna T206 took off from Avignon-Provence airport for a first survey mission in the Camargue region west of Marseille. However, it had already started to rain in Montpellier further south-west and so another scheduled project there had to be cancelled

in-flight. The OE-KRI crew decided to refuel in Avignon before continuing with the experiment in the rocky area of Cap Sicié and then continuing for more data acquisition towards the French-Italian border before returning to the home airfield in Austria in time. Ground handling was limited to the strictly necessary in order to minimize Covid-related risks for the crew.

The seafloor in the measurement area is composed of sand, which provides good reflectance due to its color yet causes water turbidity when disturbed

Arriving at Cap Sicié shortly after 10:00 with an easterly wind at force 4, the sea state was slight. The waves reached 1-1.3m in significant height with a rather weak swell from the south-east. Cap Sicié is a cliff off the bay of Toulon and La Seyne sur Mer in the French Provence area of Var. The cape is known because – in contrast to the sheltered bay area – the wind, in particular the Mistral and Levant, can be particularly strong. The highest point at 352m offers a panoramic view of Toulon Bay and, when the air is especially clear, much farther to the Côte d'Azur islands. To the east, an eye-catching twin

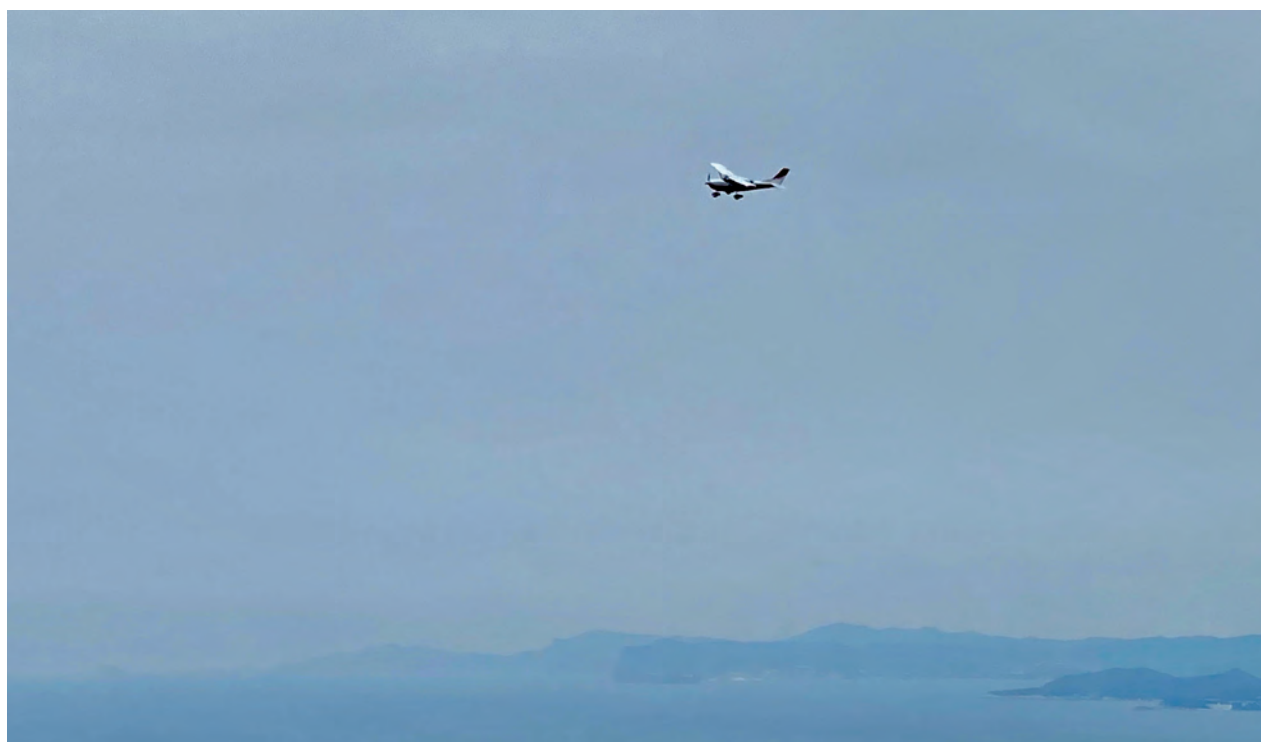
rock formation, 'Les Deux Frères', served as a focus for the data acquisition.

Located just below the cape, Amphitria is a wastewater treatment plant, an astonishing architectural structure embedded smoothly into the steep cove. The building is exposed to both hazards from land and water, and therefore

subject to continuous security measures, in order to ensure a safe working space for on-site personnel. The restricted accessibility due to topographic characteristics and protection of the natural habitat needed to be considered, serving as an example of the potential use of non-contact, yet close to surface, surveying methods.

COMPARING THE RESULTS WITH REFERENCE DATA

The test area (approx. 1152ha) was covered in 12 overlapping flight strips, resulting in a total of 60,864,774 single measurement points. For a



▲ Cessna T206 OE-KRI at Cap Sicié.

point density check, only data from a single flight strip was taken into account. A first analysis of the Lidar data showed that the topographic parts provided reliable multi-echo coverage, thus well capturing terrain beneath vegetation. The seafloor in the measurement area is composed of sand, which provides good reflectance due to its colour yet causes water turbidity when disturbed.

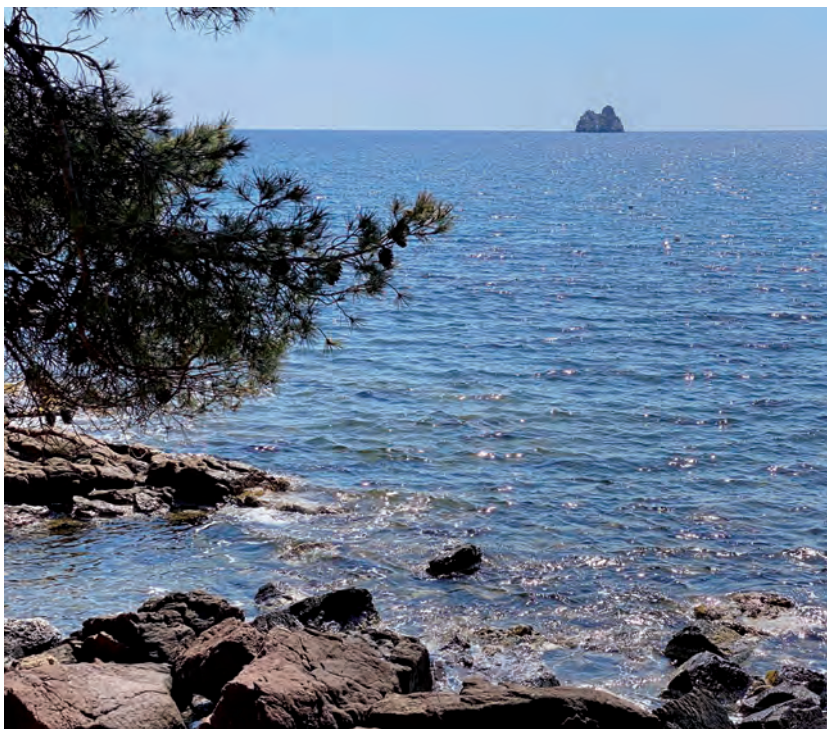
In order to reference and validate the results, the data was compared with existing, publicly available ALB Lidar data carried out by SHOM (the French Naval Hydrographic and Oceanographic Service). In the national Litto3D

programme, a digital altimetric reference model of the French coast for a littoral zone up to 10m isobath and up to 6 nautical miles offshore has been generated.

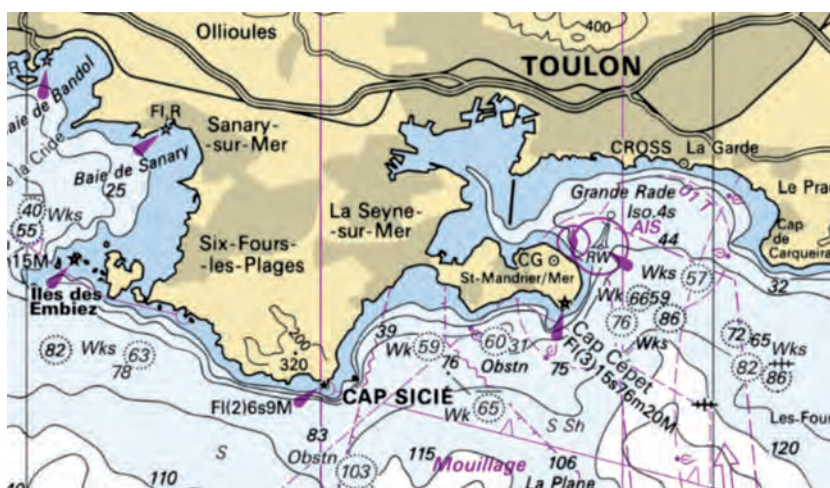
The acquired data was superposed onto the Litto3D data to obtain a visual impression of the two datasets. An excellent match was obtained of the point clouds both on dry ground and also the seafloor. While the Litto3D data extends to greater depth, the VQ-840-G's data provides a more detailed view due to its higher spatial resolution. At the seafloor, the Litto3D data is specified to have 0.04 pts/m², on dry ground this is 1 pt/m². In the area

investigated, it is even slightly higher for both contexts. The VQ-840-G provided a resolution above and below the water surface of 7 pts/m². These results might therefore perfectly complement wide-area survey data in regions of particular interest.

The brief field trip to the French coast provides insight about the VQ-840-G's performance in a maritime context, operated from a manned aircraft. The results achieved are a motivation for taking the next challenge, which is to operate from a drone and a higher sea state. A test series to further fine-tune the system for different survey applications is planned. ◀



▲ Les Deux Frères seen from the shore of Mar Vivo, La Seyne sur Mer.



▲ Marine area chart. (data source: SHOM, <https://diffusion.shom.fr>)

Acknowledgement

The authors would like to thank the local air traffic control service Base d'aéronautique navale de Hyères Le Palyvestre for flight coordination and Bateau-ecole de la Méditerranée à Toulon for advice.



Ursula Riegl is assistant to the CEO at RIEGL Laser Measurement Systems GmbH located in Horn, Austria. A trained PPL pilot, she is responsible for aviation admission procedures for UAV missions. In RIEGL's bathymetry sector she is coordinator for experimentation and demo projects.



Beatriz López García successfully completed her Bachelor's degree in Technical Survey Engineering and a Master's degree in Geodetic and Cartographic Engineering at the University of Jaén. Since April 2015, she has been working as a support engineer in the field of airborne and mobile laser scanning, software and data processing at RIEGL Laser Measurement Systems.



Dr Martin Pfennigbauer holds a PhD in engineering from Vienna University of Technology. He has been employed by RIEGL Laser Measurement Systems since 2005, presently as director of research and intellectual property. He is also business division manager for hydrographic laser scanning systems. His special interest is the design and development of Lidar instruments for surveying applications, with a focus on rangefinder design, waveform processing and point cloud analysis.

Your View Below the Surface

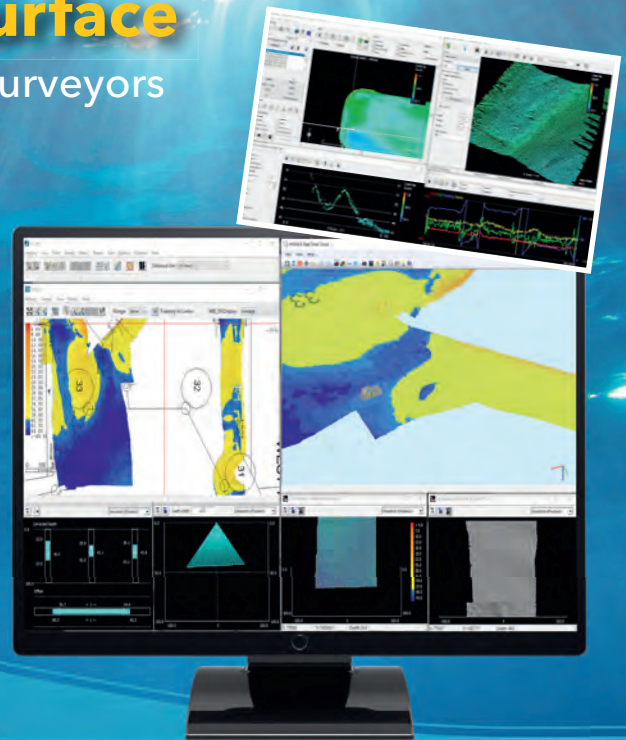
The complete software solution for surveyors

HYPACK®

Navigation, survey, and processing software for single beam, side scan, ADCP, water quality, sub-bottom, and magnetometer systems.

HYSWEEP®

Acquisition and processing software for multibeam bathymetry, water column, and backscatter, as well as topo LiDAR systems.



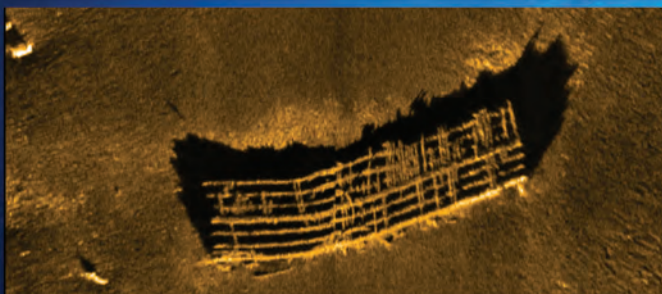
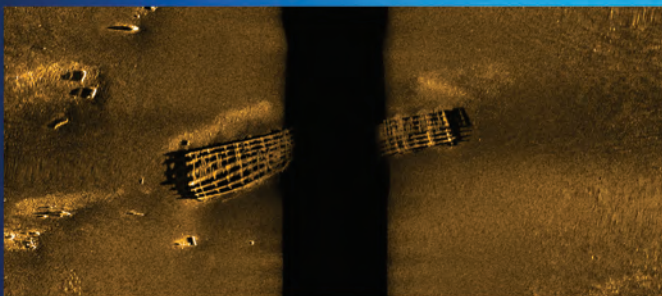
HYPACK
a xylem brand

 sales@hypack.com



KLEIN
A MIND Technology Business

INTRODUCING: KLEIN AUV-MAKO



Submerged Bridge
Klein MAKO Focused Sidescan (top) and MA-X Gap-Filler (bottom)



Innovative, Integrated Sidescan, Gapfiller and Hazard Avoidance Sonar System

- Full swath coverage
- "SAS Grade" focused sidescan resolution
- IHO standard bathymetry
- Hazard and Terrain Avoidance
- Automatic Target Recognition (ATR)

WANT TO KNOW MORE?

+1 (603) 893-6131

kleinsales@mind-technology.com

Transitioning to a 4.0 Industry by Tackling Environmental and Societal Challenges

Remote Hydrography

Hydrography is undergoing dramatic change. The current pandemic has made it very difficult to go to sea and mobilize vessels and crews, while the use of traditional research vessels is rapidly becoming obsolete as environmental regulations are introduced that are increasingly difficult to meet financially. At the same time, the blue economy is booming. International initiatives like Seabed 2030 are being implemented, and never before was there such a need to monitor not only seabed dynamics, but seabed ecosystems and water columns too. This involves collecting, processing, interpreting, plotting and archiving a massive amount of data in a more efficient and cost-effective manner. All of this requires a global change in the way that hydrography is conducted. And, while technology has evolved in that direction in the past decades, with major breakthroughs made in the fields of subsea monitoring and mapping systems, covering large areas of our seas and oceans in a timely fashion and within budget remains a challenge. This can now be solved with the advance of new purpose-made supervised autonomous platforms and remote hydrographic operations, which make it possible to use sensors to the best of their capabilities, providing ideal acquisition environments through enhanced stability, speed and reduced radiated noise.

OBLIGATIONS AND RESPONSIBILITIES

In addition to the environmental responsibilities that the hydrographic industry has, it is also important for its societal role to be taken into consideration. Keeping surveyors out of harm's way must indeed be a permanent goal, just like keeping the environment that we are serving safe from irreversible impacts. The transition towards the use of uncrewed surface platforms brings just that. Not only do such platforms reduce human exposure to hazardous environments, but they also enable more sustainable operations by consuming less fuel than traditional survey vessels, reducing greenhouse gas emissions.

The rise of autonomous platforms also allows operators to either enhance the capability of their exploited assets by acting as force multipliers, or to benefit from a single low investment and low operating costs for those who cannot afford large investments.

The hydrographic industry's societal role also extends to granting easier and less expensive access to assets and acquired hydrospace data for a larger community,

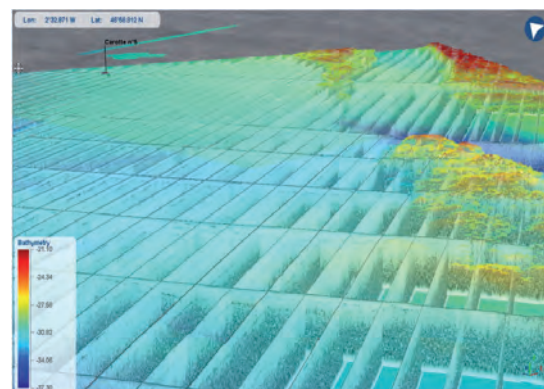
including scientists (e.g. marine biologists, oceanographers, archaeologists, geologists), fishermen and other actors in the blue economy. This should be among the industry's priorities, and can now be met through the increased deployment of advanced autonomous survey platforms that widen operating windows, enabling much larger amounts of data to be collected.

SOLUTIONS AND CHALLENGES

Thanks to the advances taking place in these newly developed autonomous platforms, hydrography is now accelerating its revolution towards a 4.0 industry. With the deployment of uncrewed surface vessels that remotely conduct recurrent tasks such as data collection, human skills and expertise can now be put to better use exploiting and qualifying the collected data, all from the safety of a remote control centre, either on a mother vessel, or at an onshore location. This evolution not only involves technology, but also requires rethinking the whole concept of the hydrographic 'operation'. Greater progress will indeed be made once developers and service providers adapt their survey methodology

to the use of these new remotely supervised platforms.

Autonomy is key in the response to the previously made observations. Making use of purpose-built platforms, the design of which is based purely on their end function (data acquisition), plays a big role in this transition. Leveraging purely hydrodynamic designs that do not have to be constrained by human presence onboard the vessel, uncrewed surface platforms benefit from high stability that allows them to work at greater speeds and in higher sea states than traditional



▲ 3D representation of simultaneous MBES and SBP data collection using the iXblue DriX USV.

survey platforms, while still acquiring higher quality data. Among the possibilities brought about by uncrewed vessels, modular gondolas – such as the ones developed by iXblue for the DriX USV – indeed provide unique low noise environments away from hydrodynamic acoustic turbulence, and guarantee cleaner acoustic data.

Developing an ecosystem around autonomous platforms is also key to the smooth transition towards remote autonomy, as it enables efficient deployments and successful missions

without creating new operational constraints. Aware of this challenge, iXblue is developing a full ecosystem around its DriX USV, consisting of functional launch and recovery systems, as well as purpose-made towing tools, gondola adaptations and shallow water support tools.

Overall, uncrewed survey platforms, which are able to cover extensive areas at a fraction of the time and costs of traditional survey methods and keep downtime to a minimum, have become a leading-edge survey technology that

force-multiplies data acquisition and helps optimize survey productivity, efficiency and safety as a whole, defining the essence of remote hydrography itself.

SUPERVISED AUTONOMY

Supervised autonomy is defined as the ability to operate unmanned survey platforms autonomously to achieve high-level mission goals while they are supervised by a remote operator who can take over control whenever circumstances require. In the context of hydrography, mission goals are usually defined by an area to be surveyed, as well as by measurement objectives (e.g. coverage, measurement density). A mission consists of the sequential execution of autonomous behaviours that represent elementary tasks. Most uncrewed platforms operate with deterministic behaviours, such as following run lines or predefined survey patterns. One of the challenges to reach the next level in terms of autonomy will be to develop reactive autonomous behaviours that use the data collected by the payload to optimize the platform mission plan.

The need for supervision is driven by the technology readiness and societal acceptance. As with self-driving cars, the path towards full autonomy will consist of multiple steps. Of course, autonomous systems use advanced communication systems to provide pilots with a high level of situational awareness, and communication in the maritime environment remains a challenge, as the performance of marine communication systems can vary greatly depending on the environmental conditions. Uncrewed surface vessels have to rely on a wide range of communication infrastructures, depending on the operation scenarios (Wi-Fi, radio, LTE or satellite). Managing the User QoE (Quality of Experience) also remains a significant challenge.

To respond to the challenge of optimizing the use of available communication channels, iXblue has been working on an adaptive strategy in terms of managing the transfer, remote processing and access to data according to user priorities.

Another choice made by iXblue to offer an adaptive strategy is its developments on the DriX USV command and control. Built as an open platform, it supervises third party software to use onboard data



▲ iXblue DriX USV acquiring data meeting exclusive order criteria in sea state 5 off the coast of La Ciotat, Mediterranean Sea.



▲ Radical design choices made possible by uncrewed platforms lead to highly hydrodynamic and stable platforms that excel in complex and constrained environments. iXblue DriX USV can for instance conduct surveys at speeds ranging from 4 to 14 knots and in weather conditions up to sea state 5 without impacting data quality.

processing and management to its best capabilities, while continuously accessing and integrating the right amount of data required to make decisions that support supervised autonomous operations. The flexibility provided by this kind of open platform allows the best adaptation to the constraints linked to communication channels to support supervised autonomy, while maintaining a very high level of onboard autonomy and responsiveness to potential working environment and situational changes.

OPPORTUNITY FOR NEW GENERATIONS OF SAILORS AND SCIENTISTS

Overall, the transition to remote hydrography will call for a new generation of marine technicians and scientists that will need to be trained to support uncrewed platform mobilization, operation and maintenance, as well as to support the increasing need to interpret the massive amount of data collected.

While traditional survey vessels were crewed with sailors in charge of navigation and deck operations, as well as with onliners and offliners for data acquisition, mission planning, data processing, pre-interpretation and charting, uncrewed survey platforms will now require a smaller team of a new kind of technicians. True specialists in autonomous platforms and remote operations, they will organize field mobilizations, liaise with local authorities

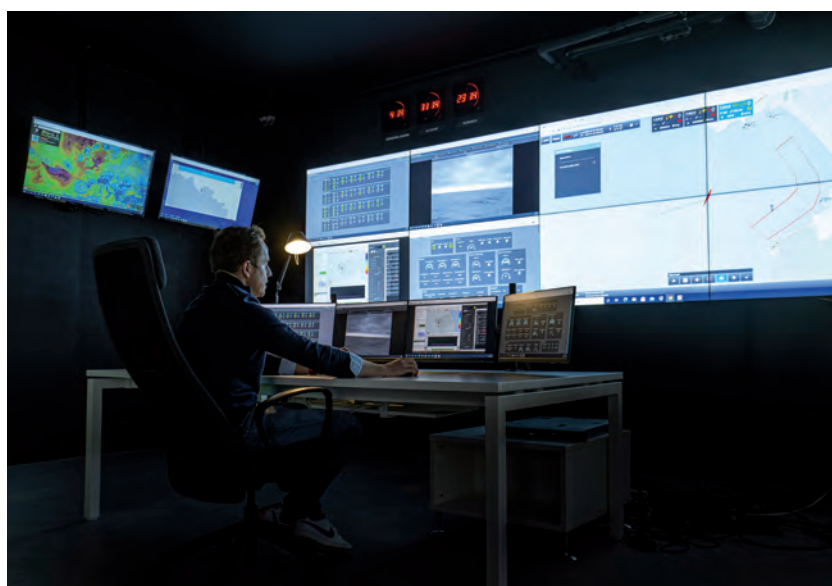


▲ *DriX being deployed from NOAA's Thomas Jefferson hydrographic survey vessel.*

and communities, and be able to maintain autonomous platforms.

And because autonomous survey platforms provide higher data quality – iXblue DriX's latest remote operations have indeed shown a reduction by a factor of ten of the required cleaning and processing of hydrographic data – more time will be given to onliners and offliners to concentrate on much added-value QC, interpretation and charting tasks. Globally, using uncrewed

vessels such as the iXblue DriX USV supported by a strong ecosystem will not only save precious time during these phases, but also during all other stages of the survey operation, including mobilization, thanks to smaller pre-calibrated and normalized platforms, and during the operation itself, thanks to the development of efficient mission planning algorithms and autonomous data acquisition. All of this allows onliners and offliners to work remotely on multiple assets and missions at the same time, bringing much added value to the industry. ◀



▲ *Multi-DriX USV operation conducted from iXblue onshore control centre.*

David Vincentelli is a Cat. A hydrographer with a Master's degree from ENSTA Bretagne Engineering School. After seven years at sea conducting a wide range of survey operations in the Arabian Gulf, northern Europe and Mediterranean regions, he joined iXblue in 2012 as a business developer for the sea operations division. In 2020, he was appointed co-director of the division and now coordinates the iXblue transition towards remote hydrographic services.

Vincentelli is also involved in pro-bono activities. As president of the Francophone Hydrographic Association, he works actively to promote francophone hydrographic expertise, supporting the creation of a francophone hydrographer certification scheme and participating in IHO and IFHS technical working groups.

Increased Integration of Remote Technology Will Transform Maritime Operations and Maintenance Practices

Robotics and Automation Advance the Offshore Wind Industry

During the life cycle of offshore wind farms (OWFs), operators must maximize the uptime of wind turbines to generate as much energy as possible. As OWFs are constructed further from the coast, maintenance and inspection with crewed vessels becomes increasingly risky, time-consuming and expensive. To overcome this challenge, the industry is turning to remote and autonomous technological solutions that can support OWFs far out at sea.

The integration of autonomous technologies brings significant benefits for the offshore wind industry, including improved safety and efficiency and reduced overall environmental impact. A key example is the accelerated design and development of uncrewed surface vessels (USVs) that can perform tasks in remote offshore locations while being controlled from remote operations centres (ROCs) as far away as in different time zones. With a wide range of applications, from seabed and asset data acquisition to research, surveillance and marine exploration, USVs are set to transform the maritime business and lay the foundations for a new way of working in the offshore wind industry.

UNCREWED SURFACE VESSELS: IMPROVED SAFETY AND EFFICIENCY

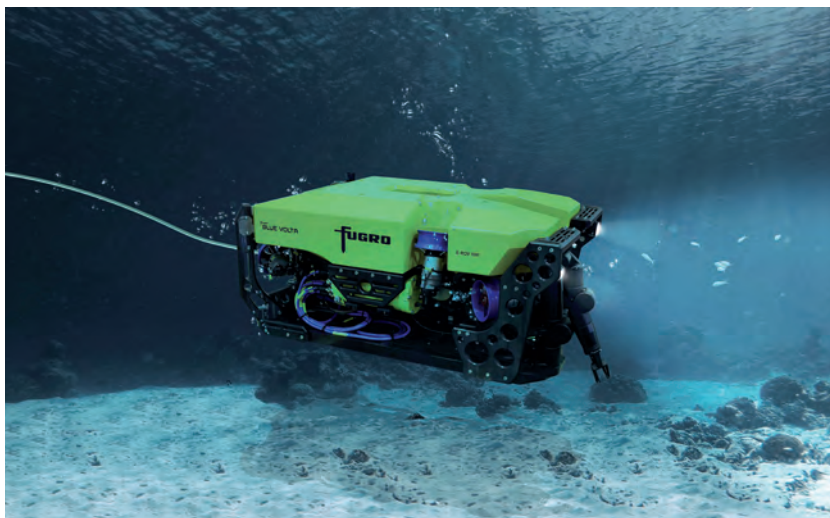
USV technology does not replace the need for skilled personnel within the industry; rather, it has the potential to allow them to work more efficiently and in a safer ROC environment. The ability to deploy, manage and operate uncrewed vessels from ROCs anywhere in the world means that fewer people need to work in extreme and potentially hazardous offshore environments. Additionally, USVs offer an extremely efficient mode of data acquisition, allowing maritime staff to prioritize complex analytical tasks rather than spending time supporting the delivery stages. This leads to another advantage: increased output and speed of the delivery of high-quality

insights to clients, using cloud-based processing and reporting solutions so that clients can receive the first results just hours after initial data acquisition, anywhere in the world.

The integration and adoption of USVs will also significantly benefit the overall environmental impact of marine expeditions and operations. Some USVs have hybrid diesel-electric engines that allow vessels to operate further offshore, increasing the operational window while also significantly lowering the carbon footprint. At Fugro, we see USVs playing a prominent role in the future of maritime exploration and operations and, as such, we have partnered with SEA-KIT International, a global provider of hi-tech solutions to maritime and research industries. Through this partnership, we are helping to drive the development of USVs to support the greater use of remotely operated vehicles and autonomous underwater vehicles to inspect marine assets.

INNOVATION BRINGS NEW CHALLENGES

While the benefits of USVs are undeniable, these technological advances have uncovered further challenges. Offshore robotic solutions work most efficiently when there is a local, in-field facility that can accommodate the systems for safety, recharging and data transfer in an autonomous capacity that does not need onboard personnel. Without this offshore support, USVs and other autonomous robotic solutions regularly have to travel large distances to coastal locations such as marinas or ports for



▲ Fugro designed Blue Volta electric ROV, performing a seabed inspection off the coast in Australia.



▲ Impression of the Fugro Blue Essence USV, preparing to RoboDock at IJmuiden port, The Netherlands.

recharging and data transfer, which consumes time and fuel that could otherwise be used to deliver operation and maintenance plans. Thus, to ensure that OWFs can maximize the capabilities of autonomous solutions, Fugro is developing an automated docking platform from which uncrewed vessels can perform inspection and maintenance operations. This 'RoboDock' platform will enable various uncrewed vessels and drones to carry out inspection tasks both above and below the sea's surface, as well as serving as a recharge station. Effectively eliminating the need for autonomous assets to return to shore, RoboDock will incorporate storm-resistant docking points, automated launch and recovery, and charging points. The platform will also facilitate data download to and communication with the onshore ROCs, and ongoing monitoring of wind farms.

SETTING A NEW INDUSTRY STANDARD

This cutting-edge technological breakthrough will not only allow the offshore wind industry to accelerate the adoption of remote and autonomous solutions, but will also have huge safety advantages. By deploying RoboDock, the offshore industry can remove human workers from extreme environments to de-risk offshore operations. Additionally, compared to current

practices that require large support vessels, robotic operations will consume far less energy, making them a more sustainable long-term solution.

RoboDock is designed to be operational year-round and will withstand challenging weather conditions. While the initial prototype will be small-scale, the platform will demonstrate its potential as a scalable technology that could be used to create large floating offshore hubs and maintenance islands for deploying robotic and autonomous technologies. For example, RoboDock stations could offer coastal security and coastguard operations support, aiding in maritime search and rescue, and shipping traffic and environmental monitoring. RoboDock also offers a number of potential applications within the scientific community. These include advanced monitoring, research and acquisition of environmental and metocean data via the addition of sensors to the RoboDock platform, or cameras for advanced subsea flora and fauna surveys. In this way, the platform could help scientific researchers gain a better understanding of the pressures affecting marine and coastal environments, and therefore support environmental protection programmes. As a support system, RoboDock could benefit activities as varied as wind farm security, coastguard operational support, maritime aid,



▲ Aerial view of Fugro Blue Essence USV performing a survey using Fugro Blue Volta electric ROV.

search and rescue, monitoring of shipping traffic and many more.

THE FUTURE IS REMOTE

The offshore wind industry will significantly benefit from the uptake of remote technology at every level. Innovations such as RoboDock will help to bring about faster, more efficient and safer operations, functioning on a significantly more sustainable scale and accelerating the maritime industry's digital transformation. Robotics and automation will ensure a continued drive to increase the maximum energy output of wind farms throughout their entire life cycle and will expand the capabilities of offshore wind and other maritime operations. ◀

For more information:

Ivar de Josselin de Jong
i.josselin@fugro.com



▲ Fugro Blue Essence USV performing inspection off the coast in Australia.



Ivar de Josselin de Jong is director for remote inspection at Fugro. His career started in site investigation and high-end geophysics. He later moved to O&G IRM and Offshore Wind O&M

solutions and has gained a broad experience in the maritime arena. His current focus is enabling the transition to remote and autonomous operations, with ongoing USV developments in partnership with SEA-KIT, developing the Blue Essence and Blue Eclipse USVs, and the next-generation electric ROV programme. He holds an MSc in Geology from Utrecht University in The Netherlands.

✉ i.josselin@fugro.com

IIC Academy Hydrographic Surveying Course

An Introduction to the S-5 Category B Programme

Hydrography plays an important role in the economic and social development of nations. The proper mapping of the coastlines and bodies of water of a nation helps with the management of natural resources, preservation of marine species and habitats, marine trade, defence, safety for navigation through national and international waters, and more.

PROFESSIONAL-LEVEL TRAINING

IIC Academy's S-5 Category B Hydrographic Surveying programme has been recognized by the FIG/IHO/ICA International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC) and is designed to maximize the advantages of online delivery, especially considering the circumstances imposed on us by the Covid-19 pandemic.

THE IIC ACADEMY'S S-5 CATEGORY B

programme provides candidates with the theoretical and practical competencies necessary to effectively conduct the planning and implementation of hydrographic surveys at a professional level.

MAXIMIZED ONLINE DELIVERY

IIC Academy offers the S-5 Category B programme flexibly, in tune with the

health and safety requirements of the world today. By utilizing online learning and communication tools that have become so familiar during the Covid-19 pandemic, students are trained without the normal expectation or expense of having to move to distant geographic locations for the full duration of the programme.

THEORETICAL AND PRACTICAL EXPERIENCE

IIC delivers this programme in an engaging manner, utilizing a learning framework that blends relevant theory and practice. The programme gradually guides students through the topics, from basic to advanced degrees of difficulty, both in the theoretical and practical knowledge areas. The practical tasks reinforce the theory of each topic and evolve students' competencies from supervised sessions to autonomous work.

Students benefit from having a team of instructors leading and monitoring them throughout the programme. This is continued and strengthened when students co-locate with their instructors for the practical and assessment portion of the programme.

IS THIS PROGRAMME FOR ME?

IIC's S-5 Category B Hydrographic Surveying programme is designed for both surveyors in the early phase of their career and new candidates with some relevant previous education who want professional-level training at the Category B level. The programme's remote learning delivery allows employees and employers the flexibility to customize the timing of the learning process so that it best fits into their work schedules, potentially enhancing the training through practical synergies.



▲ Hydrography continues to support global development.



▲ IIC Academy instructor Veronique Legat and students prepare for surveying field exercises.

WHAT WILL I LEARN?

The content of the programme has been carefully designed to align with the content and intended learning outcomes defined by the FIG/IHO/ICA guidelines. The learning outcomes have been organized into modules, units and lectures, with the following structure:

- Introduction to hydrographic surveying
- Computation tools
- Nautical science
- Environmental science
- Positioning
- Underwater acoustics
- Water levels
- Quality control
- Remote sensing
- Hydrographic practice
- Hydrographic data management
- Comprehensive final field project

PROGRAMME DETAILS AND TIMELINE

IIC Academy's Hydrographic Surveying programme – global delivery runs for a total of 20 weeks, divided into three phases:

- Phase 1, Theory/remote learning. The programme delivers 13 weeks of remote learning to cover all of the required theory, in the comfort of the student's home or office; this includes instructor-led webinars and e-learning modules.
- Phase 2, Practicals. The remote learning phase is followed by three intensive (condensed) weeks of on-site practicals. These practicals review and consolidate the theoretical material delivered during the remote learning phase. The practicals are held in three scheduled regions of America, Australasia and Europe.
- Phase 3, Final assessment. The programme completes with a four-week period in which the student completes a comprehensive final field project. This project is designed to confirm that students have all the necessary theoretical knowledge and practical skills to plan, conduct, assess and submit a hydrographic survey.

Although the final field project is considered to be the central component

for graduation, students are regularly tested throughout the programme using in-lecture quizzes, simple practical exercises, written exams and data processing tasks. This is designed to ensure that the students are obtaining the understanding and ability that they require throughout the course, and to identify where additional in-course training and assistance may be required.

An overall and tangible benefit of the structure of this programme is that it is designed to parallel how hydrographic surveying teams work in practice. ◀

How do I Enrol?

Those interested in enrolling in the programme or requiring further information can visit:

www.iictechnologies.com/sites/default/files/iicacademy/IICS5Program.html

or contact hydrographicsurveyor@iicacademy.com.

How a Small California Company is Innovating in Turbulent Times

Breakthrough on the Horizon; Giving Sight to USVs

Every player in the survey industry has been affected by the pandemic in unique ways. What each had in common though, was an almost complete halt of face-to-face interaction with competitors and collaborators alike. Seafloor Systems, based in Northern California, took this opportunity to focus on its product development and advance the autonomous capabilities of its existing remote survey platforms.

AUTOMATION FOR HYDROGRAPHERS

Seafloor Systems has been designing and building Uncrewed Surface Vessels (USVs) for over a decade. From drawing board to field testing, the team of twenty-five employees pumps out remote platforms for a variety of clients and disciplines within the land and hydrographic survey sectors. Its star products, robot boats, make it possible to send pro-grade instrumentation and sensors into areas

that a crewed vehicle would find challenging (streams, dredge ponds, shorelines, etc).

The employees at Seafloor Systems are no strangers to pioneering technologies for remote, hydrographic survey applications. When Seafloor launched its AutoNav control system for USVs in 2015, users were given the ability to pre-programme remote vessels to follow track lines in the water and carry out hands-free missions. The AutoNav, which is still a staple

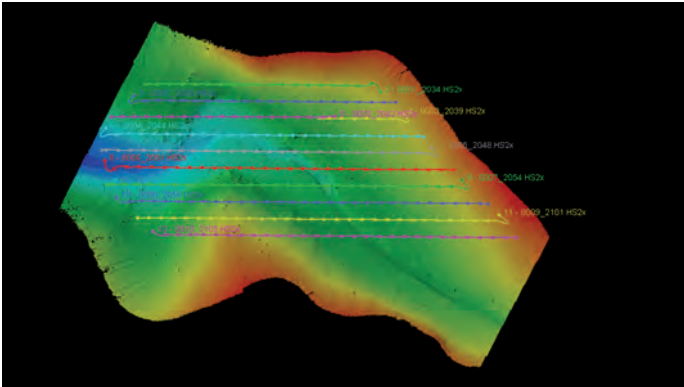
product, reduces overlap in sonar beam swathes and ensures clean, consistent data collection. Even so, the AutoNav has limitations when obstacles stray into the pre-planned route without warning.

However, the biggest obstacle in the way of recent efforts to address the AutoNav's limitations was the onslaught of the worldwide pandemic. Fractures in the global supply chain and mandatory stay-at-home orders made it difficult for businesses to operate, let alone invest in new projects. Despite this setback, the nimble Seafloor crew set a goal to pioneer a package that could be integrated into USVs to autonomously navigate around obstacles during survey missions on water. In other words, they wanted their robot boats to see, identify and react to surface threats in real time.

A VISION FOR FUTURE UNCREWED VESSELS

It is no easy task building a computer vision navigation system for uncrewed vessels. Not only would it have to identify obstacles in the path of the survey mission, but also react to them in real time and adjust the steering propellers to avoid collisions. Luckily, there is a company out there that helps clients do just that. AlwaysAI, a leading provider of flexible ways to build and deploy computer vision applications to a wide variety of devices, offered up its platform for the Seafloor team to build from. With a strong artificial intelligence partner secured, Jenna Opsahl and Marcos Barrera, Seafloor's computer vision and robotics specialists, began the daunting





▲ Seafloor's AutoNav enables Uncrewed Surface Vessels (USVs) to follow a pre-programmed route. This semi-autonomous feature increases survey efficiency and repeatability.



▲ Bounding Boxes are placed around common maritime objects to train the computer vision model to better identify obstacles in the USV's survey path.

task of formulating a computer vision model specific to maritime environments. (There are several land-based models out there, but limited options for the niche maritime survey industry). Opsahl collected and sifted through video clips frame by frame that contained objects commonly found in bodies of water. Boats, buoys, ducks, plants – anything that was above the surface that might pose an obstacle for unmanned vessels – were selected with bounding boxes and labelled so the artificial intelligence model could learn and adapt.

Barrera was tasked with developing a perception and control infrastructure that would work in tandem with the computer vision model. For this, he utilized Amazon Web Services (AWS) IoT Greengrass, which enables programmers to remotely manage and operate software on devices in the field. The obstacle avoidance package for USVs began to take shape.

TESTING THE WATERS – CV SUCCESS

Fast forward a few months and hundreds of hours of annotating through video footage, and the team was on the cusp of testing a prototype. The computer vision

model had seen leaps in object recognition abilities, and COVID restrictions were simultaneously being lifted in California. The Seafloor crew met in San Diego (the first time in person in almost a year) to test the obstacle recognition and avoidance system on an EchoBoat-160 USV.

Initial testing garnered promising feedback. The computer vision model, now integrated into the EchoBoat-160's AutoNav, picked up on several objects in the water and indicated its confidence (in a percentage) that it was, in fact, that object. For example, when the vessel stumbled upon an inflatable inner tube, the model determined it was 94.01% certain that it was a 'raft'.

Now it was time to see if the vessel could identify objects along a plotted survey route and react accordingly. Seafloor's Ocean Engineer, JT Meyers, volunteered to cruise out on his paddle board to play the role of an unsuspecting bystander. A navigation route was programmed into the vessel's AutoNav from the shore, and Meyers positioned himself between two of the wayfinding points to create an

obstacle. To the team's surprise, the computer vision system picked up the paddleboarder with no issue, and quickly altered the vessel's path to avoid a collision. Computer vision success.

MACHINE LEARNING FOR THE FUTURE

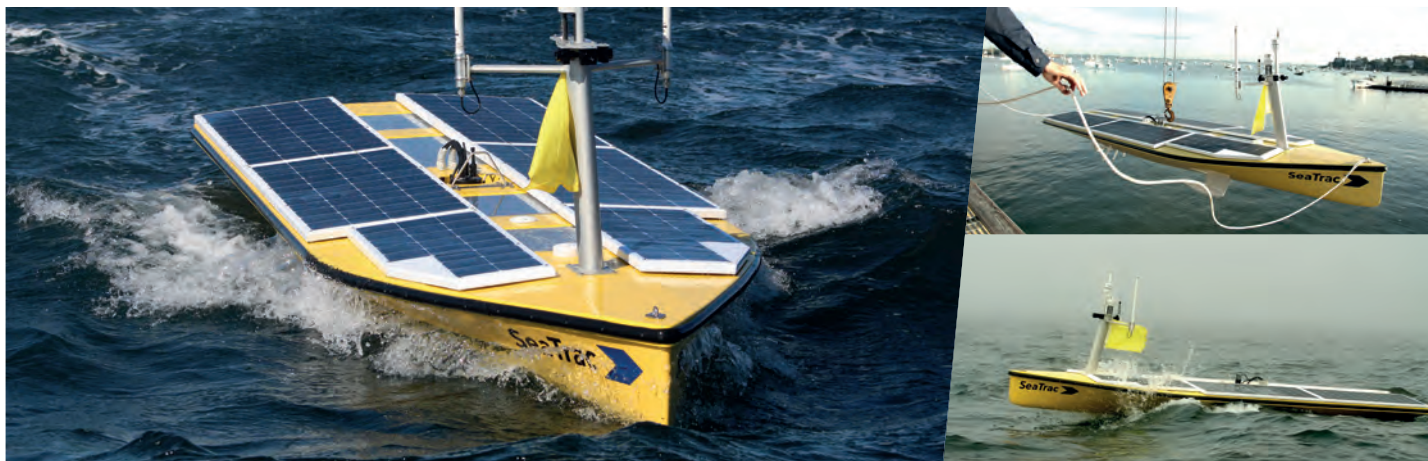
With a successful obstacle avoidance test under their belts, the research and development team at Seafloor could now take a deep breath. Months of tinkering with machine learning and limited face-to-face collaboration stemming from the global pandemic were turned into the triumph they were all hoping for. This technology is scheduled to be introduced into various Seafloor remote survey platforms of the future to advance the autonomous capabilities of unmanned vessels. For now, the team says their work is not done. Further training of computer vision models will take place to account for different environments, objects and scenarios. Innovation can arise in some of the most turbulent times, and obstacle avoidance is just one of the advancements driving the hydrographic survey industry forward. ◀



▲ The computer vision model on board the EchoBoat-160 USV determined with 94.01% confidence that the obstacle in its way was a raft.



▲ Computer Vision Success. The USV avoided the paddleboarder, altering its pre-programmed route (green line) to go around the obstacle and continue surveying (white line).



Looking for persistent, cost-effective, real-time data for your missions?
Our Technology: Solar Powered USV for Maritime Data Collection and Communications

Introducing the SeaTrac SP-48, a persistent sensor-agnostic USV that can autonomously operate in shallow to open ocean environments continuously over long durations reducing the risk and costs for marine data collection over conventional methods. Perfect for hydrographic, metocean, oceanographic, environmental, data harvesting, security and other applications.

- Carbon Neutral Platform
- User Defined Payloads including power hungry sensors
- Over the horizon operations
- Automated collision avoidance
- Low logistics

To learn more, contact SeaTrac Sales:

- sales@seatrac.com
- +1 (617) 981-4620
- www.seatrac.com

SeaTrac 

The Next Wave of Uncrewed Surface Vehicles



Grow your business!



TECHNICAL B2B MARKETING FOR SMART GEOSPATIAL COMPANIES
WWW.GEOMARES-MARKETING.COM

Meeting Rising Offshore Wind Demand Through Innovative Technologies and Services

How Early Engagement Can Cut Costs and Enhance Project Outcomes

Acteon, a leading provider of services to the offshore wind industry, is growing, along with the rapidly expanding offshore wind market. The company believes it is important to listen and respond to customers and to get in early on projects to deliver benefits such as new survey methods that increase safety and reduce costs.

According to the International Renewable Energy Agency, an almost tenfold increase in installed offshore wind power capacity is needed by 2030 to meet the Paris Climate Agreement goals. Investment in offshore wind may be accelerated if governments back a green recovery following the global Covid-19 crisis.

Furthermore, barely a week goes by without a new wind-powered green hydrogen scheme being announced, such as the Shell-led NorthH2 wind-to-hydrogen project in the North Sea. The expansion of offshore wind is no longer confined to northern Europe and China, and offshore renewable energy projects are now

gathering pace in places such as Taiwan, Japan and off the US East Coast.

The levelized cost of offshore wind energy has halved in just five years and some new developments are competitive without subsidies. This has been achieved by applying lessons learned from one project to the next: cumulative



▲ Turbine construction, East Coast US. TerraSond performed UXO clearance surveys of the area.

improvements in survey and installation efficiency are delivering significant savings owing to the scale of developments.

DOUBLING SURVEY SPEEDS

TerraSond's geophysical work on the US East Coast is a good example of early engagement and the Acteon group's desire to listen to customers and respond to their needs. TerraSond, a geoservices survey company and part of Acteon, has been involved in nearly all of the East Coast offshore wind developments, including the Mayflower, Atlantic Shores, Coastal Virginia and Kitty Hawk projects. Early

and continued participation has helped the company to understand the needs of its customers and the regulatory environment. The TerraSond teams know how to do the work to meet the technical specifications and regulatory and safety requirements and, ultimately, to help customers to design, build and maintain wind farms safely and effectively.

Renewables development is driven by the climate emergency, so developers need to demonstrate to their stakeholders that they are actively reducing the carbon footprints of offshore operations while improving safety and environmental performance and driving down costs.

In 2018, TerraSond helped to address these needs for Bay State Wind, a joint venture between Ørsted and Eversource, off Massachusetts, through the deployment of the first unmanned surface vessel (USV) to be equipped with a full range of geophysical sensors. The 40-ft USV was remotely operated from and worked in parallel with a standard, manned, 200-ft survey vessel. This effectively doubled the survey capacity and speed, thereby improving safety by halving the time that the 35-person crew spent offshore. Cutting the survey time also helped to reduce the project costs. In addition, the smaller, lighter vessel burned less fuel and posed less collision risk to marine life, including the remaining 400 North Atlantic right whales – one of the world's most endangered species.

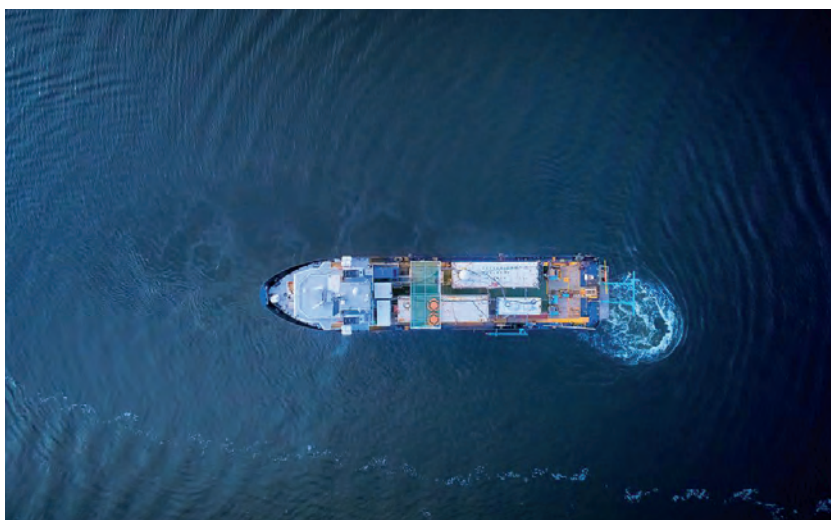
Other companies are starting to use smaller USVs but without the full array of sensors necessary for a comprehensive geophysical survey. TerraSond uses these smaller USVs for its charting work for the National Oceanic and Atmosphere Administration.

Acteon is further reducing the number of offshore personnel through the development of innovative, automated, sensor launch-and-recovery systems and data compression methodologies that enable real-time data quality control to be brought onshore.

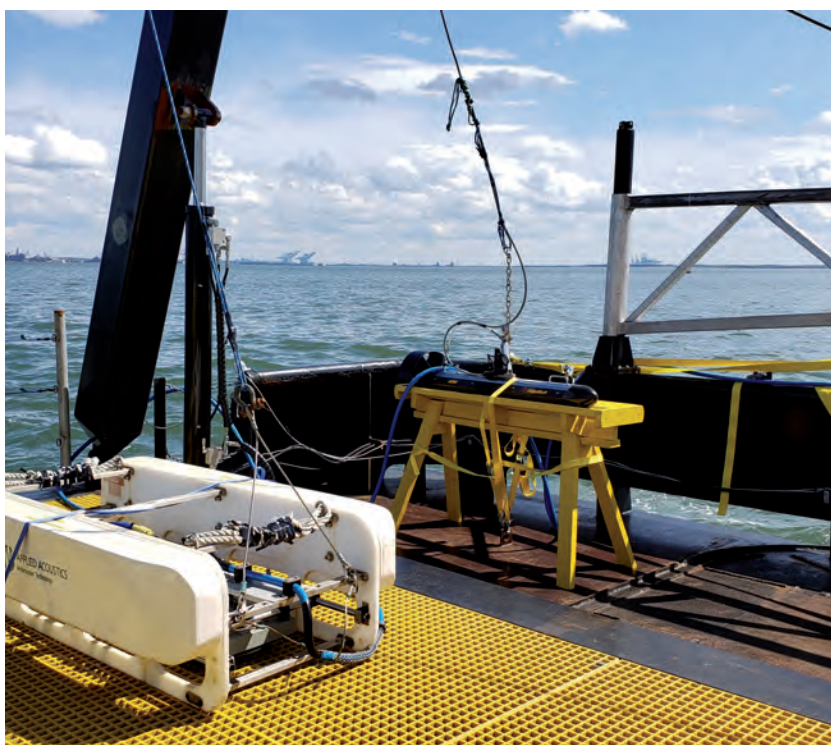
Site investigation surveys are part of the early-stage development of an offshore wind farm. Get them wrong and the wind turbine foundations could have structural issues and a suboptimal layout that affect the project throughout its life.

Integrating geophysical and geotechnical surveys can help to improve project outcomes. TerraSond previously worked alongside Benthic but, now that both are Acteon operating companies, they respond like one company. Collaborative working helps to avoid laborious data reformatting and reduces the risk of data integrity issues. This enhances efficiency and leads to higher-quality data and, ultimately, a more accurate ground model for de-risked, more cost-effective structure designs.

Customers get a single point of contact and contract, which makes their lives easier too. Major contractors may prefer to procure individual services but, if they are willing, Acteon can integrate its services to simplify project interfaces and reduce the back-of-boat footprint. For example, the company offers installation, handling, pile-cleaning, grouting and positioning services, which, when integrated, can lead to the sharing of people and equipment such as generators.



▲ TerraSond Chartered survey vessel conducting COP surveys on the US East Coast.



▲ Survey Sensors installed on the back deck to support Construction Operations Planning surveys.

DESIGNING OUT MARINE NOISE

The nature of site investigation means that survey teams are among the first people on-site, but Acteon believes that early engagement of the construction supply chain is beneficial too, as it is easier to challenge specifications and designs early on (on paper) for reduced costs and improved performance over the project's lifetime.

Customers have valuable experience, but Acteon brings inch-wide, mile-deep domain knowledge and lessons learned from previous projects that can help customers to transform their project results. Acteon teams know their equipment intimately. For example, the noise generated by piledriving must be kept within strict limits to protect marine life. Acteon company MENCK works closely with major contractors to optimize monopile design, down to the properties of their hammers, and a site's geotechnical conditions. This helps to engineer out some of the installation noise, which enables more efficient driving and thus reduces installation time for each monopile. The optimized design also uses less steel. Multiply the time and material savings by the large number of monopiles installed for each wind farm, and the figures become significant. MENCK has recently completed piledriving for Van Oord on Vattenfall's Kriegers Flak offshore wind farm, which will be Denmark's largest.

NEW VENTURES

Listening and responding to customers is not only about coming up with technical innovations; it is also about being agile. For example, in Taiwan, Acteon customers need to demonstrate local content development, so, in 2020, the organization established an operational base that it is using to build a local supply chain and develop local talent. Developing local expertise and services enables Acteon to respond more rapidly to customers' needs and helps to drive down costs by reducing reliance on international support. Acteon is supporting several offshore wind projects from the new base. For instance, two of its operating companies, Pulse Structural Monitoring and Deepwater, are designing and delivering an integrated structural and corrosion-monitoring programme for one of the latest wind farm developments in the region. High-quality corrosion, bending and torsional strain, inclination, displacement and acceleration data from key components of the jacket legs, nodes and wind turbine generator towers are providing information via a web-based system.

In 2020, Acteon also formed a partnership with Siemens Gamesa to provide a fully integrated offshore wind turbine operations and maintenance package for Dominion Energy's Coastal Virginia Offshore Wind pilot project in the USA. In this instance, Acteon companies TerraSond, Seatronics, Deepwater and Clarus are providing subsea asset integrity equipment and services. Coordinating above- and below-water services aims to reduce turbine downtime for planned maintenance activities and thus lower the cost of energy.

There are early engagement advantages to asset integrity management too. Designing an asset integrity programme during the pre-development phase, when designs may easily be adapted, can yield efficiencies throughout a project's operational phase.

A FLOATING FUTURE

Floating wind will be a major part of the future energy mix, and an estimated \$33 billion of contracts will be awarded over the next five years. More than 80% of the total offshore wind energy resource is in waters deeper than 60m, where bottom-fixed installations are not feasible. The wind is stronger and more consistent further offshore. For example, the world's first commercial floating wind farm, Hywind Scotland, set a new capacity record in 2019 with a median output of more than 59% of peak power; the next-best North Sea wind farm achieved just 48.4%. Floating wind also opens regions where the seabed drops away steeply, such as off Japan and the US West Coast. One of the main advantages of floating wind farms is that the structures can be assembled in port and towed to the site. This reduces the need for expensive installation vessels, cuts the number of offshore personnel and supports local supply chains. The installation of the anchors is also less invasive than driving monopiles or piles for jackets, creates less noise disturbance, and is further from fragile coastal ecosystems and marine users such as fishing and transportation.

Floating wind is rapidly decreasing in cost. For example, Equinor expects the cost of its Hywind Tampen floating wind farm in the Norwegian North Sea to be 40% lower than the Hywind Scotland project.

Early engagement will be even more critical for floating wind. Acteon company InterMoor has plenty of experience in mooring and anchoring mobile offshore drilling units and other floating oil and gas assets. However, the obvious difference is scale. Whereas a floating production storage and offloading vessel

typically has an array of 12 chains and anchors, a large floating wind farm might need such arrays for tens or hundreds of floating structures.

The supply chains will need to be brought in early, as mooring has never been attempted at the scale needed to enable deepwater offshore wind. Acteon knows how to do this well for oil and gas assets. Early engagement will help to drive down costs for larger-scale projects. For example, when Acteon began grouting multiple jackets and monopile wind foundations, it modified its equipment to help reduce cycle times and ensure sufficient capacity and robustness to complete large, continuous installation campaigns. The same process needs to happen for floating wind installations; with its extensive mooring equipment inventory, InterMoor is in a prime position to deliver this at the cost customers need.

Site investigation in these deeper waters requires geophysical data collection using autonomous underwater vehicles, something TerraSond and others routinely use for oil and gas projects. In addition, Benthic's Portable Remotely Operated Drill (PROD) seafloor drilling system may be more cost-effective than using drillships in deep water.

ENGAGE EARLY TO CAPTURE DEEP DOMAIN KNOWLEDGE

The rapid growth of the offshore wind industry, including its expansion into new regions such as the Far East and the US East Coast and into deeper water continues to gather pace. To lower the cost of offshore wind energy further and improve project outcomes, suppliers need to engage early in projects to fully harness their deep domain knowledge, something that Acteon is keen to do. ◀



Ivan Harnett is the renewables market development lead at Acteon with responsibility for building Acteon's renewables market strategy and engagement with key clients.

Prior to his current role, he founded the Acteon group company Core Grouting Services, which provides specialist grouting services to offshore wind farm construction projects. He has also worked as a management consultant with A.T. Kearney and spent several years designing and building gas plants with Bechtel.

Harnett holds a degree in Chemical Engineering from the Cork Institute of Technology and an MBA from INSEAD.

Biological, Hydrographic and Oceanographic Accomplishments in the Late 19th Century

The Siboga Expedition

The Indonesian archipelago is one of the world's most beautiful archipelagos. Home to over 17,000 islands, mountains rising to over 5,000 metres, including over 70 historically active volcanoes, fabled spices, and a rich flora and fauna, Indonesia has beckoned fortune-seekers and naturalists for centuries. The shores of its far-flung islands are bathed by 2 oceans and at least 11 separate seas, making it a challenging area for hydrographers. In the late 19th century, Indonesia was administered by the Dutch and known as the Dutch East Indies.

The terrestrial flora and fauna of the area was fairly well known because of the work of the English naturalist Alfred Russel Wallace between 1862 and 1869. Wallace, also known for being credited by Darwin as having independently formulated the theory of evolution, discovered that species west of a dividing line between Borneo and Sulawesi and between the Philippines and Halmahera were more closely related to Asian species and those east of the line were more closely related to Australian species. This line became known as the Wallace Line and helped to provide at least partial inspiration for a Dutch expedition 30 years later.

A project for the study of the marine fauna, particularly that of the deep-sea basins of the Dutch East Indies, was suggested by the Society for the Advancement of Scientific Research in the Netherlands' Colonies in 1896. Dr Max Weber, a noted Dutch zoologist of German-Dutch descent, volunteered to lead this expedition. Weber was primarily known for his

work as a mammalogist but in 1881 had been the naturalist on the voyage of the *Willem Barentsz*, a Dutch expedition to the Arctic Ocean. He had also married Anna Antoinette van Bosse, a wealthy widow who was unique in that she was an outstanding marine biologist and expert in marine algae. Together they had spent three summers in northern Norway; he studying the anatomy of whales, and Anna studying calcareous algae. In 1888, they went to the Dutch East Indies to study the distribution of animal life throughout the archipelago. They were therefore exceedingly well qualified to lead a scientific expedition.

FIRST WOMAN SCIENTIST

Serendipitously, the government of the Dutch East Indies was constructing a small gunboat that was modified for dredging and sounding operations. This vessel was the *Siboga*, a twin-screw vessel of slightly over 50 metres in length. Launched in 1898 in Amsterdam, it sailed to the East Indies, and on 7 March 1899, began its year-long

exploration of the Indonesian seas. The ship's complement included 10 Dutch naval officers, 45 native crew, 6 scientists including Max and Anna Weber, and 2 personal servants. The inclusion of Anna Weber in this expedition marks a milestone as she was the first woman scientist to take part in a major oceanographic expedition.

From a biological viewpoint, the Siboga expedition was a great success. Many new species were discovered and Weber showed that the Wallace Line was more of a transitional zone than a sharp demarcation. He determined a line that marked the 50/50 distribution of Asiatic versus Australian species which today is known as the Weber Line. Over 60 volumes were published detailing the results of this expedition, the most recent being published in 1986. As early as 1922, the importance of this work was recognized in the journal *Nature*:

"The stately series of reports on this expedition, which have been appearing under his (Weber's) editorship since 1902, form a contribution to the science of the sea scarcely surpassed in importance save by those of the Challenger expedition. Dealing with only a restricted area of the ocean, but paying far more attention to the fauna and flora of the shallower waters than the naturalists of the Challenger were able to do, it is not too much to say that the Siboga expedition has given a new aspect to many problems of the distribution of marine animals in tropical seas." *Nature*, 22 December 1922. ◀



▲ The gunboat *Siboga*, used for the Siboga Expedition.

[Read the full article on hydro-international.com!](https://hydro-international.com/)

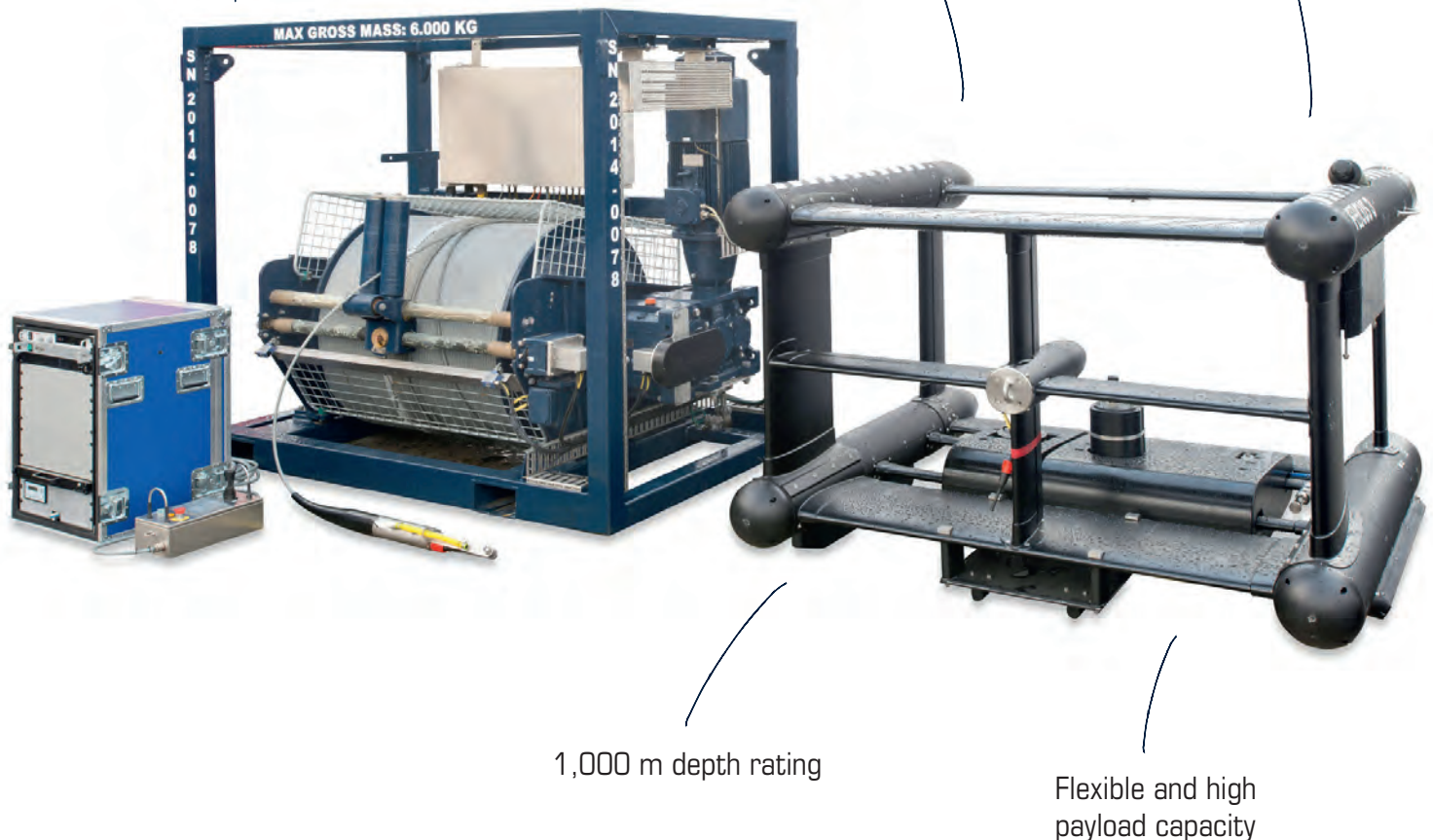
FOCUS 3

Latest generation FOCUS survey solution

Powerful, low-maintenance
electric winch system

Cost-effective, high-speed
survey platform

Modular design



MacArtney global solutions

Denmark | Norway | Sweden | United Kingdom | France
Italy | Germany | Netherlands | USA | Canada | Chile
Brazil | India | Singapore | China | Australia





Evo
Logics®

SMART SUBSEA SOLUTIONS

Delivering data in most adverse conditions: underwater acoustic modems with advanced communication technology and networking

Accurate USBL and LBL positioning of underwater assets

Modem emulator and other cost-saving developer tools

Autonomous surface vehicle for bathymetry, monitoring and AUV support



**JOIN OUR
WEBINARS**

[evologics.de/
events](https://evologics.de/events)